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IRRIGATION IN CALIFORNIA.

[SOUTHERN.]

THE FIELD, WATER-SUPPLY, AND WORKS,

ORGANIZATION AND OPERATION IN

SAN DIEGO, SAN BERNARDINO, AND LOS ANGELES COUNTIES.

THE SECOND PART

OF THE

REPORT OF THE STATE ENGINEER OF CALIFORNIA

ON

IRRIGATION AND THE IRRIGATION QUESTION.

WM. HAM. HALL, C.E.,

State Engineer.

SACRAMENTO:

STATE OFFICE, : : : : J. D. YOUNG, SUPT. STATE PRINTING.

1888.

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SACRAMENTO, October 1, 1888.

To His Excellency
R. W. WATERMAN,
Governor of California:

GOVERNOR:

There is handed to you with this letter the Second Part of my Report on Irrigation. You will find in its preface and introduction some explanations for which I bespeak your attention.

In the former volume, "Irrigation Development," acknowledgment has been made of the intelligent coöperation and courteous action of some of your predecessors. Short as was Governor Bartlett's term, I feel that his memory should fully as much be connected herewith as that of a patron and helper to the end.

Of yourself in this connection, it is not too much to say that, after all, whatever of good or value may come out of my work has been saved to the people of California by you, and I sincerely hope you will receive from the people due recognition therefor.

I heartily thank you for your manly and unprejudiced attitude towards this work, and for your uniform kindly confidence in me.

I am, sir, respectfully,
Your obedient servant,

WM. HAM. HALL,
State Engineer.

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PREFACE.

The preface in IRRIGATION DEVELOPMENT—the first volume of this report—was intended for the whole work, and it was supposed at the time of its publication that an Introduction to the special subject would suffice to open each subsequent part. Such, now, is not the case. The circumstances of production of the present volume and the third, immediately to follow, have not been such as were hoped for at the time the first went to press.

It was then the intention of the writer to embody in this publication, only thoroughly digested results. To effect this, it was the purpose to first put into print, in the ordinary form of state reports, the data acquired by a completed investigation for the districts covered; and then to write therefrom a condensed and systematic review, under the title of IRRIGATION IN CALIFORNIA, covering the fields and facts of, and water supply for irrigation—the present practice, works, waters—the past development, history, conflicts—and with such deductions as could be made to promote its advancement and a general as well as local betterment by irrigation.

This would have constituted the second volume of the report, as outlined in the preface in the first volume. And it would have been at once, so far as the writer could make it, a comprehensive and condensed report, in one volume, on the subject, proper, for so much of the state as had been gone over. It is here to be remembered that the first volume was put together in 1885, and carried through the press in 1886.

It was then the further intention to print a closing volume under the title of IRRIGATION QUESTIONS, treating of matters of legisla-

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tion and policy, as also outlined in the preface in IRRIGATION DEVELOPMENT.

It has been impossible to carry out this plan, and it were useless to recite the reasons here. The Legislature of 1887 made an appropriation of $3,600 for the office of state engineer, and one year's salary for that officer, with the proviso that it should be in full for the completion of all work then in the hands of the state engineer; and with that, and the implied understanding, on its part, that two additional volumes were to be produced and the lithographing of the maps be completed, it appropriated but little more than half enough to cover these printing and lithographing costs.

In the meantime, irrigation matters had developed wonderfully in the southern part of the state, data that was collected up to the spring of 1886, most of it in 1885, however, and previous years was far behind the times. In order to do his subject justice, the state engineer undertook in 1887 and 1888, personally, and at his own cost not only for individual expenses, but largely for assistants and their expenses, to go over this field still again.

The work was more than was anticipated. But it has been done. The primary results—the recital and delineation of facts—are to be found in this volume—IRRIGATION IN SOUTHERN CALIFORNIA—and on twelve DETAIL IRRIGATION MAPS of the southern counties, now being lithographed. The data for the report and maps, in all important matters, are brought down as late as July, in very many matters as late as September and October, and in some particulars are revised to as late as November of this year.

It will be understood immediately that this must necessarily change the cast of the report. This, the second volume, is not an epitome of the subject at large. It is a detailed account for one part of the state.

The third volume will now be a similar work for the remainder of the field heretofore examined with respect to irrigation, by the

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state engineer—namely, San Joaquin valley. The manuscript for this volume has been prepared, and awaits the possibility of printing after the legislature makes an appropriation therefor, and leaves the state office in form for undertaking such work to advantage.

If there are any special shortcomings in the present volume in the way of omissions of developments made since 1885–86, it is to be remembered that the state has not paid for half of that which is in it, relating to this period, and will not do so, and the state engineer cannot afford to do any better at his own expense.

With respect to material designed for the third volume as originally projected, if the legislature makes suitable provision for its publication, for the maintenance of the office, and for lithographing the state maps, the state engineer proposes, if His Excellency, the Governor, desires him so to do, to put this data into form, and thus close the work with a fourth volume.

The work would then stand in this condition: VOL. I. IRRIGATION DEVELOPMENT—published and speaks for itself; VOL. II. IRRIGATION IN SOUTHERN CALIFORNIA—the present volume—an account of the subject for Los Angeles, San Bernardino, and San Diego counties, brought down to the fall of 1888; VOL. III. IRRIGATION IN CENTRAL CALIFORNIA—an incomplete presentation of the subject for the counties of the San Joaquin valley—brought down for the most part not later than 1886; VOL. IV. IRRIGATION QUESTIONS—as outlined under the heading of VOL. III., in the preface in VOL. I.

This will leave Sacramento valley and other notable northern and eastern irrigation fields without mention in this report. There ought to be another volume covering these. The state engineering department has never undertaken any special irrigation examination north of the San Joaquin valley, except at two or three limited localities. It has not done so, because there

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have been no means available for the purpose. The early appropriations for this department—the only ones of sufficient amount with which to cover any considerable field—were expended on costly detail surveys of the great rivers of the Sacramento and San Joaquin valleys, for purposes of the debris, arterial or flood drainage, and improvement-of-navigation investigations, and, for the first two years, in a line of surveying for possible irrigation works, on the hypothesis that the state might itself undertake such constructions, which policy at that time was urged by many legislative representatives.

The investigation, of which these volumes are the outcome, has not been reasonably well provided for; even for the comparatively limited field attempted to be covered. On the contrary, the appropriations have been insufficient and uncertain. In these matters there is nothing so extravagant as insufficiency and uncertainty of appropriations. Under such circumstances the work cannot be organized on either an economical or efficient basis, and the smallest results are secured per dollar expended. The institution is crippled. This is precisely what has been done with respect to the irrigation investigation, and to this treatment many shortcomings in this work as a whole may be attributed.

The state engineering department might have published voluminous annual or biennial reports of data collected throughout the years of its work—there has been material enough acquired for a volume a year, and half a dozen maps to accompany it. But it takes time and money to edit and arrange such matter, so as to be worthy, in the opinion of the state engineer, of the cost of publication. The state engineer has not had the time to prepare it, and the state has not provided sufficient money for such preparation. Up to the period of the last appropriation when for two years' service and supervision of the work, the legislature appropriated one year's salary, the state engineer devoted his

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entire time and thoughts to this work, almost without exception or vacation.

Probably had Professor Whitney, who was in charge of the geological survey of California, gotten his own consent to take his mind off the main ultimate object of his work, and, by preparing or having prepared current accounts of the surface of things, in response to the clamor for immediate results, he would have been applauded, and the survey would have been amply sustained, instead of being closed up and boxed up, to the great material loss and lasting disgrace of the state.

Had the state engineer, during the half dozen years past, thrown into the state printing office a voluminous biennial report of what must have been unsubstantiated, unchecked, and undigested statistics and narratives, as might readily have been done, possibly there might not have been complaint at sessions of legislature that the department was effecting nothing.

That the state engineer has now, in a measure, departed from the original cast of the work, and put such an account as this volume contains, in print for the southern counties, is due to the force of circumstances. But few people have, as had Professor Whitney, so high a standing professionally as to warrant them in failing to accomplish a work, because they cannot carry it out the way they know is right and best in the end.

This is the difference between the chapters now presented, and accounts of work which are put out currently as work progresses: Irrigation in Southern California is prepared on a set plan—systematized throughout for reference and practical use, and is not a mere collection of narratives, descriptions, and contributions.

There are circumstances which make it right to say, and thus permanently record the fact, in closing this preface, that—as was the case with IRRIGATION DEVELOPMENT—this volume, IRRIGATION IN SOUTHERN CALIFORNIA, is the work of the state engineer per-

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sonally, without assistance whatever, with one exception: Mr. James Dix Schuyler, C.E., has not only assisted in gathering material for this volume, but has made the first rough writing of some of its articles, and notwithstanding the fact that all has been revised and rearranged, and practically rewritten by the state engineer, individually, in molding it into the special form adopted by him for presenting the subject, it is to be understood that Mr. Schuyler is entitled not only to the thanks of the state engineer for his able and faithful service, but also to credit as a contributor to the report.

Other assistants have, from time to time, been engaged in collecting material, gauging streams, etc., over the field of which this volume treats. They are mentioned in a memorandum at the close of the report. One, however, must be specially named here. Mr. George Sandow, a most excellent, rapid, and accurate topographical draughtsman, who has collected much of the material for, and revised and, in fact, made over the detail irrigation maps relating to these southern counties, has the hearty thanks of the state engineer for his good, faithful coöperation and hard work, and he should receive much credit for the irrigation maps, on which his name shall appear as they come from the press.

The general state maps herewith inclosed were made from time to time by several draughtsmen and assistants, among whom Messrs. N. King and C. E. Grunsky were the principal.

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INTRODUCTION.

Keeping in view the purpose of this whole work—to afford an insight upon its subject, not only for those who may want to have to do with irrigation itself, but for the guidance of those who may be called on to legislate concerning it—a study on irrigation divides itself into four branches:—(1) That which relates to the field for, and the works of irrigation—the material facts, as they are and might be made by the mere spending of money or labor in construction of works;—(2) That covering the organization and operation of irrigation enterprise, and maintenance and running of irrigation works—the business make-up of irrigation;—(3) That embracing the questions of water-supply for, and use of waters in irrigation—flow of streams, conservation of waters, and extent and circumstances of irrigation practice; and (4) That embodying lessons of the past in irrigation—the local history of its development, from the standpoint of each of the foregoing three divisions.

In accordance with this idea it will be found that the material of the present volume is arranged under these headings, namely: (1) District and Works;—(2) Operation and Maintenance;—(3) Water-supply and Use;—(4) History and Water-rights. Subdivisions of the subject, within each of these are made, more or less systematically and completely, throughout, as indicated by the side-headings.

With this general idea of the subject at large, has gone the one of orderly division and description of the field for irrigation and the sources of water supply, and the systematic grouping of works and projects. This is apparent in the arrangement of matter in the chapters and sections.

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The object has been to make all as clear and commandable as possible. A result, foreseen, is exposure of whatever omissions or faults the report has. No one can be more conscious than the writer, of at least some of these faults. It is hoped that those who know the circumstances of the production will overlook them.

Remember: This is not a completed subject in this volume. The summarizations on *Irrigable and Tillable Lands*, *Water-supply*, *Practice of Irrigation*, *Storage of Water*, and others scarcely less important, are yet to come, each in a separate chapter with its addendum of tabulated matter. These summarizations are not put in this volume because, (1) there is not room for them, (2) it is desirable and economical of space and words to summarize the whole report together, (3) it is desirable, as far as possible, to correct errors or omissions before final publication, and this will, in some degree, be effected by the course which is being pursued.

It may be thought by some who look into this volume that its descriptions are unnecessarily minute. Unquestionably this is so, for those who are familiar with irrigation works, and understand such subjects. For irrigators, ditch men, old-time residents in irrigated sections, the information and ideas in this book could have been put in much shorter space; for engineers, in still shorter space. Tabulations would convey it, nearly all, on a few pages to them. The general reader, though, will not look a second time into a book made up of tables.

Again, it may be thought that there is unnecessary repetition in succeeding articles. Yes, this is a fact, if the book is to be read through, page after page. It is believed, however, that few people would thus read any report on this subject; but rather that it will be read, a chapter, or a section, or subdivision concerning some special work here and there; or referred to by the side notes on some special line of the subject, as a whole, following through. If such is to be its use, repetitions in explanations,

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besides references to preceding explanation, often become necessary.

If seeming pains are herein taken to describe works which, from an engineering or practical standpoint, are unimportant, let it be remembered that it may be because of this insignificance that they are thus carefully drawn without comment.

If works, from a scientific or technical standpoint, unsafe or unsound, are described without comment, let it be remembered that it is not the purpose of this report to say anything which might attack the value of any individual property, other than to squarely present the facts.

Where works have good qualities they have been guardedly commended; where faults that may be remedied, and fair criticism might do good, they have been mildly criticised. This is the case more especially with the properties of communities and not the subject or means of private or corporate speculative enterprise. This is no place either to write up or write down special money ventures. There are a number herein referred to that deserve commendation; some high praise, some condemnation. Classes of works and of enterprises are freely spoken of in a closing chapter of the final volume.

Two general state maps are herewith inserted: The DRAINAGE AREA MAP and the RAINFALL DISTRIBUTION MAP. These are of a set of four maps projected as general exhibits of the subject throughout the state.

The "Drainage Area Map" is fairly well completed as a general exhibit for the State at large. It is, of course, intended as a basis for calculations on the subject of water-supply. Knowing, from observation of the flow, what amount of water some streams produce in different seasons and in different months, per square mile of drainage area, a fair approximation may be made to the output of other streamss, knowing the comparative extent and

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characters of their catchment basins. This map is only a general exhibit. To study the subject to practical purpose, it has been the intention to prepare detail maps of every distinctive quarter of the state. Such an one, for the Los Angeles and San Bernardino region, is found in this volume and will presently be spoken of.

The second general state plat—"The Rainfall Distribution Map"—is of course another showing on the subject of water-supply, and which it was intended to supplement by local studies and diagrams as data could be acquired therefor. This is a general exhibit, based on reduced annual averages for about two hundred stations, to a standard period of sixteen years to and including the season of 1883–84. The table of annual means, printed on the map, has been brought down, for the several periods named, for most stations, to the season of 1887–88, inclusive, and, hence, does not correspond with the station-means from which the limitation curves were projected. The state engineering department has not had the money with which to revise this map upon the basis of the later and fuller information.

It was really not intended, originally, to put any of this set of maps within the covers of these volumes of the report. The proper way to have issued them would be in a special atlas or a separate binding of some kind—all together; but there being no money at disposal for this purpose, and the idea being to put before the public at once whatever there is of results sufficiently advanced to be useful, the state engineer has decided to embody these two maps with this first volume. As elsewhere explained, at least one other will accompany the next volume.

The OUTLINE MAP of the irrigation region of Los Angeles and San Bernardino counties is properly an accompaniment of this volume. Reference to it, although it is far from complete in detail—only a map in outline—will make more intelligible the

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descriptions of locality herein contained. Those who would have the details of this field, in graphic form, before them, should get the twelve "Detail Irrigation Sheets," prepared by the state engineering department, and now being published.

The "Outline Map" is intended to show more especially the relation between the drainage areas of the region, and the irrigable lands to which they are tributary. Each noteworthy catchment basin, or shed, is separately outlined, and its area in square miles is given. Where of sufficient size to admit lettering the names are shown, and all are numbered from one to one hundred and thirty-five, for reference from a table elsewhere found herein. The valleys, plains, and outstanding hills also come into this grouping. The grand divisions or groups, as indicated by the heavier color-lines, will, of course, be noticed and understood.

It is to be regretted that a map of this kind covering San Diego county is not available for this volume, and that this one map does not extend over the northern as well as the south side of the Sierra Madre, and also into Ventura county. Nothing but the lack of means for the work has prevented such a presentation. It were easy enough, of course, to get up some kind of an outline for this additional region; but to gather materials for, and project the detail maps from which areas may be correctly delineated and calculated, is a work of time, labor, and cost.

The state engineer has of his own means, virtually, prepared the portion of this report relating to San Diego. When the legislature, at its last session, made an appropriation of $3,600 for the office expenses of the department, and with one year's salary for the state engineer, "*provided* that this shall be in full for all work now in the hands of the state engineer," nothing whatever had been done in San Diego county by the department, except to gather some data as to water-supply.

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The subjects of the artotype illustrations have been chosen as the best examples of works from which instruction might be had. It is not necessarily to be inferred that they are all commended or to be copied after. It is to be regretted that there are no illustrations of the Riverside works, and none of Los Angeles county works. The fact of their absence is consequent upon the absence of state money with which to get any at all.

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NOTES.

As these pages may be read by persons not familiar with the Spanish terms and names commonly employed throughout the region written of, an explanation of those used herein will not be out of place.

Cien'ega—This name, pronounced in English *seën'egah*, is applied to a peculiar class of springs which rise, ordinarily, from gravel beds, through alluvial soils, on the plains or in ravines of the plains. It includes the spring and the marsh usually formed for acres around it.

Zan'ja—This word, pronounced in English (properly) *than'ha*, with a slight aspiration accompanying the *th*, but ordinarily spoken as *sankha*, is the general Spanish term for irrigation ditch.

Toma—Pronounced with the broad sound of *a*, as also in the two cases above, is the name applied to works of diversion—the head-works and dams jointly—of canals. It means the *taking* works.

Cañon—This term is applied more especially to mountain gorges, gulches, or ravines in Southern California, and the word *arroyo* applies very frequently under the definition of cañon given by Webster.

Cañada—Pronounced *canyad'tha*, the *th* being obscure, applied to an open cañon between hills or mountains; also a pass, whether open or contracted, between hills not precipitous.

Mesa—Pronounced *mā'sah*, with long sound of *a* in, and accent on, first syllable; properly a nearly level-topped table-land, but in Southern California applied to steeply sloping as well as nearly level lands lying higher than and overlooking the immediately adjacent valleys or plains. From the fact that *mesas*, proper, in these counties are almost always composed of a rich, friable, red clay soil, carrying some gravel, and underlaid more or less deeply with gravels, cobbles, and bowlders, the term *mesa* has become applied to lands where this formation is found, whether lying properly as a table-land or not.

Arroyo—This term is in Webster defined as a water-course, rivulet, or small river. It is applied in Southern California not only to water-courses, great and small, as such, provided the flow be not perennial, but to any channeled-out way through a plain or mesa, whether a water-course or not.

Barranca—Pronounced *barran'car;* a deep, abrupt-edged channel-way through a plain or mesa—a much accentuated and large arroyo. There are but few places in Southern California where this name applies.

Zanjero—Pronounced *thanthā'ro;* a water-overseer on irrigation ditches. This name is quite commonly used, even on the newer works and those which are not at all of Spanish origin.

It will be understood, of course, that these terms are employed in this report, because they are universally used in the country of which it treats.

For the same reason the measures of water volumes are herein given in "inches" instead of cubic feet per second. Although the "inch" as measured is not everywhere the same throughout this southern country; when not otherwise specially stated, the inch herein meant is the equivalent of the fiftieth part of a cubic foot per second, in quantity.

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INDEX.

A subject index will not be prepared for this volume. Its matter is so classified throughout, and commanded by the side headings, that an index to the technical divisions of the subject is not indispensable. There will be found at the close of the volume, however, (1) an index to streams and other water-sources, (2) an index to canals and other irrigation works, (3) an index to mountains and other features of topography, (4) an index to irrigation organizations, (5) an index to localities written of, and (6) a table of cases reviewed or cited.

ERRATUM.

It is scarcely possible that a publication of this size prepared as this has been, is without many errors in statement of fact. The information originally obtained may have been wrong; it has gotten wrong in formulation; or errors have been made in printing. No attempt will be made to prepare an erratum for issue at first with the work. Such an erratum may be prepared and inserted afterwards. The summaries to be printed in the third volume will afford opportunity for correcting errors in this. Meanwhile the state engineer will be glad to have his attention called to any material errors which may catch the reader's eye.

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IRRIGATION IN CALIFORNIA.

SOUTHERN CALIFORNIA.

SAN DIEGO; SAN BERNARDINO; AND LOS ANGELES.

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IRRIGATION IN SOUTHERN CALIFORNIA.

SAN DIEGO.

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SAN DIEGO COUNTY IRRIGATIONS.

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SECTION I.

GENERAL PHYSICAL CONDITIONS.

Topography and Rainfall.

That portion of California lying adjacent to our neighboring Republic on the south possesses features of physical conformation, geological structure, soil, and climate quite distinct from all other sections of the state—conditions, which influencing the development of irrigation, seem to compel the adoption of methods of procedure not generally employed elsewhere on a large scale.

Light rainfall along the coast; heavy rainfall, rather than heavy snows, in the mountains; mountain masses and ranges too low

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to husband snows until late in spring, as in the high Sierras farther north; the proximity of a warm desert that aids in the melting of snow soon after its precipitation: all these conditions result in intermittent streams, large of volume in winter but dwindling to feeble rills in summer, necessitating storage reservoirs to conserve the supply.

The irregularity of the country's surface, too, and the very general disposition of its most desirable and fertile soils in sloping, broken mesas, and in elevated plateaus difficult of access from adjacent streams, call for the conveyance of irrigation waters in expensive conduits, by long and circuitous routes. These are conditions, whose difficulties have, until recently, baffled the enterprise of settlers and would-be irrigators, and given the county a reputation for drought and sterility.

Along the eastern border of San Diego county for more than a hundred miles flows the Colorado river, whose turbid waters drain from the heart of the continent. In comparison with all other water-courses in Southern California, it is a mighty flood, the greatest river of the Pacific Coast, the Columbia alone excepted, flowing on undisturbed to the sea, close past a vast desert, which challenges the power of man to utilize it. Nearly all of California that slopes toward the Colorado, and drains into it, if there be any drainage from a region so seldom and so sparingly visited by rain, is an absolute desert, within whose limits is included nearly three fourths of the entire area of San Diego county.

The Mountains and Pacific Slope.

The remainder of this county, and which is now regarded as the arable portion, is separated from the desert by a series of mountains, whose axes are generally parallel with the trend of the coast, and distant from it sixty to eighty miles. These mountain masses, looked at from the sea, do not form a continuous high chain or range, but are ranked rather as a succession of peaks and ridges along the upper margin of a sloping plateau. The plateau, if the term is admissible of a region so very irregular, and so cut up by cañons, and broken by hills and mountains, reaches an altitude of four thousand to five thousand feet, and the peaks and long spurs maintain an elevation of six thousand to six thousand five hundred feet, and in one instance, that of San Jacinto mountain, nearly twelve thousand feet.

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To the east the slope from the plateau is abrupt, without a break in the descent until the edge of the great desert basin, whose bowl is three hundred feet below sea level, is reached. Westward, toward the ocean, the slope is gradual, and a succession of open valleys is met with upon whatever contour of elevation one may follow.

Immediately bordering the coast is a mesa, varying in width from five to fifteen miles, rising with more or less abruptness, fifty to two hundred feet in the first mile, and thence continuing to rise more gently eastward to an altitude of eight hundred to one thousand feet, where it blends into the mountainous or plateau region. From a distance, the coast mesa, viewed in profile, presents to the eye a uniformly sloping surface, but on closer inspection it is found to be intersected by all the streams that drain the interior, as well as by numerous local arroyos, cañons, and barrancas.

Immediately beyond this mesa is a peculiar chain of land-locked valleys, lower in elevation than the mesa, unconnected with each other, and drained by separate water-courses that deeply cut their ways to the sea. The Janal and Jamul valleys are drained by the Otay river; the Jamacha and Upper Sweetwater valleys by the Sweetwater river; El Cajon valley by the San Diego river; Poway valley by Las Peñasquitas creek; Bernardo and San Pascual valleys by the San Dieguito river; Escondido valley by San Elijo creek. The streams enter these valleys generally with a precipitous fall through rocky cañons, after draining a higher series of valleys to the eastward, and leave them by narrow passes or barrancas in the hills, or inner mesa border.

The mountain landscapes are more gentle in outline than the precipitous crags and gorges of the Sierra Madre of Los Angeles, or the bold and serrated ridges and spurs of San Bernardino. There are limited exceptions to this rule, but looking at the country's surface comprehensively it is one such as a person would expect of a region rising by easy gradations from sea-level to culminating peaks in the far interior. The great abrupt bulwark of Mt. San Jacinto, in the northeastern corner of this region, considered in connection with the broad, level plains lying immediately at its foot and westward of it, constitutes an exception to the general topographical configuration of the country.

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The remote position of these plains from the coast, and the intervention of another mountain-side south and west of them and in the path of the rain-clouds, render the San Jacinto valley more arid than the region of equal altitude to the south. But this condition is partly compensated by the fact that Mt. San Jacinto towers far above all other mountains; precipitation on it is greater, and the snows linger later in the season, maintaining the flow of streams and springs, from which the plains may, in part, be supplied.

SECTION II.

Arterial Drainage Toward the Sea.

The Three Rainfall Belts.

The streams which drain the western slope of the county seldom flow continuously to the sea during the dry months of summer and fall, except following seasons of unusual rainfall such as those of 1854–55, 1861–62, 1873–74, and 1883–84. The volume of their flow depends, in each case, not so much on the area as on the altitude of their water-sheds. Precipitation over the country is in a marked degree proportional to altitude: least upon the coast, greatest upon the mountain tops. This common rule it would seem unnecessary to mention were it not so clearly emphasized here and so potent in effect on irrigation water supply.

The country is naturally divisible into three rainfall belts, the first of which comprises all the mesas and valleys adjacent to the coast below an elevation of one thousand feet, and covers an area of about one thousand one hundred and thirteen square miles. Within this belt are by far the greater portion of lands irrigable that require irrigation, and the greatest area which is generally free from frosts.

The rainfall in this belt is subject to great fluctuation, but is generally so small as to be unreliable for all agricultural purposes. The record kept in San Diego from 1849 to 1860 by the United States War Department, and since 1871 by the Signal Service, shows that thirteen years out of twenty-three the rainfall was less than ten inches, and during five years was less than six inches per annum, while, with one exception, it never exceeded sixteen inches. These figures doubtless represent the minimum rainfall

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of the coast belt, as the record kept at Poway (elevation 550 feet) for six years, shows an average precipitation 17 per cent greater; and a record kept at Fall Brook (elevation 700 feet) indicates a rainfall 42 per cent greater than that for the same years at San Diego.

The second belt, comprising the territory generally between one thousand and three thousand feet in elevation, covers an area of about one thousand four hundred square miles. Except on the San Jacinto plains, and in all but very dry seasons, the rainfall over this belt is usually sufficient to render irrigation unnecessary for all but certain special crops. The average rainfall cannot be stated satisfactorily, because there have been no systematic observations made. It is asserted by residents to be eighteen to twenty-four inches, but it is probably fourteen to twenty inches. The general character of the local water-sheds is more precipitous than along the coast, and a larger percentage of the rainfall reaches the streams. The slopes are more or less wooded with live-oak and underbrush. Snow frequently falls on the higher peaks and ridges, and frosts visit the valleys in winter and late in spring.

The third belt, lying above an altitude of three thousand feet, has a climate similar to that in some of the southwestern states, except that summer rains are very rare and light, and the snows of winter not so deep or long continued. Its area is about one thousand six hundred and fifty-four square miles, of which, perhaps, three fourths is less than four thousand five hundred feet in elevation. It comprises many fertile valleys, heavily wooded mountain slopes, and a small area of timber lands of commercial value. It is a superior grazing country, and produces its best cultivated crops in moderately dry years, as it not infrequently has an excess of rainfall for purposes of tillage. Within this belt are capacious sites for storage reservoirs, which bid fair to be utilized. Springs abound, and many of even the smaller streams rarely fail. The larger streams all head in this region. A list of them is here presented with the approximate area of their shed in each belt, arranged in the order of their geographical position:

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Name of River.	Area of Water-shed below 1,000 ft. Elevation.	Area of Water-shed from 1,000 to 3,000 ft. Elevation.	Area of Water-shed above 3,000 ft. Elevation.	Total Area of Water-shed.
	1st Belt—Sq. Miles.	2d Belt—Sq. Miles.	3d Belt—Sq. Miles.	Sq. Miles.
Tia Juana	31.4	141.3	226.9	399.6
Otay	80.0	31.4	4.4	115.8
Sweetwater . . .	63.0	52.8	99.8	215.6
San Diego	167.0	131.4	110.7	409.1
San Dieguito . . .	87.4	127.3	117.3	332.0
San Luis Rey . .	116.6	200.0	250.0	566.6
Santa Margarita .	84.6	478.3	167.8	730.7
San Jacinto . . .	. . . . .	120.0	678.0	798.0
Totals	630.0	1,282.5	1,654.9	3,567.4

The sheds of the smaller streams which do not take their source above three thousand feet of elevation, and the lesser water-ways which drain the coast belt, represent an aggregate area of about six hundred and twenty square miles, in addition to those shown in the above table. Altogether, the territory described, comprising the ocean slope of San Diego county, covers about four thousand one hundred and eighty-seven square miles, an area more than half that of the state of Massachusetts.

Water-shed Characteristics.

Considered as a water-shed area, it is, to a great extent, barren of forest growth, and such vegetation as holds and prevents the rapid escape and evaporation of the waters of precipitation. The higher part of the mountain plateau, and the northern slopes of the main ridges and peaks, as a general rule, are wooded with varieties of pine, oak, and madroña. The higher portions of the main cañons and the upper valleys are sparsely wooded with oak, madroña, laurel, and aspen. The main ridges and frequently the northern slopes and lesser spurs are covered with dense low growth, commonly known in California as chaparral or chemisal. Along the streams—in the medium range of valleys—there are growths of cottonwood and willow, principally; and along the main streams and on the sandy bottom lands adjacent to them, similar vegetation abounds, in some places quite densely. But the entire coast mesa, the broadest parts of the river valleys, the large valleys just within the line of the mesa formation, the greater portion

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of the plateau region, and a considerable portion of the mountain ridges are treeless and devoid of vegetation, such as is generally thought to conduce to the conservation of waters for the supply of streams. The light rains are all absorbed; and up to a point where the ground becomes well saturated, there is but a small flow of surface drainage water finding its way to the rivers; but when this point of saturation is reached, then a large proportion of the waters of precipitation are shed off, and torrents form, which rush to the main drainage lines, and contribute to sudden and excessive freshets in those streams, carrying great loads of sand and finer sediments. The rains ceasing, and there being but a small amount of snow to melt, on a limited mountain area, the streams soon run down.

For reasons given heretofore, there are no large springs or areas of summer drainage of living waters. This, then, is a country where, in the aggregate, an amply sufficient rainfall may be had to supply an abundance of water, but where, for the most part, it runs uselessly away to the sea. It is preëminently a country where the reservoiring of waters is necessary to maintain any great irrigated area.

SECTION III.

Rivers and Streams.

The Tia Juana River.

The Tia Juana river gathering its supply from the Laguna and Milquatay mountains in the extreme southern part of the county, combines its waters with Lower California tributaries on Mexican territory, and some six miles above its mouth, reënters the United States. The main fork in American territory is known as Cottonwood creek, a perennial stream whose tributaries drain no less than six mountain valleys, some of which are believed to be available for storage reservoirs.

To a limited extent the water may be advantageously utilized for winter irrigation on bottom lands along the coast. The extensive Otay mesa, a body of fertile agricultural lands on a high plateau between the Tia Juana and Otay rivers, may be reached from Cottonwood creek by conduits carried around the mountain side through Mexican territory. The upper water-shed of the Tia Juana

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is well provided with little springs and small streams, which are, as yet, almost entirely unutilized for irrigation purposes.

The Otay River.

The Otay river lies almost wholly within the lower rain-belt, and without storage of its winter flow, is comparatively insignificant as a source of irrigation supply. The highest elevations within its water-shed do not exceed three thousand feet, and its entire basin is, for the most part, devoid of timber or other growth of a character tending to conserve its water supply. The tributaries which form the stream descend rapidly from the higher peaks, and converge into the Jamul valley at an elevation of about eight hundred feet. Thence its nearly uniform slope to the sea is unbroken, except at a short, narrow cañon at the outlet of Janal valley, where it flows over bed-rock, between walls of rock, before emerging into the coast valley.

Its mouth is at the head of San Diego bay, but its waters seldom flow on the surface there in any considerable volume. Two favorable sites for storage reservoirs are known to exist on the main stream, and one on the southerly branch, which would command the bench-lands of the Otay ranch, a part of the Otay mesa, and all the lower valley of the stream for ten miles above its mouth. The latter is, however, very limited in area of water-shed, and although affording a fair site for a dam, is reported not to possess storage capacity proportionate to the probable expense of the dam construction.

The Sweetwater River.

The Sweetwater river heads in one of the highest of the three Cuyamaca peaks—culminating points in the range that form familiar land-marks forty miles northeast of San Diego—and empties into San Diego bay at National City. Its shed is long, narrow, and precipitous. Green valley at its source is about four thousand five hundred feet above the sea, and is full of springs, cienegas, and green meadows, from which the river passes through a cañon four miles to Guatay valley, three thousand five hundred feet above sea-level; thence through eighteen miles of rocky cañon, with occasional small valleys on its course, it descends to an elevation of five hundred feet at the Upper Sweetwater valley, extending six miles to the Jamacha cañon. Passing through this

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narrow gorge two and a half miles, it debouches into the Jamacha valley, four miles long, drained by a short, rocky gorge, half a mile in length, through which the stream passes to the Lower Sweetwater valley and enters the bay seven miles below the last rock-bound pass. One of its tributaries drains the Valle de las Viejas, one of the most notable of the numerous high mountain valleys of this region, about two thousand acres in area, and whose meadows are green the year around.

Were the stream presented to the eye in longitudinal profile, its descent from the summit of the mountains would be seen to be a long slope, but slightly broken by a succession of flat valleys and steep cañons, and having far less abruptness of fall over any considerable distance than its neighbor on the north—the San Diego river—in its upper course. The high mountain portion of its water-shed is also wooded to a larger degree in proportion to its area. Its feeders are perennial, although their summer flow is comparatively small and is almost all lost by absorption and evaporation before reaching the lower valleys.

The main stream has a winter flow reaching as high after storms as fifty thousand miner's inches—one thousand cubic feet per second. There have been seasons, however, when it has carried a large volume of flow throughout the year, but when this occurs the whole country is well saturated. No use had ever been made of the stream for irrigation until the construction of the Sweetwater dam in 1886–87, as without storage of its flood waters, the volume of supply was not to be relied upon when most required.

The lands suitable for and requiring irrigation, and at all easily reached from this stream, are of limited extent above the dam—possibly two thousand to three thousand acres all told—in the Jamacha and Upper Sweetwater valleys, and the low mesas bordering them; but below the dam they embrace the whole of the Sweetwater valley, and the mesa lands to the north and south of it, along San Diego bay, a total area of twenty thousand to twenty-five thousand acres. The lower Otay valley, a part of the Otay mesa, and the lower Tia Juana valley, may also be reached from the same source.

The San Diego River.

The water-shed of this stream is fan-shaped as compared with the more narrow and contracted basin of the Sweetwater, and embraces a much greater area of high mountain territory. Its

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various tributaries plunge precipitously down rocky cañons, and converge into one channel of much lower grade, at an elevation of nine hundred feet, and ten or twelve miles before it enters El Cajon valley at an elevation of something more than five hundred feet. Leaving El Cajon valley it is confined to a narrow, rocky channel for two to two and a half miles, when it enters Mission valley at a distance of twelve miles from the coast, and at an elevation of about two hundred and sixty feet above sea-level. Throughout Mission valley and El Cajon, and indeed for nearly forty miles above its mouth, from the point where its various tributaries converge after their plunge off the mountains, the river occupies a broad, sandy bed, with low banks, and with grades from twenty to thirty-five feet per mile.

Were the stream perennial, the field for irrigation in these fertile and extensive valleys would have been an inviting one, and canals and ditches would ere now have there been in existence. As it is, no works since the time of the mission fathers, in the early part of the century, until recently, have been projected, and these are proposed in connection with storage reservoirs. There are several available reservoir sites; one, being at the head of Bowlder creek, between the Cuyamaca peaks, where there is a high, flat valley with a narrow outlet suitable for a dam site, and recently taken for that purpose—forming the Cuyamaca reservoir.

The character of the river is, in general terms, similar to the Sweetwater, except that, as its shed is greater, the flow of the stream is maintained somewhat later in the season, and its flood discharge is greater in volume. Both streams emptied into San Diego bay until the United States Government diverted the San Diego river into False bay by a dyke thrown across its channel from the bluffs at Old Town to the headland of Point Loma. This circumstance bears testimony, not only to the greater volume of the San Diego, but also the recent greater rate of disintegration of its water-shed, for whereas no notable shoaling of the bay has occurred at the mouth of the Sweetwater, the deposits from the San Diego river threatened immediately to impair the navigability of the bay, and necessitated the diversion of the stream.

There are indications that San Diego bay and False bay formerly have been joined in one, leaving Point Loma headland an island, and that the lowlands that now connect this point with the mainland and cut off False bay, have been entirely built up

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by the flood deposits of the river. In seasons like 1884–85 the river is not fordable at its mouth the summer through, but ordinarily after May it shrinks up the stream day by day, until in the middle of July one must ascend its sandy bed for thirty miles to find flowing water on the surface, and nearly forty miles by September.

The facts that the lowlands which may be irrigated by inexpensive water ditches from this river, do not generally require irrigation to raise ordinary crops, and that to construct great reservoirs to save the water, and works to conduct it to the high mesas required large capital, sufficiently explain the reason why the stream has not been utilized extensively heretofore.

The San Dieguito River.

This stream is known as the San Dieguito at its mouth; farther up it is called the Bernardo; still higher, the San Pascual; and near its source it is named the Santa Ysabel. This custom of calling a stream by different names along succeeding portions of its route, was derived from the Mexicans (who name the streets of their towns, also, after the same fashion), is a confusing one, and has led to misunderstanding regarding the identity of this river.

The San Dieguito has a total length of about fifty miles, from the summits of Mesa Grade and Volcan mountains, to the sea. Its main fork, the Santa Ysabel, gathers together various tributaries from the rugged and well wooded Volcan mountains, into the high open basin known as Santa Ysabel valley. Thence it drops from an elevation of three thousand two hundred to nine hundred feet in twelve miles through a rugged cañon, to the Pamo valley, where it joins the Pamo creek. Leaving the latter valley, it again enters a cañon for four miles, descending to the San Pascual valley at an elevation of six hundred feet. The valley of San Pascual is six miles in length, and the river here has so slight a fall, and such a broad, sandy bed, that its summer flow is wholly lost and absorbed.

Here it is joined by the Santa Maria creek, the main tributary from the south. This fork drains about one third of the river's entire water-shed, but is less constant in flow than either the Pamo, Santa Ysabel, or Guejito forks; all of which head on higher altitudes. The creek enters the Santa Maria valley from the Ballena valley, at an elevation of about one thousand five hundred

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feet, by a narrow channel between high hills, in places rock-bound, and in other portions open and bordered by strips of cultivable lands, and leaves it through a precipitous, rocky cañon, some four miles in length, with a total fall in that distance of eight hundred to nine hundred feet from the lower end of Santa Maria valley to San Pascual valley. From San Pascual valley, the river next passes through Bernardo valley, enters an open cañon a few miles from the coast, and emerges into a low, narrow valley through which it runs sluggishly to the sea, joining a tidal estuary at its mouth.

No other river in the county passes through such a succession of large, arable valleys as this, and for that reason, doubtless, more attempt has been made to use it for irrigation. These endeavors, heretofore confined to individual farm ditches, chiefly in the Santa Ysabel and San Pascual valleys, are lacking in importance on account of the intermittent nature of the stream, whose waters in summer are seldom visible above the surface of the sand that fills its bed throughout in all the valleys below the Santa Ysabel.

The Pamo, Santa Ysabel, and Ballena valleys afford favorable storage sites, the former of which is to be utilized as hereinafter spoken of. The district naturally commanded by this river embraces the mesas north of San Diego river, the Poway, Bernardo, and San Pascual valleys, and the plateaus adjacent to them. Escondido valley may also be reached. The total area requiring water which could be most readily carried out from this source, far exceeds the capacity of the stream to provide it.

In this country, where storage of water and diversion from the streams can best be made at elevations of one to three thousand feet above sea-level, and where pipe and flume lines may be carried thence in almost all directions, the field commanded, and the district irrigable, is limited only to the supply of water, or by the amount of capital available, and is definable only by the action of individual and community interests that may be involved in the works projected.

San Luis Rey River.

The largest and most reliable water-supply in the county is that afforded by the San Luis Rey river. Its high mountain drainage area is more than double that of the San Diego river,

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and it is more nearly perennial in its flow than any other of these streams. This is chiefly due to the influence of Smith's mountain, a huge ridge, whose crest line maintains an elevation of about six thousand feet for twenty miles, and stands out westerly from the main range of mountain peaks. Confronting the course of the storm clouds drifting northward and inland from the ocean, this ridge so effectually intercepts them that but little moisture is left to be precipitated upon the Temecula valley, and the San Jacinto plains, beyond. This drainage and that of the other high mountains in the vicinity feed the source of the San Luis Rey river, whose water-shed, though less than the Santa Margarita, next northward, affords a greater average discharge.

For twenty-three miles up the stream from its mouth to Pala (the site of one of the old missions) extends an open valley, in places over a mile in width, comprising an area of six thousand to seven thousand acres of moist, alluvial soil, naturally sub-irrigated. In the ordinary acceptance of the term, this valley would be the natural irrigation district of the stream, but it is the higher, warmer, more fertile mesa soils adjacent—which can only be reached by diverting and storing the stream at high elevations—that afford inducement for works of an important character and large capacity.

In this lower section of the stream there are but two places where the valley is contracted and the hills approach within a few hundred feet of each other. The first of these is about ten miles from the coast, the second about nineteen miles, on the easterly line of the Rancho Montserrato. The latter point has been considered a favorable site for a submerged dam for the diversion of the stream. Below it the river receives several tributaries, one from the Fall Brook country on the north, and two others on the south—the Moosa and Van Meter creeks, which drain the elevated plateau region known as the Bear valley country, and lying between the San Luis Rey and the San Dieguito rivers.

Above Pala, the river is bordered for several miles on the north and east by a high plateau, which breaks off abruptly with bluff banks one hundred feet, or more, high. The plateau is, as it were, a flattening of the base of Smith's mountain, and through it several living streams cut their way to the river from off that great ridge. These are the two Agua Tibia creeks and the

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Pauma, the latter being one of the few never failing streams of the county. Above this upper plateau region, the river is shut in by a narrow, rocky gorge, for a long distance, opening out into a large flat valley, familiarly recognized as Warner's ranch. The head of this gorge at the outlet of the valley, two thousand six hundred feet above sea-level, presents a favorable site for a storage reservoir dam to impound waters within the lower portions of the valley.

The leading characteristics of this stream differ, as will be observed, from all others of the county. Its extreme source is in a region east of and beyond the higher mountain ridges which it drains, and on a plateau overlooking the desert. From this region it plunges rapidly downward through a rocky cañon to an open valley, receiving many feeders as large as its main source, on the way, and again receives other tributaries from the lower plateau region, all along its lower valley section, a feature not to be found on the other streams.

Of the Bear valley country it may be observed that it consists of a number of basins of considerable area, timbered with oak, and surrounded by hills and fringes of granite bowlders. Its general elevation is one thousand three hundred to one thousand six hundred feet. These valleys and slopes are cultivable, and have already attracted quite a population. Several of the basins are suggestive of dry mountain lakes, and their possible utility for reservoirs to be filled from the San Luis Rey river is apparent.

The Temecula or Santa Margarita River.

This river is no exception to the rule of light summer flow and winter torrents which is applicable to all Southern California streams. In July or August, one unfamiliar with these watercourses could not suspect it of the extreme violence displayed in such winters as 1884–85, when it destroyed the California Southern railroad for nearly twenty miles. Several thousand cubic feet per second (possibly five thousand) must have been the volume of its flow at that time, sustained for several weeks. The ordinary winter flow, however, does not exceed six or eight hundred cubic feet per second, and that immediately following protracted storms, only. In summer it is never dry in the long cañon, and maintains a discharge of two to four cubic feet per second (100 to 200 miner's inches) throughout the driest months. Its three main tributaries

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drain an elevated but sparsely watered region of large area, back of the Coast Range hereinafter to be described, and join at the head of Temecula cañon some twenty-five miles from the coast, at an elevation of about nine hundred and fifty feet.

The westerly fork of these tributaries heads near the Elsinore lake, following the fertile valley at the foot of the Santa Rosa mountains. The middle fork extends to the San Jacinto valley. The easterly or south fork follows along the foot of and behind Smith's mountain, receiving some of the drainage of that high region. The cañon of the stream is about thirteen miles long, opening out into a flat, fertile valley, or bottom, at an elevation of three hundred feet. Near the mouth of this cañon it receives a tributary from the Santa Rosa mountains on the north, called De Luz, a stream for some miles of its course perennial, and to a small extent, already utilized for irrigation.

Above the cañon the lands that may be classed as irrigable are limited to about three thousand acres, in the Temecula, Pauba, and Little Temecula ranchos. Below the cañon there are no less than three thousand acres of bottom lands that are easily irrigable, but are naturally moist and require little, if any, irrigation, while on the rolling masses on either side of the valley are forty to fifty thousand acres irrigable only by conduits carried from the upper end of the cañon, and embracing the lands that will best repay the cost of irrigation works. The greater portion of these lands are in the Santa Margarita rancho and the region known as the "Fall Brook Country."

A comparison: An idea of the general character, in one respect, of all the streams described in the foregoing pages may be formed by the distance from the coast at which they have an elevation of one thousand feet. This elevation is reached on the Sweetwater twenty-two miles from its mouth; on the San Diego, thirty-eight miles; on the San Dieguito, thirty-three miles; on the San Luis Rey, thirty-four miles; and on the Temecula, about twenty-five miles inland.

The San Jacinto River.

The valley of the San Jacinto consists of an extensive plain, one thousand four hundred to one thousand six hundred feet above the sea, covering some two hundred thousand acres, wonderfully uniform in surface, of gray and reddish mesa soil, nearly surrounded by mountains, and dotted by irregular conical hills

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and bald tables of granite, standing alone like islands in the plain. From a rim of this plateau one may look north and northwest down upon the Riverside plain and the San Bernardino valley. To the northeast, east, and southeast, the peaks, spurs, and outlying ridges that form the San Jacinto system of mountains, whose highest peak is eleven thousand feet in altitude, interpose a lofty barrier between the valley and the Colorado desert. To the south lies Smith's mountain, a high east and west ridge. To the west and southwest are the low Temescal and Pinacarte mountains.

The higher portions of the San Jacinto mountains are the receptacle of heavy snow and rainfall, which chiefly drains towards the great valley by numerous channels that, combining, form the San Jacinto river, which in this part of its course has all the characteristics of a torrent. The main tributaries are the North fork, South fork, and Strawberry fork, that join some three miles above where the river debouches upon the plain. Hemet valley on this South fork, at an elevation of four thousand four hundred feet above sea-level, is almost hemmed in by a rocky barrier through which the very narrow and abrupt walled outlet channel presents one of those dam sites calculated to tempt man to close the gateway and reform, artificially, what was once probably a large mountain lake.

The local testimony on the relative permanence and volume of these tributaries is conflicting. They are probably very nearly equal, as they each have about one hundred square miles of water-shed, of the same general character. The North fork and Strawberry fork tumble from the mountain top to the valley in a succession of cascades, while the South fork takes a leisurely pause in Hemet valley, before making its plunge through ten miles of almost inaccessible cañon, at the end of which it unites with the Strawberry fork. Two miles further down the North fork joins in, and the river course is thence through an open cañon for three miles, over a rough bed of bowlders and cobbles, emerging upon the valley five miles above the town of San Jacinto.

After leaving the mountains the San Jacinto gradually changes character, loses itself rapidly in a broad, gravelly, and sandy bed, diminishing steadily from the mouth of the cañon, to a wide, shallow laguna, situated some fifteen miles out in the valley in a northwest direction. In dry seasons no water reaches the laguna,

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and in wet ones the river must fill this lake before continuing in its course farther across the valley, over which it meanders twenty miles or more in a channel about eighty feet wide, and six to eight feet deep, whose grassy banks and bed of soil present the character of a slough, and indicate a sluggish current. Its course in this section is southwesterly, passing from the valley by an open cañon, through the Pinacarte hills, nine miles, to Temescal lake, now known as Lake Elsinore.

This sheet of water is on the flat summit from which Temescal creek drains northward into the Santa Ana river, and Temecula creek southward into Santa Margarita river. The lake is maintained by springs and the drainage of mountains to the west of it, as well as by the occasional contributions of the San Jacinto river. The rim of the lake being lowest on the northeast side, its overflow, whenever it is filled, which is at rare intervals, runs into Temescal creek, and thence to the Santa Ana river. It is quite possible that if a very great rush of water should come down the San Jacinto when the lake is full, a portion might run over into the Temecula creek.

Thus, the character of the San Jacinto river is such that its waters are principally lost by evaporation without reaching the sea even in time of flood—first in the sandy bed of the upper valley, then in the lagoon, and lastly in Temescal lake. At the mouth of the main cañon, however, and for about five miles below to the junction of Coahuila creek, the stream is perennial in its flow. The slight fall which the channel has after leaving the laguna and its limited size, renders it apparent that no considerable amount of water ever passes that upper lake basin. Probably the artesian belt in the upper valley is fed by the subterranean percolations of the stream, and the maintenance of surface water, found in wells all over the plain at depths of twenty to forty feet, also is due to the sinking of the river water after leaving the mountains. It is therefore not wholly lost, although as a source of irrigation supply, the San Jacinto is of but little importance after it enters the valley, and the few irrigation ditches that have been taken from it are unreliable in flow—even in the winter and early spring months.

The volume of discharge of the San Jacinto reaches a maximum of one hundred thousand to two hundred thousand inches (two thousand to four thousand cubic feet per second) in winter,

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and probably never flows less than three hundred to four hundred inches (six to eight cubic feet per second) in the driest portion of the year at points on its tributaries where they run on bed-rock. To obtain a summer supply it is necessary to go a considerable distance into the mountains, and carry the water in pipes, or other tight conduits. This has been done, or is being done, by two corporations hereinafter referred to.

SECTION IV.

Soils: Irrigable and Tillable Lands.

The Mountain Valleys.

About 15 per cent of the seaward slope of the country, or say four hundred thousand acres, is adaptable to and requires irrigation, and is a field worthy of development thereby. Geologically considered, the surface of this seaward slope, with the exception of a small corner adjoining Los Angeles county, is of a granitic character. In the hills and mountains, gray granite bowlders crop out on every side, all well rounded, and partially imbedded in soil, formed by their slow disintegration; while surrounding nearly every valley is a fringe of granite masses shorn of their angles by the slow action of the elements.

The cultivable lands of the country are found in the high mountain valleys, in those described as being just inside the coast mesa, on some of the ridges of the plateau, upon the coast mesa, and in the lower river valleys. The agricultural adaptabilities of the high mountain valleys have been sufficiently noticed already. It may be said of those on the seaward slope that irrigation is not considered essential; but its use as an aid in the cultivation of small fruits, orchards, and vineyards would greatly increase the returns, no doubt, from some of them. A number of these valleys would be devoted to a better purpose, however, if devoted to the storage of water for lower and more accessible lands, than if utilized for the cultivation of their own soils. Of the high mountain valleys, the following named are the most notable:

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Water-shed: Where Situated and Names.	Approximate Area in Acres.	Approximate Elevation in Feet Above the Sea.
Tia Juana River:		
Pine Valley	100	3,200
Lyons Valley	150	....
Campo Valley	2,000	....
Mataqueguat Valley	500	....
Corta Madera Valley	100	....
Sweetwater River:		
Green Valley	250	4,000
Guatay Valley	350	3,500
Japatul Valley	100	3,200
Valle de las Viejas	2,000	3,000
Lawson Valley	200	....
San Diego River:		
Cuyamaca Valley	7,000	4,500
Coleman Valley	1,000	4,000
Julian Valley	1,000	4,200
San Dieguito River:		
Santa Ysabel Valley	3,000	3,200
Ballena Valley	500	2,600
Guejito Valley	250	2,300
San Luis Rey River:		
Valle de San José	10,000	2,800
Agua Caliente Valley	....	3,000
Palomar Valley	....	4,000
San Jacinto River:		
Hemet Valley	1,500	4,500

Besides these larger ones, there are small valleys, and many of them, through the mountain region, ranging from twenty to fifty acres in area, and occurring in the most unexpected places. On the desert slope also, at high elevations, are several valleys of the same class: notably, the San Felipe, comprising six thousand to seven thousand acres of tillable lands, of which five thousand or six thousand are irrigable—one thousand five hundred to one thousand eight hundred being moist.

The Plateau and its Valleys.

The lower plateau valleys, the most important of which have already been mentioned by name, comprise an aggregate area of about sixty thousand acres, and these, together with the great

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plain or valley of the San Jacinto, of the same class of land—all, for the most part, demanding irrigation—make up an aggregate area of two hundred and sixty thousand acres, lying at elevations of five hundred to two thousand feet above the sea. As a general thing, the soil of these valleys is excellent, and, for the most part, is directly traceable to the disintegration of granite. In the valley of the San Jacinto the soil is a gray loam, from ten to one hundred feet in depth, mellow and fertile under cultivation when moisture is at hand sufficient to maintain vegetation. Such is the general character of the soils in all these valleys; although, as a general thing, it is not so deep, and is frequently more highly colored.

Surface water is found at moderate depths in these valleys, and usually in large quantity. The deeper sub-soils hold water in a remarkable degree, and the soft, disintegrated granite, lying underneath, seems to form a reservoir, holding water like a sponge. But in the absence of irrigation, or of continued cultivation, the surface of the country soon becomes dry and parched, and except after winters of at least average rainfall, is, in its natural state, generally barren of all but sparse vegetation that withers very early in spring.

The Coast Valley and Mesa.

For some miles back from the coast, the streams draining seaward are bordered here and there by low bottom-lands, composed of sandy alluvial soil, generally moist from percolation, and with sub-soil waters found within two to ten feet of the surface. The Tia Juana valley has about three thousand acres of land on the American side of the National boundary. The Otay valley about one thousand five hundred acres; the Sweetwater about two thousand five hundred acres; the San Diego, or Mission valley and lower El Cajon about seven thousand nine hundred acres; the Peñasquitas creek about six hundred acres; the San Dieguito about three thousand acres; the San Elijo creek about one thousand acres; Agua Hendionda creek about one hundred and fifty acres; San Luis Rey river about six thousand acres; Santa Margarita river about three thousand acres; San Onofre and San Mateo creeks about five hundred acres. The total area of this class of lands is about twenty-nine thousand one hundred and fifty acres, all of which is generally irrigable in the winter from

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the streams, and is, for the most part, adaptable for the growth of alfalfa and other forage plants of similar nature, vegetables, root crops, and deciduous fruits, when sufficiently watered. These valleys are more subject to frosts in winter, and are consequently not well adapted to citrus fruits. They are the class of lands originally esteemed as the most valuable by the earlier settlers, because of their moist condition, but the soils are frequently alkaline, and maintain a growth of "salt grass" as the natural vegetation.

A classification of the mesa lands bordering on the coast between the streams, and extending back into the interior five to fifteen miles, would show a very wide range; from deep, mellow brown or red sandy loam, easily cultivated, and of wonderful fertility, to gravelly, shallow, cobble-stone land, underlaid with "hard-pan" very near the surface. The mesa surface is also largely composed of adobe soils, in places black, deep, and rich, and in other spots, shallow, full of salts, and known as "dry bog." These are by no means the poorest soils of the county, but they are the most difficult to cultivate, especially by irrigation. The extent of the coast mesa is from three to four hundred thousand acres, of which nearly three fourths is land susceptible of a high degree of cultivation, but generally requiring irrigation. In some limited parts, especially near the sea-shore, and on some of the deeper and more mellow soils, the necessity for irrigation is not so strongly emphasized, and crops are raised without it. Thriving young vineyards, vigorous young orchards, and fair crops of corn, melons, etc., may be seen in the vicinity of Oceanside, Encinitas, and Del Mar, growing on the mesa without irrigation. In the neighborhood of Fall Brook, a farming community, where there have not heretofore been any facilities for irrigation, a variety of crops are produced; yet the farmers are free to admit that with water to irrigate, these crops could be increased many fold, and the element of uncertainty removed. In many places on the mesa, the depth to surface water is great—fifty to one hundred and fifty feet are not uncommon depths of the wells that have been bored or dug to the first water stratum only. On the Otay mesa, the settlers, for more than half the year, depend upon house cisterns for domestic water, and on small catchment basins, excavated in ravines, or formed by low dams across little dry channels, for water for their stock.

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The extent to which this irrigable territority of San Diego county may be watered depends upon the degree of success in conserving the flow of the streams named in the foregoing table, and the projects and works for this conservation will now be described in their order.

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CHAPTER II.—SAN DIEGO[2]; WORKS AND PROJECTS[1].

SECTION I.—*Tia Juana River Project:*
Mount Tecarte Land and Water Company;
An International Irrigation Project.

SECTION II.—*Otay River Projects:*
Otay Water Company;
Otay Mesa Scheme.

SECTION III.—*Sweetwater River Works:*
San Diego Land and Town Company;
Reservoir and Pipe Lines;
Water Supply and Use;
History of Work and Water Claim.

SECTION I.

TIA JUANA RIVER PROJECT.

The Mount Tecarte Land and Water Company.

District and Project:—Reviewing this region by the route along which the streams have been described—the order of their geographical position from the state boundary northerly—the first irrigation project is found immediately at the line, and is international in its scope, in that it aims to utilize both the American and Mexican tributaries of the Tia Juana river; to carry American waters through Mexican territory, and to deliver them again in the United States; to store both Mexican and American waters for irrigating Mexican and American soils; and to harmonize local questions of international water-rights, by serving lands on either side of the line equally with water to the extent of the capacity of the stream. Eight reservoir sites have been selected for storage.

The Otay mesa lying north of the Tia Juana river, at an elevation of three hundred to seven hundred feet, extending as far north as the Otay river, and lying chiefly on the American side,

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is the principal field to be commanded. A subsidy of one fourth of certain large bodies of these lands on the American side, and one half on the Mexican side, is being negotiated by the company with land owners, as a consideration for water-rights for the remainder. The proposed main conduit flumes are two in number. One, to convey the waters of the Cottonwood fork some sixteen miles to the upper edge of the Otay mesa, is to start at an elevation of sixteen hundred feet, and run part way south of the line, although a tunnel has been projected to avoid passing the border, if need be. The second flume line is planned to lead out from the main stream at a point on the boundary three fourths of a mile below the Tecarte fork. This is a mere outline of the character of the enterprise, upon which no actual work has yet been started beyond the preliminary surveys. The extent of the field commanded by the proposed works is very large, and irrigation need be limited only to the supply of water available, and the measure of success in its storage.

ORGANIZATION:—The Mount Tecarte Land and Water Company, which has taken up this project, was incorporated February, 1888, with a capital stock of $3,500,000, in three hundred and fifty thousand shares of $10 each. Since that date the company has made contracts with a number of land owners on the Otay mesa to supply their lands with water, and are preparing for construction on the upper flume line during the coming season.

SECTION II.

OTAY RIVER PROJECTS.

The Otay Water Company's Scheme.

For some years past preparations have been made periodically by the Otay Water Company, whose leaders were of the Coronado Beach Company, for the construction of a mammoth dam at the lower cañon of the Otay, but as yet nothing of importance has been done. The proposed dam was to be of concrete, one hundred feet in height. Its site is four hundred and sixty-six feet above tide-water, and the capacity of the reservoir when full would be about eight thousand million gallons.

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The Otay Mesa Scheme.

On a southerly branch of the Otay that joins the main stream below the cañon, a masonry dam, to be sixty feet high and two hundred and sixty feet long on top, was started in 1887 by a partnership association of three San Diegans. After spending some $10,000 in roads and a foundation, the work was stopped. The reservoir was to be but three hundred million gallons capacity, and to cover seventeen acres. Its limited water-shed and light rainfall render it of minor importance. It was designed for the irrigation of a part of the Otay mesa.

SECTION III.

SWEETWATER RIVER IRRIGATION AND WATER-SUPPLY WORKS.

The San Diego Land and Town Company's Works.

Because the first of the various projected irrigation works in the county, depending on storage for supply, that has been completed, the enterprise of the San Diego Land and Town Company is thus far first in interest. The engineering works would be notable in any country, and the lesson which the enterprise is working out on the subject of large storage reservoirs for the conservation of winter water for summer irrigation in this dry country is already highly instructive. It is now looked to with satisfaction by San Diegans, as a type of what may be accomplished under even unfavorable circumstances upon nearly all the streams of this region.

District and Works:—The works consist of a high masonry dam, forming a large storage reservoir, and an extensive system of iron pipes reaching thence for distribution over a great part of the district commanded by the reservoir. The district embraces the Lower Sweetwater valley, and the mesa lands bordering San Diego bay, to the north and south of the Sweetwater, and extending back to an elevation of one hundred and seventy-five to two hundred feet above sea-level. In general this elevation is reached in two to two and a half miles from the bay shore. Its area within the limits of the National rancho, including National City, is about fifteen thousand acres. The water may be carried both north and south, beyond the limits of the rancho, by an extension of the

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pipes, and it is feasible to cover nearly forty thousand acres by the system. Any such extension would, however, enter the district more directly commanded by other projected works, and at present the distribution is confined to the lines of the National rancho.

STORAGE RESERVOIR:—The reservoir site is located almost entirely within the Rancho Jamacha (as the dam is but one thousand feet inside the boundary of the National rancho), having an extreme length of three and a half miles, and a maximum width of three fourths of a mile. It is inclosed by high hills, and lies at the foot of Mt. St. Miguel, whose elevation is about two thousand five hundred feet, the most conspicuous peak lying near the coast. At different elevations of the water-plane, its areas and corresponding capacities are as follows:

Elevations of Water-Plane.		Corresponding Areas—Reservoir Surface.	Capacities of Reservoir above Lowest Working Outlet.	
Above Sea-level.	Above Lowest Working Outlet.			
Feet.	Feet.	Acres.	Million Gallons.	Cubic Feet.
145	. .	3.50	. . . .	. . . . .
150	5	10.72	11.64	1,556,000
155	10	17.12	30.57	4,086,000
160	15	43.10	79.62	10,643,000
165	20	75.21	175.81	23,504,000
170	25	113.40	329.45	44,044,000
175	30	153.75	547.06	73,136,000
180	35	200.77	835.95	111,758,000
185	40	272.22	1,221.35	163,262,000
190	45	326.96	1,710.58	228,687,000
195	50	397.85	2,302.26	307,788,000
200	55	463.80	3,005.64	401,823,000
205	60	538.94	3,824.19	511,255,000
210	65	630.94	4,778.54	638,842,000
215	70	721.86	5,882.27	786,390,000

Analyzing this table of capacities, it appears that nearly 19 per cent of the maximum holding space is in the upper five-foot layer, 35 per cent in the upper ten feet, 61 per cent in the upper twenty feet, and 80 per cent in the upper thirty feet. If the reservoir were once filled to start with, the fluctuation in level of water surface from anticipated use would probably be within narrow limits of elevation for a number of years to come.

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Evaporation begins as a factor of serious importance about June first, up to which time it is probably counterbalanced by the ordinary flow of the stream, as also in the late fall and early winter before the heavy rains. From some definite data and casual observation, it is thought that loss from the lake's surface by this action will be, in feet, about as follows: January, 0.15; February, 0.15; March, 0.20; April, 0.25; May, 0.30; June, 0.40; July, 0.45; August, 0.50; September, 0.50; October, 0.40; November, 0.20; December, 0.15; total per annum, 3.65 feet. It is not probable that the total loss will exceed four feet per year, on the average.[1]

Sweetwater Dam:—The dam is located across the cañon of Sweetwater river, near the head of the rocky pass, through which the river escapes from Jamacha valley. At the beginning, a dam wholly of earth was contemplated. The best of clay was available for a puddle wall, and an earthen dam could have been built more cheaply than the masonry structure ultimately cost. The superior quality and unlimited quantity of the stone on the spot, however, decided the adoption of that material. When the work was begun the dominant idea was to secure a water supply of some volume as soon as possible. The question of quantity that might be stored, the area of land that might be served, the volume of supply needed, or the relative costs of different heights of structure were not preliminarily studied or at all considered.

The plan originally was to build a dam fifty feet high above the general level of the cañon bed—sixty feet above the general level of the river channel, or sixty-five feet above the general level of the bed-rock plane which was exceedingly uneven. When, however, it was ascertained—some months after the work had begun, and subsequent to the development of facts that are usually known before any decision or plan is reached—that a greater supply was desirable than such a dam could assure, and that an increase in height afforded such a great advantage in retaining a supply sufficient for more than one season, and that holding water at a higher average level would serve some most desirable higher lands, it was decided to continue the structure to the height of ninety feet.

Before this decision was reached the originally planned work was nearly completed. The subsequent work necessitated an in-

[1] The experience for the current season, data of which was obtained after the above was written, seems to show that the total loss will not exceed three feet per year.

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crease in the width of base. The lower toe of the dam was stripped to bed-rock, and the new work started from the bottom, joining and overlapping the old work in successive steps, which had been left for the purpose on the lower face. As completed, the dam has the following dimensions: Thickness at base forty-six feet, at top twelve feet; height ninety feet to floor of roadway; length on top three hundred and forty feet, at base about one hundred feet. In plan the dam lies in the form of an arch, whose radius is two hundred and twenty-two feet to the upper face line at the top. Including gate tower, waste-way walls, and other immediate accessories, it contains twenty thousand five hundred and seven cubic yards of masonry.

The masonry is of the type known as rough rubble—rough blocks of stone, laid without courses or ranges, with all interstices filled with smaller stones and mortar of Portland cement rammed in place. Along the upper face at top runs a parapet wall, three and one half feet high and two feet thick, which serves not only as a guard wall to the roadway on that side, but which, when the reservoir is full, will serve to prevent waves from washing over the roadway. This road, which is wide enough for a carriage drive, is protected on the lower side by an iron fence, the posts of which are imbedded in the masonry, and set at intervals of six feet. A stone stairway with iron railing reaches from top of dam to bottom of cañon below the structure at the north end.

The waste-way is located at the south end. It consists of a weir opening forty feet in length by five feet in depth, divided into eight bays, of five feet each, by masonry piers, inclined on the face to receive loose flash-boards. By removing these boards, the water-level can be lowered five feet from the top of dam. A training wall built parallel with the direction of the cañon forms one side of this flood-escape channel, and carries the waste-water fifty feet below the lower toe of the dam, where it falls down an incline over the face of the cañon wall. The capacity of the waste-way is one thousand five hundred cubic feet per second, and is designed to carry the maximum flood flow of the stream when the reservoir is full. There is no sluice-way at the bottom of the dam other than the main conduit, which has a thirty-inch blow-off gate one thousand six hundred feet below, capable of discharging three hundred cubic feet per second.

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The delivery to the main conduit is effected through a masonry tower, situated fifty feet above the dam, and reaching three feet above high water mark. Cast iron elbows, twenty-four and thirty-six inches in diameter, are placed at intervals of ten feet from the top to bottom. These open upward, with bell mouths, that may be closed with plain cast iron covers. The work was begun in November, 1886, and finished in March, 1888, occupying sixteen and one half months in construction.

DELIVERY AND DISTRIBUTION WORKS:—The inside diameter of the tower is six feet, and at its bottom three pipes, fourteen inches, eighteen inches, and thirty-six inches in diameter, respectively, enter it. The two smaller pipes of cast iron are laid side by side at the bottom, inclosed in masonry, and pass through the dam. On top of these is built a masonry conduit thirty inches thick from the tower into and through the dam. In this conduit the largest pipe, of wrought iron one-half inch thick, passes through the dam. All of these pipes have gates to close them outside the dam. The two smaller pipes are to supply water and power for a pumping plant to throw water to a higher level than may be reached by the mains.

Main Pipe-line:—The largest exit pipe is attached to the main conduit. This is a wrought iron pipe whose diameter is thirty-six inches for one thousand six hundred feet to the mouth of the cañon, where it turns southward following the valley, and is reduced to thirty inches diameter. At the end of the thirty-six-inch division, a thirty-inch blow-off gate is placed, affording a means of draining the reservoir. From the dam to the blow-off the pipe is covered with masonry as a protection from injury in the cañon. The thirty-inch main follows the Sweetwater valley for twenty-six thousand feet, and thence ascends the mesa south of the river to an elevation of ninety-two feet, and terminates in Chula Vista, about twenty-nine thousand eight hundred and seven feet from the dam.

Distribution Pipe System:—The distribution system, as far as at present carried out, comprises the following piping: 24-in. wrt. iron, straight riveted, 2,034 feet; 24-in. wrt. steel, spiral riveted, 5,950 feet; 18-in. wrt. iron, straight riveted, 16,468 feet; 12-in. lap-welded tube, 25,903 feet; 12-in. spiral iron, 10,029 feet; 8-in. spiral iron, 4,020 feet; 8-in. lap-welded tube, 7,620 feet; 6-in. lap-welded tube, 132,333 feet; 6-in. spiral, 17,870 feet; 4-in. lap-welded

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tube, 50,745 feet; 3-in. galv. iron, 760 feet; 2-in. galv. iron, 1,885 feet; total, 275,597 feet. The total length of pipe laid is about fifty-eight miles, with five and a half miles on hand to be laid this year. This distribution system covers an area of about ten thousand acres, with gates and outlets as complete for five and ten-acre tracts as the ordinary water works of a large city for its building lots. The main has an estimated capacity of delivering one thousand two hundred miner's inches (24 cu. ft. per second) at its terminus, or about fifteen million gallons daily. The laterals are proportioned to carry as much as the main will deliver.

The general plan of distribution to consumers is to tap the laterals with the ordinary service clamp tap, and insert pipes varying in size from three fourths of an inch to two inches in diameter, according to the area of the tract to be watered and the pressure at point of delivery. The usual tap for a five-acre tract, where the pressure in the mains exceeds forty pounds to the square inch, is one and one quarter inches in diameter, attached to a one and one-half-inch distributing pipe. With a small reservoir or tank to be filled at regular intervals, the service would be better. The object is to deliver ten to fifteen-inch streams to the five-acre tracts. Where pressure is light, large taps, up to four inches, are put in. The work of building the dam and digging the trenches, and laying a portion of the pipe, was done by the day. The main conduit and some of the laterals were laid by contract.

COST OF THE WORKS:—The cost of the work in the aggregate was $736,837 77, distributed as follows: The cement (twenty thousand five hundred and seven barrels) cost $63,111, an average of $3 66 per barrel. The first four thousand barrels cost $3 85 per barrel in San Diego. Other lots cost $3 75 to $4 25, according to the condition of the market. After September, 1887, when several cargoes arrived in San Diego direct from Europe, the price was reduced to $3 25 per barrel. Hauling the cement to the dam cost $8,614 18. The bulk of it cost 70 to 75 cents per barrel for hauling, but the last two thousand or three thousand barrels were reduced to 20 and 25 cents per barrel by the proximity of the railroad that was being built to the dam, and finally reached within half a mile of it by December, 1887, some three months before completion of the work.

Lumber used for shops, houses, cement platform, mortar, railroad or tram-way, running plank, staging, etc., cost $2,408 08.

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Iron work cost $4,915 99, and pipes, gates, etc., cost $5,152 58. These last two items include one thirty-six-inch gate ($815), one fourteen-inch gate, one eighteen-inch gate, two thirty-inch gates, one hundred and forty feet each of fourteen and eighteen-inch cast pipe, eighty feet thirty-six-inch boiler plate pipe, one-half-inch thick; four twenty-four-inch elbows (cast), three thirty-six-inch elbows, with covers, for tower, tower house and bridge ($2,100), etc. Miscellaneous materials—powder, etc.—cost $3,229 84.

The labor account was distributed as follows:

Skilled and common labor	$93,590 55
Foremen	6,866 49
Teams	19,696 12
Salary and expenses of engineering	10,555 20
Clerical work	653 88
Miscellaneous expenses	1,376 90
Earthwork (contract)	7,666 51
Total	$140,405 65

The rates of labor were, per day: Masons, $4 to $5; foremen, $4 to $6; blacksmiths, $4; carpenters, $3 50 to $4; common labor, $2 to $2 75, the latter price for drillers, quarrymen, and specialists in any one branch after long service. General price for common labor was $2 25 per day.

Dam, cost summarized:

Plant	$6,236 76
Materials	87,431 70
Labor	140,405 65
Total	$234,074 11

Pipe lines, cost:

Cost of Risdon Iron Works' wrt. iron pipe	$135,232 74
Cost of National Tube Works' kalameined tube	132,096 14
Cost of Abendroth & Co.'s spiral steel and iron	34,599 92
Total cost of pipe	$301,928 80
Freight on pipe	39,183 03
Distribution	6,271 06
Trenching, pipe laying (including engineering about $7,000)	144,630 78
Materials, tools, etc.	5,932 57
Right of way and misc. expenses	2,376 41
Gates	1,849 62
Misc. materials, small pipes, etc.	591 59
Total	$502,763 86

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Reservoir lands, cost to date:

Land acquired to date	$16,426 93
Clearing, grubbing, etc.	10,808 46
Legal expenses	452 50
Total	$27,687 89

A suit for condemning 350.41 acres in the upper end of reservoir basin was brought, tried, and resulted in a verdict by jury awarding defendant $280 per acre for the land, and $1,805 damages for severance. As the lands were purchased two years before for $2 70 per acre, and one third of it was sandy river bed and rocky hillsides, worthless for any purpose, and the remainder was unimproved, the judgment was considered extortionate, and the case has been appealed to the Supreme Court on motion for a new trial on the issue of the land value, and on ground of error in lower court in admitting evidence on the special value of the tract as a reservoir site. The defendant was offered $75 per acre for the land. The remainder of the reservoir cost $3 to $60 per acre, one small piece $75, and another with improvements, $100.

The cost of the dam per thousand cubic feet of reservoir capacity was 30 cents; per million gallon capacity, $38 79. The total cost of reservoir, per unit of volume of capacity, is yet undetermined until the condemnation suit is settled.

Operation and Maintenance:—IRRIGATORS'S WATER-RIGHTS:—No water-rights are sold by the company, but water is delivered to all who make application for it. The value of the water-right is practically included in the increased price set upon company lands that are served by the mains. Lands without water facilities have been selling for $100 per acre or less, and with water, from $300 per acre upward.

REVENUE, WATER-RATES:—Placing the capacity of the reservoir for irrigation at ten thousand acres in round numbers, and assuming that within five years one half this area will come under cultivation and pay for water, the revenue from irrigation would, at present rates ($3 50 per acre per annum) be $17,500. Thus far the service connections put in give an annual revenue, outside of irrigation, of about $4,000. This will, it is said, be increased this year to about $10,000, and, it is claimed, will probably reach $25,000 in five years. At the end of five years, therefore, the

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utmost that may be expected at present rates is about $42,500 per annum revenue. From this take about $20,000 for running expenses, taxes, etc., the remainder, $22,500, would represent the probable net income derivable from the investment of, say $800,000, or less than 3 per cent interest. This estimate is much below the expectations of the company. The profit in this investment comes in the increased value of the lands owned by the investors, which in this case seems likely to reach two or three millions. The present charge for water for irrigation is fixed at $3 50 per acre per annum, there being no restriction placed upon the amount used. Until the demand begins to reach a maximum limit, restrictions, it is thought, are unnecessary, and it is believed by those controlling the enterprise, that when such time comes, the irrigators will have learned by experience that an excessive use of water is injurious, and restrictive regulations may never be required. It remains to be seen how far this idea is a safe one.

Water-Supply and Use:—The position of the dam, regarding its command of irrigable territory below it, is advantageous in the matter of proximity, but its usefulness would be enhanced were its elevation above sea-level two or three hundred feet greater. A large portion of the National rancho (about 40 per cent) lies above the reach of its waters. For the region at present served by its pipe lines the pressure is generally ample. The volume of supply can only be determined by experience. If one were to judge from the water-shed area (186 square miles) tributary to the reservoir, the supply should ordinarily suffice to fill the reservoir annually. Allowing a loss of 80 per cent of the rainfall in absorption and evaporation, nine inches of precipitation on an average over the water-shed would suffice to fill the reservoir. During the winter of 1887–88 the yield of the stream was but 40 per cent of the reservoir capacity. The rainfall at San Diego during the season was 9.81 inches, nearly half of which fell before the stream began to flow. Traditional accounts of former dry seasons assert that in occasional years the stream does not flow at the reservoir site at all. It is to provide against seasons like this that the reservoir capacity was wisely made doubly sufficient for the anticipated necessities of any one year.

Flow of the Stream:—In November, 1886, when the dam was started, the stream was flowing at the site about two hundred

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miner's inches; February 1, 1887, about three hundred inches; March 16, 1887, three hundred and eighty-five inches. The only severe storm of the season was February twelfth to fifteenth, when the stream was swollen for two days, fourteenth and fifteenth, swamped the temporary escape-way, overflowed the masonry, and reached a maximum of about five hundred cubic feet per second. The total output of the stream for this time was estimated at about one billion five hundred million gallons. The flow diminished in a fortnight to about five hundred miner's inches. On March sixteenth it was flowing three hundred and eighty-five inches, and by April first diminished further to about one hundred and fifty inches. The waste-gate was closed about April twentieth, and the stream ceased flowing about June first. In that interval of six weeks, the catchment was about eighty million gallons. This reached to an elevation of about fifteen feet above the lowest outlet (one hundred and sixty feet above sea-level). This catchment was held in the reservoir—diminishing only about 2.5 feet by use (a hydraulic ram pumping water for mixing mortar was running constantly) and evaporation—until the following January, about the third, when, as the stream began flowing again, it was all emptied out, having become foul and stagnant, and the space allowed to fill up anew. This stream continued flowing until about June fifteenth, when it disappeared in the sand above the reservoir, although in the rock cañon two and one half miles above it. at the end of June, 1888, it was still flowing a small quantity. The water-plane reached its maximum height of 50.6 feet in the reservoir on May tenth, and was on June twenty-eighth one foot lower—the difference representing use and evaporation.

IRRIGATION:—The present rate of use is, approximately, one million five hundred thousand gallons daily. It supplies National City (about six thousand inhabitants), the National City and Otay railroad, the California Southern railroad and shops, the wharf, creosote works, etc., the Coronado Belt railroad, and some irrigation in Sweetwater valley, Chula Vista, Paradise valley, etc. The use of water from the works began February 15, 1888. From that time until June first, two hundred service connections had been made, and three hundred and eight acres placed under irrigation. The annual revenue from that number of services is $4,963 60. They include the domestic service of National City. The principal demand for water is in Chula Vista, a suburban residence subdivision of the rancho, laid off in five-acre tracts.

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History and Water-Right:—The San Diego Land and Town Company was incorporated under the laws of Kansas, January, 1881. Among the objects named in its incorporation was the "supply of water to the public; the construction and maintenance of dams and canals for the purpose of water-works, irrigation, and manufacturing purposes." Its capital stock was originally $1,500,000, since increased to $2,250,000. Two water-appropriation notices were duly posted and recorded, respectively, in September, 1886, and March, 1887, claiming five thousand miner's inches of the flow of the Sweetwater at the point of diversion, viz.:—the site of the dam.

The construction that should be placed upon an appropriation of this character, where a reservoir is filled by a stream, is an interesting question that has not hitherto been raised. If all the flow of the stream should be allowed to escape, except the maximum claim of five thousand inches for example, the greatest volume of flood waters would be lost, and the reservoir would not be filled. On the other hand, unless the conduit has the capacity to carry currently the amount claimed, is not the actual appropriation by the reservoir excessive? Where a reservoir is to be supplied, it would seem desirable that the reservoir capacity should be made the measure of appropriation rather than the capacity of the conduit, as the latter is intended to distribute through the year what may be impounded in a few weeks.

No other actual diversions from the Sweetwater river have been started. The only other claims on it having any pretense of life at present, are those of the San Diego Flume Company, to four thousand inches at a point just high enough to allow of diversion into its flume by the Cajon-Sweetwater divide, and two thousand inches of the head-waters of Guatay creek, where they may be turned over the divide into South fork. These claims are dated in December, 1885, and June, 1886—antedating the appropriation of the San Diego Land and Town Company. A later appropriation of five hundred inches dated in June, 1887, on the creek flowing through the Japatul valley, a smaller branch of the Sweetwater, is intended as a reservoir appropriation. No work has been done directly on any of these claims, but they are specified as branches of the main system under construction by the Flume company.

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CHAPTER III.—SAN DIEGO[3]; WORKS AND PROJECTS[8].

SECTION I.—*San Diego River Works and Projects:*
San Diego Flume Company;
Cuyamaca Reservoir;
Diverting Dam and Flume;
Irrigators Water-rights;
Water Supply and Water Claims;
History and Outlook.

SECTION II.—*San Diego River Works and Projects:*
Mission Valley Water Company;
Diverting and Reservoir Works;
History of the Operation.

SECTION III.—*San Dieguito River Project:*
Pamo Water Company;
Proposed Reservoirs and Pipe-line;
The Organization.

SECTION I.

SAN DIEGO RIVER WORKS AND PROJECTS.

The San Diego Flume Company's Enterprise.

The commanding elevation occupied by the works under construction by the San Diego Flume Company, their far reaching design in accumulating from different sources the waters of distant streams, their costliness, the wide extent of the district commanded, and the fact that they terminate at the city of San Diego, which may receive its supply at high pressure on the summits of its greatest elevations, render them in many respects more important to the prosperity of the region than any other, and second in rank to the Sweetwater dam and its distribution only because they are yet in an incomplete state.

District and Works:—As far as they have been outlined by what has been begun or completed, the works consist of a storage

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reservoir on the head-waters of the Bowlder creek tributary of the San Diego river, a diverting dam of masonry in the river proper, and a line of flume thirty-six miles in length—skirting the cañon's side for twenty-one miles, then circling south of the valley of El Cajon, and finally emerging upon the mesa ten miles east of the city of San Diego. The plans of the company contemplate the diversion of the head-waters of the Tia Juana and Sweetwater rivers on the south, and the San Dieguito on the north, into the head of the main flume, the construction of various additional storage reservoirs in the mountains, and a distributary reservoir at the end of the flume, the development of tributaries of the San Diego by tunnels under their beds and gathering them into the main conduit by smaller lateral flumes, and the distribution of the water from the end of the main flume by pipe lines over the mesa.

The field of irrigation development which these works command embraces the entire valley of the San Diego river, including El Cajon, the high mesas between the river and the Sweetwater on the south, and the Linda Vista mesa north of San Diego, an aggregate area of seventy-five thousand to one hundred thousand acres. The flume line proper dominates the whole of El Cajon, and a portion of the upper Sweetwater valley, while the pipe-lines, which are to be laid westerly from the end of the flume, command the mesa east of the city. In order to reach the Linda Vista mesa, a long pressure pipe will be needed to pass the depression of Mission valley. The distribution generally over the mesas might be by pipes under pressure, or by cement pipe channels, as explained in subsequent chapters hereof, relating to San Bernardino county works.

STORAGE RESERVOIR:—The main dependence of the works for a summer and fall supply is at present the Cuyamaca reservoir, located forty-three miles northeast of San Diego in the Cuyamaca mountains, at an altitude of four thousand five hundred feet. The water-shed of this reservoir is about fifteen square miles in area, draining two of the highest peaks of the range. The reservoir is formed by an earthen dam six hundred and thirty-five feet long on top, forty feet in height, thrown across the outlet of a broad, flat mountain valley. The little streams tributary to the reservoir are supplied by the winter rains and melting snow of early spring.

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From the eastern rim of the water-shed the country drops abruptly into the desert. The hills on this side are low and barren. The two Cuyamaca peaks on the west are clothed with forests of pine and oak.

As compared with the Sweetwater reservoir, its capacity when full is 63 per cent of the latter. The full-water reservoir space covers over one thousand acres. Its capacity, according to the elevation of its water above the outlet, is as follows:

	Mill. Galls.	Cubic Feet.
5 feet above outlet	.11	15,060
10 feet above outlet	5.04	675,065
15 feet above outlet	126.54	16,917,400
20 feet above outlet	523.15	69,940,300
25 feet above outlet	1,262.10	168,730,200
30 feet above outlet	2,342.28	313,139,300
35 feet above outlet	3,739.11	499,880,930

Cuyamaca Dam:—The site of the dam was one which had all the surface indications of solid rock. The whole surface was covered with loose granite bowlders, and before sinking test pits, preparations and plans had been made for building a masonry dam. The excavation for foundation developed a bed of clay instead of bed-rock as anticipated, and an abundance of good clay being found in the immediate neighborhood, the plans were changed and an earth-work dam built. A puddle trench was cut under the center of the embankment, and the clay filling built up in layers. The embankment has a base of one hundred and fifteen feet, inside slope of two to one, outside slope of one and one half to one, top width fifteen feet. The high-water mark is fixed at five feet below the top, at which point a waste-way fifty feet wide is placed on one side. The water-face of the dam is covered with stone riprap laid, dry, eight inches in thickness.

The outlet culvert is of masonry three and a half feet wide by four feet six inches high inside, one hundred and twenty feet long, its bottom placed at the level of the original surface with a fall of three and a half feet in its length. At the upper end it opens into the base of a circular brick tower eight feet in diameter outside, five feet in diameter inside, and carried to the level of the top of the dam. This tower is provided with two gates of wood, closing openings three feet wide by four feet six inches high. The lowest opening is at the bottom of the tower, the second fifteen feet nine inches higher, immediately above the lower. These

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gates slide up and down in wooden grooves, and as they are to be moved by chains or ropes, are not convenient, particularly when they are to be closed quickly under pressure. An iron gate is provided inside the tower to close the head of the outlet culvert. The work was begun late in the fall of 1886, and completed about the middle of February, 1887, in time to catch a part of the only heavy rainfall of the season of 1886–87. The catchment was about thirty-three million cubic feet, equivalent to a little over an inch in depth over the water-shed, and filled the reservoir to fifteen feet in depth. The reservoir was filled to a depth of twenty-four feet by the rainfall of the following season, 1887–88. Both seasons were dry ones, as compared with the ordinary mountain rainfall. It is intended to release the water at the dam and allow it to follow the rocky cañon of Bowlder creek, ten miles, to the diverting dam in the river.

DIVERSION AND DELIVERY WORKS:—The diversion is made from the San Diego river about thirty-one miles from its mouth, at an elevation of about eight hundred feet above sea-level, and where the stream, falling at the rate of about thirty feet per mile, is in an open cañon flanked by barren mountain slopes rugged and steep.

San Diego Diverting Dam:—The diverting dam is built of masonry of the following dimensions: Maximum height, 34.5 feet; length, 447.5 feet; width at top, 5 feet; up stream batter, 1½ feet in 20 feet; back batter, 7 feet in 20; width at base, 18 feet. The dam contains 4,000 cubic yards of masonry, and required 2,410 barrels of cement. The average depth of excavation in the bowlders that formed the bed of the stream was ten to twelve feet, and the foundation rests upon the soft, disintegrating granite, forming the bed-rock of the country. This material may be readily cut with the pick and crumbles on exposure to the air. After the dam was completed and tested, the leakage was considered excessive, and the upper face was again stripped to the foundation, and an apron of masonry two feet thick was sunk to a depth of some six feet lower than the original base. The wall was then repointed and partially plastered on the face. The top of the dam is at an altitude of 813.5 feet. In alignment the dam has an angle in the center whose apex is pointed up stream. Otherwise the structure is straight, depending upon the weight of its mass for stability.

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The head of the flume passes through the wall with wooden gates to control the water. The level of the flume bed is nine feet below the top of the dam, or four feet below the overflow weir. The main waste weir is two hundred and ten feet long, with a secondary weir twenty feet long. The floor of these weirs is of pine plank spiked to timbers that are bolted to the masonry. In addition to the overfall waste weirs, there are two culverts passing through the dam for draining the basin above. One of these is 2.5 feet square, seven feet below the grade of the flume, the other three feet square, eight feet lower than the first.

Main Conduit: Flume Line:—The flume is set on a bed cut in the mountain side, except where it is supported on trestling. All fills are made with loose rock laid with some care on the outer face. Its total length is thirty-six miles. The grade is 4.75 feet per mile.

Tunnels.—There are eight tunnels upon the work, lined with masonry on the sides, timbered overhead, except in solid rock, and plastered with cement on bottom and sides.

Tunnel No. 1 is 330 feet long; No. 2 is 230; No. 3 is 83; No. 4 is 705; No. 5 is 319; No. 6 is 316; No. 7 is 1,905; No. 8 is 280. Total, 4,168 feet. The tunnels are finished six feet wide by six feet one inch high in the clear. In loose material the sides are walled up with masonry twelve inches thick to a height of four feet, on top of which rests timbering, six by eight-inch, with lagging of three-inch plank; the bottom and sides being finished smoothly with cement.

Flume:—The flume is made in rectangular form, five feet ten inches wide by three feet ten inches deep, in the clear. The bottom and sides are of two-inch redwood plank, planed on the inside. The frames, placed at intervals of four feet, consist of a sill four by six inches by twelve feet, two posts four by four inches by four feet, and two diagonal braces two by four inches, three feet three inches long. The sub-structure where it rests on the ground consists of mud-sills of redwood, two by twelve inches by nine feet, two stringers four by six inches, one under each side of the flume box, and a block eight inches long supporting the sill in the center. Where on trestle, the sills of the flume rest on three longitudinal stringers, two of which are four by twelve inches, and one in center six by twelve inches. The trestle bents

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are placed sixteen feet apart, and for trestles up to twenty feet in height, consist of two posts eight by eight inches set on a batter of one to six, a cap eight by eight inches by six feet, a sill eight by eight inches of proper length, and two diagonal sway braces two by ten inches. For higher trestles, more posts are introduced, and trussed bridges carry the flume over the deepest gorges that are crossed. Ten million feet of timber will be consumed in the structure. The flume has a theoretical capacity when filled within three inches of the top of one hundred and ten cubic feet per second, or about five thousand five hundred miner's inches. The flume for its full length of $36\frac{8}{10}$ miles is now carrying water, with sideboards sixteen inches high; the remaining boards for full completion are to be added later.[1] Water was being delivered in El Cajon valley, and irrigation commenced from it in the latter part of June.

DISTRIBUTION SYSTEM; PIPES AND RESERVOIR:—From the end of the flume to San Diego, the main pipe line will be nine miles in length to the top of the mesa overlooking the city. A branch pipe one mile in length will deliver surplus water to a reservoir to be constructed for storing the unused delivery. A main four miles long will be required to tap this reservoir and join the through line below. This reservoir is called the City reservoir, and will have a capacity of seven hundred and sixty-one million gallons, covering an area of one hundred acres. It will be formed by a masonry dam fifty feet high, located in a narrow gorge through blue trap rock, whose width at a height of thirty feet is but fifty feet. Its elevation above sea-level is four hundred and sixty feet at the base.

COST OF THE WORKS:—The following statement made on authoritative data shows the cost to October 20, 1888, with the main conduit completed, as above:

[1] This data and that of the following financial statement have been revised while in process of publication to later dates than originally written for.

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Surveying, engineering, and superintendence	$54,821 53
Tunneling and grading (contract, $58,544 71; day work, $76,092 87)	134,637 58
Miscellaneous construction (digging trestle pits, ditching, culverts, hauling supplies, etc.)	38,409 51
Right of way	1,553 00
Flume construction	486,956 09
Expense account	24,624 04
Telephone	689 72
Wagon roads	7,228 03
Cuyamaca dam construction	47,057 63
Diverting dam construction	51,601 59
Total cost of works to date	$847,578 72

To this must be added the cost of land for reservoir sites:

Cuyamaca and City reservoirs, about	$76,908 00
Interest account	25,853 56
Legal services and expenses in litigation	8,449 70
Total	$111,211 26

This makes a grand total of expenditure to date of $959,789 98 met by the company. The original projectors of the enterprise claim to have spent $10,000 on surveys and preliminary work before the company was organized. This brings the water to Eucalyptus pass, on the western rim of El Cajon valley, on the highest point of the mesa commanded by the flume, a distance of ten miles from San Diego. The estimated cost of the pipe line to the city is about $65,000, including the loop to the City reservoir (one mile north from the main pipe at a point about two miles west of the flume terminus) and return connection with the main four miles below the City reservoir—fifteen miles in all, of fifteen-inch pipe. The City reservoir dam is estimated at $34,000.

Operation and Maintenance:—The San Diego Flume Company undertakes to distribute its water supply under specific contracts to furnish stated quantities of water, annually, in perpetuity, at designated points, in an agreed manner, and for uses named in each case and no other. The holder of such contract has a "water-right" in the flume supply. If held for irrigation, the right is made appurtenant to certain described lands, the property of the holder.

Irrigators' Water-Rights:—The agreements recite in the form of a preamble the great benefits to accrue to the region generally "by the reclamation of the now desert mesas surrounding the

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city of San Diego by water brought from the distant mountain ranges," and specifically acknowledge the enhancements in value of the property of the contracting party by reason of this general beneficiation brought about by the construction of the "vast, complicated, and unusually expensive system of works" by the Flume company. And then say, that in consideration of these anticipated benefits for the lands for which the specified water-rights are taken, "and as an inducement" to the company "to incur great and unusual expense in and about the increase of its works, and to aid and encourage it in its attempts to secure a large and reliable supply of water, etc.," and in consideration of the covenant on the part of the company to deliver water in certain amounts, etc., for use on the lands described, the contracting party agrees to pay, etc., a certain sum (in the nature of a bonus), when the water becomes available for his use, or at some other period named.

And then, "in further consideration of the premises and as an inducement to the company to extend and improve its works from time to time, and to aid in extending, improving, and maintaining the same so as to increase either the flow of water, by which increase the value of all the lands in the vicinity of the lands" of the contracting party, and his own lands, also, "will necessarily be continually enhanced by reason of the increased certainty of sufficient water for irrigation purposes in the driest seasons," the contracting party agrees for himself and his heirs, etc., to pay a sum annually (apparently in lieu of a rental for the use of the waters). Then follow certain conditions of forfeiture, to the general effect that if the contracting party fails to comply with the terms of the contract he forfeits his right forever without recourse. All covenants and agreements made by the land owner for the land described go with it, and are binding upon all future owners of it, and as security for performance of them the lands are mortgaged to the Flume company.

In accepting the agreement, the Flume company binds itself, etc., to furnish annually for use on the land described, and none other, a water-supply in measure and mode of delivery as specified; *provided*, that the company's water-supply be not shortened or the company's ability to deliver it be not impaired by the act of God, or the elements, or failure of the average rainfall in the mountains, or by the operation of law, public enemies, or by riot

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or insurrection, or by accident to the works of the company. In event of short supply from any of these causes, each piece of land for which a water-right is taken is entitled to a pro rata of such water as can be supplied during the period that such impairments shall exist, and as shall be consistent with like fulfillment of other contracts of the company and the full supplying of cities and towns.

The contracting party agrees that none of the water furnished him under his contract shall be used on any other land than that specified in the agreement, nor sold for any other purpose, or at all, except with the land, and that none of the water furnished him shall be allowed to run to waste, but shall be carefully utilized, and when not wanted on his lands shall be shut off therefrom and retained in the company's flume or other conduit. In further consideration of the benefits and water-supply to be obtained, the contracting party grants the flume party right of way for its pipes, flumes, or other conduits, over the lands for which the water-rights are purchased; and also grants, bargains, and sells to the company, all his rights whether he is a riparian owner or otherwise, to divert, use, and impound the waters of San Diego river, or of other streams, rights to which are claimed by the Flume company. In brief, the individual irrigator's water-rights are attached to the land, and convey only the perpetual right to take water at a certain fixed rate per annum (not less than $3 per acre).

At the beginning of the enterprise a few water-rights were sold at the rate of $150 per miner's inch. As the work progressed values were increased, and in the summer of 1887 the company contracted to sell four hundred inches to the San Diego Land and Water Company at the rate of $1,200 per inch, which has since been reduced by special agreement to $800 per inch. The total amount of sales and contracts by the Flume company amount to $57,200, in addition to the sale of several hundred acres of land with water-rights.[1]

Water-supply and Water Claims:—The volume of supply which may be safely reckoned upon by these works, as a minimum, cannot be definitely estimated, on account of the general lack of statistics as to rainfall. A record kept at Julian (elev.

[1] This data is up only to June, 1888.

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4,200 ft.), for five years gives a mean rainfall of 37.75 inches (max. 61.62 in., min. 25.89 in.). Julian is located in the water-shed of the San Diego, on the mountain top, a few miles north of Cuyamaca reservoir. Other records kept for short periods north and south of Julian seem to agree substantially with this record.

The water-shed above the diverting dam is about one hundred and ten square miles. And there are feeders to be brought in or taken up whose drainage areas will aggregate forty-five to fifty miles more. With a mean rainfall that can be relied upon, the supply to the streams distributed evenly through the year would, no doubt, far more than suffice to maintain the flow of the flume to its full capacity the year through. This even distribution could only be effected by means of storage reservoirs, but on account of the lack of sites on the water-shed it is doubtful whether this can be accomplished.

Assuming that the ordinary flow of the river is sufficient to keep up the probable demand from November first to May first of each year, without drawing from reservoirs, and that the maximum draft from reservoirs will occur from June first to November first of each year, the amount necessary to be stored each year will be, approximately, fourteen thousand million gallons. The Cuyamaca reservoir and the City reservoir combined will store less than one third of this volume, no allowance being made for evaporation. Hence, it is evident that very much further storage is requisite to give the enterprise a full measure of usefulness. The company have contemplated several additional reservoirs, as hereafter mentioned.

APPROPRIATION CLAIMS:—Claims to water have been posted and recorded, covering all the tributaries of the San Diego river at all favorable points of diversion, as well as the streams on adjacent water-sheds that may be brought into the same system. The filings and claims, except those at the diverting dam on the main stream, are each made as for a part or branch of the main system, and the work on the flume is supposed to obviate the necessity of special work under each filing. These claims filed are presented as an instance of an extended application of this method of acquiring claims to water, as follows:

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Stream.	Appropriator.	Date Posting.	Date Filing.	Purpose, Means of Diversion, etc. Place of Diversion.	Amount Claimed.
San Diego River . .	S. H. Marlette . .	June 17, 1885	June 25, 1885	At point 100 yards above Rocky Bar. (Site of diverting dam is at Rocky Bar.) . .	6,000 inches.
Same	W. E. Robinson . .	Aug. 17, 1885	Aug. 25, 1885	About 2,000 feet above Rocky Bar . . .	All water to extent of 6,000 inch's.
Sweetwater River . .	W. E. Robinson and T. S. Van Dyke.	Dec. 3, 1885	Dec. 11, 1885	At a point about 3 miles above Dr. Post's, near mouth of upper cañon of Sweetwater. For use on Jamacha Ro., Ro. de la Nacion, and Otay Ro., claimed as branch of main system	4,000 inches.
San Diego River . .	San Diego Flume Co.	May 28, 1886	June 1, 1886	About 1,000 feet above Rocky Bar . . .	6,000 inches.
Upper Sweetwater or Guatay Creek.	Same	June 23, 1886	June 26, 1886	Diverts at first falls of creek above Descauso about 1½ miles. Intended for use in City San Diego, Ex Mission Ro., Ro. de la Nacion, Jamacha, and Sweetwater Valley, as part of main system	2,000 inches.
Santa Ysabel Creek .	Same	June 24, 1886	June 26, 1886	At point in gorge where creek leaves Santa Ysabel Valley. All waters claimed to heads of the three main branches . . .	2,000 inches.
Ballena Creek . . .	Same	June 24, 1886	June 26, 1886	Part of main system. This is the "Ballena" Reservoir site appropriation . . .	1,000 inches.
South Fork San Diego River.	Same	June 29, 1886	July 2, 1886	Diverts by flume one mile above mouth.	4,000 inches.
Bowlder Creek Fork San Diego River.	Same	July 31, 1886	Aug. 4, 1886	. . . . .	2,000 inches.
Pine Valley Creek . .	Same	1885	1885	. . . . .	2,000 inches.

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Stream.	Appropriator.	Date Posting.	Date Filing.	Purpose, Means of Diversion, etc. Place of Diversion.	Amount Claimed.
Chocolate Creek Fork of the San Diego.	San Diego Flume Co.	Aug. 14, 1886	Aug. 19, 1886	Diverts at point ⅔ mile above forks of creek.	100 inches.
Same	Same	Same . . .	Same . . .	Diverts 1,500 feet from flume crossing . .	100 inches.
Dye Valley Fork, San Diego River.	Same	Sept. 16, 1886	Sept. 20, 1886	This is the appropriation for the Upper Dye Valley Reservoir	2,000 inches.
Japatul Valley Fork of Sweetwater.	Same	June 27, 1886	. . . . .	This is at the dam site in Japatul Valley.	500 inches.
San Diego River . .	Same	Aug. 27, 1887	Sept. 3, 1887	Proposes to divert at Knowles ranch, some miles below diverting dam	500 inches.
Coleman Creek Fork of San Diego River.	Same	Mar. 27, 1888	Mar. 31, 1888	Point of diversion about ⅜ mile above junction of Coleman and Bowlder Creeks.	1,000 inches.
Same	Same	Same . . .	Same . . .	250 yards above Blattner's house	1,000 inches.
Same	Same	Same . . .	Same . . .	⅛ mile above Coleman and Bowlder Creeks.	1,000 inches.

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RIPARIAN AND OTHER RIGHTS.—It is stated that riparian rights on the stream below the diverting dam have been purchased, or the claims adjusted, so as to dispose of the possibility of future litigation on that score—the riparian owners generally surrendering all claims to damage on account of diversion or storage of the water, or any injury that might ensue by reason of the proposed works. These rights were thus obtained without cost, as an encouragement to the construction of the flume as a general benefit to the country. But one man received compensation, and this was in consideration of his prior appropriation of water. Being the only prior appropriator, and having irrigated but a small field, he was given a contract for an equivalent supply from the flume.

Governor R. W. Waterman brought suit in 1887 to have the Cuyamaca dam removed as a nuisance, on account of the fear of an excessive percolation into the Stonewall mine, owned by him, from the reservoir, and because his lands were flooded by the waters. The Flume company sought to condemn the land belonging to Governor Waterman that was in the reservoir basin. These suits never came to trial, but were compromised; the company paying fully for the lands and giving certain guarantees.

History of the Work and Financial Outlook:—The enterprise was conceived by T. S. Van Dyke and W. E. Robinson, whose familiarity with the mountain streams and reservoir sites was obtained on frequent hunting excursions. They made the water claims and surveys to prove the general feasibility of the scheme, prior to the incorporation of the San Diego Flume Company, May 14, 1886. The capital stock of the company was fixed at $1,000,000, chiefly subscribed by citizens of San Diego. Surveys were prosecuted during the summer of 1886, and in the fall of that year contracts were let for the diverting dam on the river, and the Cuyamaca storage dam. The actual construction of the flume was begun in the summer of 1887, after grading of its foundation had been in progress for some months.

Of the ten thousand shares of the company, two thousand were given to Robinson in consideration of the transfer of his interests, appropriation, surveys, maps, rights of way, deeds, assignments of riparian rights, etc., to be non-assessable until the completion of the flume, when he was to pay an amount equal to the pro rata

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assessments that may have been levied up to that time. Of the remaining eight thousand shares, seven thousand seven hundred and sixty-six shares were subscribed by residents of San Diego and outside capitalists (San Francisco and Eastern) directly interested in the advancement of San Diego. The remaining two hundred and thirty-four shares are still in the treasury. Some of the shares subscribed were sold at a premium, the total amount thus realized on premiums being about $40,000.[1]

The first assessment was levied in September, 1886, of $5 per share, to begin work on the two dams. Since then three other assessments of $10 each have been levied. The total amount raised by assessment has been $271,810.[2] An issue of $600,000 of twenty-year 6 per cent bonds was authorized, and about $300,000 were sold at 95 cents. In addition to these resources, the company has sold a considerable portion of a three thousand-acre tract of land lying at the terminus of the flume on the mesa. They bought the land for $10 per acre, and sold it for $100 to $300 per acre, with water-rights at the rate of one inch to ten acres. They have also sold or contracted for water-rights amounting in all to seven hundred and fifty inches, of which nearly one half was at the rate of $800 per inch, and the remainder at $150 and upward, to $2,000 per inch. Partial payments have been received on some of these sales. A part of the contract work was payable in bonds. They have recently obtained a loan of $100,000, for which bonds are given as security with the option to purchase at 90 per cent. This amount is considered to be enough to carry the flume to the end of the route, and on this sufficient completion of the flume for use it is expected that the remaining bonds can be placed to provide funds for building the City reservoir, laying the pipes across the mesa, and to put on the upper side-planking of the flume.[3]

The next work then to be done will be the construction of additional mountain reservoirs. In Dye Cañon fork of the San Diego, there are two sites selected, and one in the Ballena on one of the tributaries of the Santa Maria creek, a fourth in Japatul valley on the Upper Sweetwater, to be fed by means of a flume

[1] Data of June, 1888.

[2] The above is from data of June. Since then to October twentieth another assessment of $5 has been levied. The total amount raised by assessment and loans on stock has been $423,973 84, with the last assessment not yet paid.

[3] The work has now been completed except the upper-side planking, as told on pp. 73 and 74 *ante*. October, 1888.

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from the headwaters of Cottonwood creek (a tributary of the Tia Juana river). And, finally, there will have to be connecting flumes for the diversions of the waters of the two last named reservoirs, into the San Diego river water-shed above the diverting dam. No detailed estimate of the cost of this extension of the scheme has been made, and no data is available of the capacity of the various reservoirs, but the extension is admitted to be essential to the scheme, in order that there may be a water-supply for much fuller delivery than is now at command during the irrigating season.

TOTAL COST; ESTIMATED:—On the basis of construction to date, the completion of works now commenced, to utilize the present water-supply, including the mesa pipe line and the City reservoir, will cost $1,089,000, not including distribution.

Say	$1,100,000 00
(The flume with one board on each side, carrying water within two inches of top, will deliver about nine hundred inches.)	
Estimated cost of extension of system to endeavor to secure for every irrigating season, according to project, a full supply to capacity of flume (5,500 inches—110 cubic feet per second)	600,000 00
Total	$1,700,000 00

It is even possible that these works, carried out as they might be to advantage within the next ten years, to secure, store, and bring in all available water to supply the flume run, would cost $2,000,000.

If the works go no further towards securing and carrying additional waters, and deliver but eight hundred and fifty inches, the revenue derivable at $90 per inch per annum[1], is $76,500. Allowing, say, $15,000 per annum for running expenses, and say $25,000 per annum interest on bonds, this would be less than 6 per cent on the cost after deducting amount received from sale of water-rights. There being no allowance in the above estimate made for a sinking fund (for insurance and repairs, which on a work of this kind must be liberally provided for), it would seem that as an irrigating enterprise it must be carried further forward with a strong hand, to reap deserved success.

[1] On the basis of an inch of water to thirty acres, and $3 per acre per year, which are the figures for a number of the company's contracts. The supply of water for municipal purposes is an anticipated source of revenue, but the conditions are not settled, and matters are yet too uncertain to justify any further attempt at estimating a probable income, for entry in this report.

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SECTION II.

San Diego River Works and Projects.

Mission Valley Water Company.

District and Work:—Second in rating to the Flume company's works, diverting the waters of San Diego river, is an enterprise projected by the Mission Valley Water Company. The scheme contemplates the erection of a masonry dam in the lower cañon of the San Diego river, some twelve miles above the mouth of that stream, for the storage and diversion of the winter flow; the construction of a masonry conduit, and laying of iron pipes along both sides of the Mission valley, leading to and terminating in a series of eight storage reservoirs of varying elevation and capacity; and the supply of irrigation to about ten thousand acres of valley land within the boundaries of Mission valley, and some eight thousand or ten thousand acres lying adjacent to the San Diego river, and along San Diego bay and False bay.

Mission valley is the local name which the lower valley of the San Diego has acquired by reason of its having been selected by the Jesuit missionaries as the site of their first California mission establishment. Its length is ten to twelve miles, with an average width of one mile, bordered on either side by the mesa lands lying two hundred to three hundred feet higher than the valley. At the mouth of the river a wide area of alluvial soil has been formed by the deposits of floods debouching into the bay. The lands sought to be irrigated are principally of a sandy, alluvial character, adapted to market gardening when under cultivation by irrigation.

No works of any importance have been attempted for irrigation in this district since those of the mission fathers fell into disuse. The latter consisted of a diverting dam of brick in the cañon, and an earthen canal of large dimensions along the south side of the valley extending almost its whole length to Old San Diego with a branch crossing the river to the north side, supplying the orchards and fields around the Old Mission. Traces of these canals are yet to be seen, and the diverting dam is intact. It is located about a mile above the site selected by the Mission Valley Water Company, for their diversion, and is near the west line of the Cajon rancho.

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DIVERTING, DELIVERY, AND STORAGE WORKS:—The base of the diverting dam is at an elevation of one hundred and ninety feet above sea-level, and it is proposed to carry it to a height of eighty[1] feet, where the length on top will be about four hundred feet. The foundation for this dam, about ten feet high, sixteen[1] feet thick at base, and two hundred feet long, has already been built of granite masonry laid in Portland cement on bedrock. It is proposed to carry it about ten feet higher the first year, and for temporary purposes lay a pipe sixteen inches in diameter down the valley to Old Town and Roseville. When completed to its full height of eighty feet, the reservoir formed by this dam will store about one thousand five hundred million gallons. It will be long and narrow, seeing that it is located in the cañon.

The other works projected are as follows: From the diverting dam a cement-lined conduit, twelve feet wide on the bottom, six feet deep, on grade of four feet per mile, is planned for along the south side of the river one mile, where, according to the plans, it will branch into two conduits eight feet wide by four feet deep, one of which will cross the river to the north side and extend three and one half miles to Reservoir No. 5, and the other will follow the south side for two and one half miles and terminate in Reservoir No. 2. Other reservoirs will be supplied by pipes laid on grade lines beyond the ends of the open conduits. The estimated capacities and elevation of the various reservoirs projected are as follows:

RESERVOIR.	Distance from Diverting Dam.	Elevation of Top of Dam.	Height of Dam.	Capacity of Reservoir.
	Miles.	Feet.	Feet.	Mill. Galls.
Diverting Dam . .	. .	270	80	1,500
No. 1	1½	180	30	124
No. 2	3½	170	70	2,203
No. 3	3	160	60	448
No. 4	9	. . .	. .	382
No. 5	4½	160	60	1,545
No. 6	. .	120	40	125
No. 7	. .	120	40	534
No. 8	. .	140	90	2,141
Total . . .	. . . .	. . . .	. . . .	9,002

[1] These figures are as reported according to the plans. It is not stated whether it is proposed to increase the thickness of the foundation before carrying the work to its full height.

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All of the dams for the subsidiary storage reservoirs are to be of earth. No careful estimate of cost has been made, and it seems improbable that the entire system of storage as outlined will be carried out for at least many years to come.

Water-Supply:—The San Diego river is especially intermittent in its flow in its lower course, and in midsummer and fall is frequently nearly dry at the site of this diverting dam, and for miles above and below. In winter its volume sometimes reaches fifty thousand inches or more, and it is believed by the projectors of the enterprise, for four months of winter and spring the flow will exceed an average of ten thousand inches daily. The appropriation will always be subject in some degree to the prior diversion of the San Diego Flume Company higher up the stream. The diverting dam is located to utilize all the stream in its lower course, and it advantageously commands the district which it seeks to supply.

History of Project and Water Claims:—The Mission Valley Water Company was incorporated in July, 1887, with a nominal capital of seven thousand five hundred shares of $100 each, par value. A filing was made on ten thousand inches of water at the point of diversion, and work was begun on the construction of the diverting dam in the fall of 1887. The parties chiefly in interest are citizens of San Diego, who are following the judgment of the Jesuit priests, who selected this same field for the establishment of their first footing in California, and made this the point where the first of many notable irrigation works was constructed, and where irrigation is believed to have been first successfully practiced in the State.

SECTION III.

The San Dieguito River Project.

Pamo Water Company's Proposed Works.

District and Project:—A notable scheme projected for the utilization of water of the San Dieguito or Bernardo river is that of the Pamo Water Company, which seeks to provide irrigation facilities to Poway valley and the Linda Vista mesa, lying between the San Diego river and Penasquitas creek, near the coast,

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by means of a storage dam on the headwaters of the river below the mouth of Pamo creek, and a flume twenty-five miles long terminating in a secondary storage reservoir on the mesa, near the lands to be watered. The field which would be commanded by the intended works largely exceeds their projected capacity for supply, as the main conduit will skirt the San Pasqual and Bernardo valleys before reaching the particular district to which, under the project, the water is to be specially applied. No other works now outlined dominate this region, except those from the more distant supply of the San Luis Rey Flume Company, and these two above named valleys alone could consume the flow of the proposed flume by the Pamo company.

STORAGE AND DELIVERY WORKS:—Above the valley of San Pasqual the river occupies a rocky cañon some three and a half to four miles in length, opening out above the cañon into the Pamo valley, at the mouth of Pamo creek, an important tributary to the river, draining a portion of the Mesa Grande. At the head of this cañon the company design building a masonry dam on bedrock, eighty feet high, four hundred feet long on the crest, one hundred and seventy-five feet long on the bottom, which will form a reservoir having a capacity of about three thousand million gallons.

From the dam an iron pipe at least thirty inches in diameter will carry the water through the cañon, whence it will be conveyed by a flume about four by four feet, skirting the hillsides far above the river, past the San Pasqual and Bernardo valleys to a gap in the divide between the Bernardo and Poway valleys; thence through the gap, skirting the Poway valley, and terminating in a reservoir of two thousand million gallons capacity, to be formed by a second masonry dam, forty feet in height, two hundred to two hundred and fifty feet long on crest, one hundred to one hundred and twenty-five feet long on base. The stream and its tributaries above the proposed point of diversion has a water-shed area of nearly one hundred and fifty square miles, of which fully two thirds has an altitude of over three thousand feet, and reaching as high as six thousand feet. The two principal tributaries are Pamo and Santa Ysabel creeks, both perennial streams of comparatively large volume, draining a portion of the Volcan mountain and the Mesa Grande.

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The elevation of the base of the main storage and diverting dam is eight hundred and fifty feet above sea-level. This reservoir basin is a long narrow valley of alluvial soil inclosed on either side by precipitous hills and mountains. The site of the dam is at a point where hard, gray granite crops out, affording abundant material for construction purposes. The material at the lower reservoir, for dam building, will be a hard basaltic rock of close texture. The altitude at base is about seven hundred feet, which readily commands the tract to be watered, its elevation being two hundred to six hundred feet above the sea. The elevation of the upper dam as compared to the great area of arable lands that may be reached from it by gravity, facilitates the choice of routes for conduit. The San Pasqual valley (elevation 550 feet), Bernardo valley (elevation 400 feet), the Escondido valley (elevation 650 feet), and Poway valley (elevation 500 feet), are all within comparatively easy reach, as the main conduit will follow the divides above them.

That the chief reliance of the works will depend upon the winter flow of the stream stored by reservoirs, for summer use, is as true of this enterprise as of all others projected in San Diego county. The fact that the streams in this case never go entirely dry should add materially to the effectiveness of the enterprise, seeing that they may largely contribute to make up the inevitable losses in transit and in evaporation from the surface of the reservoirs. But without storage the supply would be unreliable for the irrigation of any considerable area. The winter flow, however, will probably much exceed the capacity of the present projected means of storage and transit.

History; Organization:—The Pamo Water Company which has taken up this stream was incorporated in March, 1888, with a capital stock of $1,000,000, in ten thousand shares of $100, par value. Thus far nothing has been done beyond the work of making preliminary surveys and the purchase of the lands to be embraced by the reservoir. The company propose to make the landholders along the route directly interested in the project by taking contracts for deeds to a portion of their lands as consideration for water-rights for the remainder, the deeds to be made in advance and held in escrow, or to be made on the completion of the works. With a land subsidy of this character, they consider that they will have tangible assets to hypothecate for the money needed to construct the works.

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CHAPTER IV.—SAN DIEGO[4]; WORKS AND PROJECTS[5].

SECTION I.—*San Luis Rey River Projects:*
San Luis Rey Flume Company;
General Outline of Project.

SECTION II.—*Santa Margarita River Project:*
Fall Brook Water and Power Company;
General Outline of Project.

SECTION III.—*San Jacinto River Works and Projects:*
Fairview Land and Water Company;
Diversions and Pipe Lines;
History of Organization;
Lake Hemet Water Company;
Pipe Lines and Proposed Reservoir;
History and Water-rights.

SECTION I.

SAN LUIS REY RIVER PROJECTS.

San Luis Rey Flume Company.

District and Project:—Steps were taken in 1886 by several San Diego land operators looking to the systematic utilization of the San Luis Rey river, and the irrigation of the coast mesa in the vicinity of Oceanside near its mouth, on the south side. An organization was effected, and surveys for a canal or flume line were made, and water-rights were filed upon at the second narrows, some five miles below Pala, where the elevation is about three hundred and seventy-five feet. A submerged dam extending from bluff to bluff, seven hundred feet, to raise the underflow to the surface was contemplated, but the cost of the work, the long line of conduit required, and the uncertainty of the water-supply available at the point of diversion selected, led to the expansion of the project and the formation of the present company, with

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a larger capital and embracing a more comprehensive scheme. The new company set to work to acquire all water-rights on the river that might in any way conflict with their proposed appropriations, as well as riparian rights along the stream.

STORAGE AND DELIVERY WORKS PROPOSED:—An outline of the main project is, briefly, the construction of a mammoth reservoir dam on Warner's ranch, a canal from the cañon of the river some miles below the dam, extending about twenty miles along the mountain and rolling hillsides south and west of the river, and a secondary storage reservoir at the terminus of the canal in Bear valley at an elevation of one thousand three hundred feet. From this commanding elevation, but twenty miles from the sea at the nearest point, and thirty-five miles from the city of San Diego, the territory that may be served is only limited by the supply of water available. Pipe lines are projected in various directions. The main conduit drops into this secondary reservoir with a direct fall of seven hundred feet, and the utilization of this water power and transmission by electricity to points of use are contemplated.

The company have brought actions to condemn the land on Warner's ranch required for purposes of the reservoir. Until the possession of these lands is acquired, the work will necessarily be confined to the construction of the conduit and lower reservoir dam, where the lands have already been acquired. The first pipe line to be laid from the Bear valley reservoir will probably be through Escondido and San Marcos valleys to Oceanside. San Pasqual, Bernardo, and Poway valleys are also readily commanded, and the coast mesa between Oceanside and San Diego and north of Oceanside. The full development of this scheme would take several years to accomplish, and the total cost of works to fully avail of its possibilities would no doubt exceed a million dollars.[1]

[1] As this report goes to press (October) it is learned that the company has secured $500,000, with the engagement of as much more, from New York capitalists, on the basis of its bonds, and land and water-right contracts, and that the work is to be immediately pushed forward.

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SECTION II.

Santa Margarita River Project.

Fall Brook Water and Power Company.

District and Project:—The existing diversions of water from the Temecula or Santa Margarita river are unimportant compared with that projected and under construction by the Fall Brook Water and Power Company. This company was organized in 1887, with the purpose of erecting a capacious storage dam at the head of Temecula cañon, and carrying the waters in a flume and pipe line to a body of some thirty thousand acres of rolling table lands in the vicinity of Fall Brook, lying to the south of the river, twelve to fifteen miles inland from the coast. Ten miles of flume, and two miles of pipe line laid on a gradient of eight feet per mile comprise the main conduit. An average flow of eight hundred miner's inches, maintained by the living waters of the stream, as supplemented during the dry season of the year by water stored in the reservoir, is the delivery counted upon by the company.

The proprietors of the Santa Margarita ranch, at the mouth of the river, have an appropriation at the lower end of the cañon, which may interfere with the plans of the Fall Brook company. To avoid this difficulty, it is proposed to return to the stream the water belonging to the rancho at the end of the flume line, and utilize the fall of five hundred feet for water power. The company have purchased certain conflicting riparian rights along the stream, and hope to have their works completed early in 1889. The entire cost of the project is estimated at $200,000. The character of the country to be irrigated, its picturesque beauty, clothed with live oak trees, and the special adaptability of the soil to the growth of citrus fruits, render the project an interesting one.

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SECTION III.

San Jacinto River Works and Projects.

THE FAIRVIEW AND LAKE HEMET ENTERPRISES.

As elsewhere written, the waters of San Jacinto river have, for a number of years, been, in part, crudely used in irrigation by means of several small ditches. Recently, however, two notable projects have been set on foot and partially carried out, for their economical utilization to a far greater extent. These are the works and projects of the Fairview Land and Water Company, and of the Lake Hemet Water Company.

The Fairview Land and Water Company.

District and Work:—The scheme of this company contemplates the diversion of waters of the San Jacinto river, at and above the forks in the cañon, and conducting them thence by iron pipes out to a tract of about two thousand nine hundred acres, lying in the valley near the mouth of the cañon, and south of the river, and distributing them for the irrigation of these lands. The district commanded by the works is, of course, far greater than that for which they have been constructed, and is essentially the same as that commanded by the works of the Hemet Valley Water Company, hereafter to be described, and the old farm ditches elsewhere spoken of: namely, the great San Jacinto valley, almost as a whole.

Diversion and Delivery Works:—In the south fork of the river, just below Strawberry fork, a wooden dam has been placed, diverting water by a flume, acting as a sand box, into the head of a pipe line. This, commencing at fifteen inches diameter, rapidly diminishes to eight and one half inches, and extends down the cañon a distance of thirteen thousand feet to the mouth of the north fork. Here a junction is made with another similar pipe laid in the north fork cañon from the falls, five thousand five hundred and forty-four feet above, with a total descent of four hundred and eighteen feet in that distance. From the junction of the two pipes, the main down the cañon is eleven and a half inches diameter for a distance of six thousand three hundred feet, to a relief box, where the total head is that due to about five hundred feet of elevation. From the relief box there

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are two miles of thirteen and one half inch pipe, followed by two miles of eight and one half inch pipe to the town of Florida. The total fall in the four miles from the relief box is two hundred and six feet, and the capacity of the pipe is said to be three hundred and seventy (?) miner's inches.

DISTRIBUTING SYSTEM:—The distributing system consists of fifteen thousand one hundred and sixteen feet of eight and one half inch pipe, and thirty-four thousand three hundred and twenty feet of four-inch pipe. An eight and one half inch distributing pipe terminates in a small reservoir on a hill back of the town, one hundred feet higher than the end of the main, which, when completed, will act as a regulator, receiving the surplus water not used, or supplying the deficiency when the draft exceeds the capacity of the main. At a point eight hundred feet above the relief box before mentioned, an eighteen-inch pipe taps the main river, diverting an additional supply into the eleven and one half inch pipe at the box. All of the pipe used is of sheet iron, riveted and dipped, the gauge of iron being Nos. 14 and 16, and some being single and some double riveted.

In addition to these pipe lines, the company have constructed a ditch two miles in length, tapping the river at or near the head of the eighteen-inch pipe. This ditch has a capacity of fifteen hundred miner's inches, and was used in the spring of 1887, before the pipe lines were finished to the tract, but has not since been in use.

COST:—The total length of mains and distributing pipes is sixteen miles, and the cost of all the works is reported to have been $65,000.

History and Water-rights:—In 1885, certain parties of Los Angeles county acquired the lands heretofore spoken of, and incorporated the Fairview Land and Water Company for the purpose of building irrigation works and subdividing and selling the lands in small tracts provided with water for irrigation. They made locations and filings for two thousand miner's inches of water on the north fork, another for the same amount on the main stream below the mouth of Strawberry fork, and a third on the river near the mouth of the cañon, and then began work. Shortly afterwards some other Los Angeles operators secured bonds on a large tract or tracts of arable lands nearer the town of San Jacinto, and organ-

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ized what was known as the Hemet Valley Land and Water Company, with the avowed intention of constructing a reservoir in Hemet valley on the south fork, and of appropriating the entire flow of the Strawberry and south forks at their junction.

As this point had already been selected by the Fairview company for the point of diversion into one of their main pipes, a contest immediately arose over the possession of the water and the right of way. A ditch or trench dug for their pipe line by the Fairview company was filled in by the other company, and a new and larger ditch was dug by the latter. The Hemet Valley company held their position by force of arms for some time, and serious conflict was imminent, but finally the Fairview company took possession of the ditch, laid their pipe, and maintained their claim to the water, and the Hemet company retired from the field. This was in the spring of 1886.

The Hemet Valley company had meantime made surveys of the dam and reservoir site in Hemet valley, and expended altogether some $6,000, but failing to get the necessary capital to prosecute their works, finally disincorporated, after turning over their contracts and water-rights to the principal individuals of the organization. These then organized the Hemet Land Company and the Lake Hemet Water Company, and transferred to the former their land contracts, and to the latter their water-rights, and reservoir basin-lands. These new companies were incorporated in January, 1887, and the Lake Hemet Water Company finding the Fairview company in full possession of the river, and of the lands along the cañon, over which rights of way were necessary, came into a compromise of all former difficulties, which was, in February, 1887, sealed by agreement, containing governing conditions as follows:

Lake Hemet and Fairview Companies' Agreement:—The Lake Hemet Water Company relinquishes to the Fairview Water Company all its claims to the waters of the north fork of the river, and to those of the south fork below a point one hundred feet above its confluence with the Strawberry fork; and the Fairview Water Company relinquishes to the Lake Hemet Water Company all its claim to the water of the south fork above the point named. Thus, practically, the Fairview company takes the waters of the north fork of the river, and those of Strawberry fork; and the Lake Hemet Water Company takes the waters of the south fork proper.

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The Fairview company accords to the Hemet company the right to construct and maintain its dam at that point, and accords to it a right of way over its lands for the transportation of all necessary materials for its works and for the laying of its pipe lines. The Hemet company promises and agrees that if, at any time, the waters set aside for the Fairview company be insufficient to supply and irrigate its lands, then the Hemet company will furnish water to the Fairview company upon the same terms and at the same prices it furnishes water to its customers, "by the day or by the run," and will deliver such water into the pipes of the Fairview company on its lands at such points as may be designated by the Fairview company.

Finally, the Hemet company agreed that it would "with all reasonable dispatch proceed to construct a dam and reservoir at the outlet of the Hemet valley, and that the construction thereof as aforesaid is a part of the consideration of this agreement." Thus have the waters of this important irrigation stream been amicably apportioned between these two companies; but it is to be remembered that their claims are subject to the older diversions of the individual farm ditches at lower points on the stream, as elsewhere described. The only one of these old ditches which has received a supply throughout the year, however, is the Hamler, which has utilized a constant stream of about two hundred to two hundred and fifty inches. This water-right has been purchased by the Fairview company upon terms such that it has issued one thousand nine hundred shares of its stock in payment, and will deliver water sufficient for the irrigation of three hundred and eighty acres of land.

The Fairview Land and Water Company:—The capital stock of the Fairview company is divided into twenty thousand shares of par value of $5 each, or a total of $100,000. There is incorporated, as an associate company, the Fairview Land Company, with a capital stock of $60,000, total valuation. This Land company holds the stock of the Water company, and maintains the water or irrigation works. Five shares of the Water company's stock are transferred with each acre of land sold, and one share with each town lot in the town of Florida. No defined allotment or quantity of water per acre is specified as composing a share of water stock. When all the lands are sold, the owners will also hold all the water stock, the plant, property, and water-rights of the Water company. The lands are subdivided into tracts of two

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and one half, five, ten, and twenty acres. The water is delivered near the highest point of each such tract. About seven hundred acres have been sold at the rate of $225 per acre, with the water-right. About two hundred acres are now planted in orchards, vines, etc. Work was begun on the company's pipe line in the spring of 1886, and finished in June, 1887.

Lake Hemet Water Company.

District and Work:—The general project of the Lake Hemet Water Company contemplates the storage of water in Hemet valley for supply to the stream at time of low flow, and the diversion of such waters, together with other waters of south fork from a point just above the mouth of Strawberry fork, and conducting them by means of pipe line for the irrigation of lands at the head of San Jacinto plain, in the valley below the lands of the Fairview company. The district commanded is, practically, nearly the entire San Jacinto valley.

DELIVERY AND DISTRIBUTION WORKS:—From a temporary diverting dam of brush in the south fork of the San Jacinto river, at the point above indicated, a twenty-one and one half-inch sheet iron pipe conducts water several hundred feet to a large sand box, arranged in various compartments; thence the main pipe, thirteen inches diameter, extends down the bed of the cañon, a total distance of sixteen thousand and ninety-one feet, to a relief box, into which it empties freely at an elevation of about five hundred feet below its head. From the relief box a twenty-two-inch riveted iron pipe extends to a point beyond the mouth of the cañon, a distance of about ten thousand two hundred and fifty feet. For purposes of temporary supply, an eight-inch pipe has been laid thence, a distance of twenty-two thousand seven hundred and ninety feet, to about a central point in a tract of ten thousand acres, owned by the Hemet Land Company, which is an associate organization with the Lake Hemet Water Company. But it is intended to replace this eight-inch pipe by an extension of the twenty-two-inch pipe at an early date. The total length of pipe thus far laid, including some five thousand feet of lateral distribution pipe, is about fifty-four thousand nine hundred feet, or nearly 10.4 miles. The weight of iron used has been from No. 16 up to No. 12 in thickness, and the total cost has been about $45,000. The pipe laying down the cañon of the river proved to be a tedious and expensive job, for the reason that a succession

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of large bowlders were encountered in the trench, many of which had to be blasted, and many removed with derricks and powerful pulleys, and for the further reason that the bed of the creek had to be crossed four times.

STORAGE RESERVOIR; HEMET VALLEY:—The main resource of the company in the way of water-supply is to be the projected reservoir in Hemet valley, twenty miles above the town of San Jacinto, at an elevation of four thousand three hundred feet. The south fork leaves the valley through a cañon, only about sixty feet wide at the bottom, with walls of granite, vertical on one side for one hundred feet in height, and, on the other, sloping at a very steep angle. At a height of one hundred and twenty feet above the base, at the most favorable dam site, the width across the cañon is but two hundred feet, and at one hundred and fifty feet, it is less than three hundred feet. Granite of the best quality is at hand; sand, sharp and clean, may be had convenient; an abundance of pine timber is growing in the valley and on the hills all about the site, and water, whose power may be utilized for much of the work, is flowing in the stream. Taking all these convenient materials and facilities, and the character of the dam site into consideration, there are few localities in the State more favorable for the construction of a high storage dam. The reservoir basin is a capacious one, but not notably so, as the following table of contents, at successive levels, will indicate:

Elevations of Water Plane.		Corresponding Areas of Reservoir Surface.	Capacity of Reservoir Above Base of Dam.	
Above Base of Dam.	Above Lowest Outlet.			
Feet.	Feet.	Acres.	Cubic Feet.	Million Gallons.
30	10[1]	.37	112,000	.84
40	20	2.70	1,769,000	13.23
50	30	12.50	5,342,500	40.06
60	40	27.94	14,155,000	105.88
70	50	50.45	31,232,000	233.62
80	60	90.61	61,953,000	463.41
90	70	115.96	111,947,000	837.35
100	80	176.76	175,708,500	1,314.40
110	90	238.70	266,197,500	1,991.16
120	100	349.80	389,374,000	2,911.62
150	130	.....	.....	[2]6,000

[1] Figures in this column are approximations, only.
[2] Approximation.

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At the height of 122.7 feet above the base of the proposed dam, there is a gap in the ridge on the south, near the dam site, which would serve as a natural waste-way were the dam made to a height of one hundred and twenty-five to one hundred and twenty-eight feet, but which would have to be closed with an embankment were it built to the one hundred and fifty-foot level. The plan for the work has not yet been decided upon, and before it is begun, a wagon road must be constructed some ten miles, for the purpose of transporting materials and supplies to the spot. The work will probably cost $150,000 to $200,000 if projected on a safe profile for a dam one hundred and fifty feet high. The present intention of the company is to build the road this season and get cement on the ground ready to begin the dam early in the spring of 1889.

History and Water-rights:—Sufficient reference has already been made to the circumstances of the organization of this company and the commencement of its operations, in the previous article relating to the history of the Fairview company. The capital stock of the Lake Hemet company is $2,000,000, divided into 20,000 shares, which stock is practically all held or controlled by the Hemet Land Company, the associate organization incorporated for the purpose of the purchase, irrigation, subdivision, and sale of lands.

Irrigators' Water-rights:—A water-right certificate issued by the Lake Hemet Water Company accompanies each tract of land sold by the Hemet Land Company, and is included substantially as a part of the valuation sold, there being one "water-right" transferred with each acre of land. "Each water-right granted by said corporation represents and entitles the holder thereof to a constant flow of one eighth of an inch of water from the first day of May to the first day of December of each year; or such equitable proportion thereof as may be at the disposal of said corporation after said right commences, in case of scarcity of water from any cause, or so long as said right remains in force."

In addition to this water privilege for irrigation and other purposes, the owner of each water-right has the right to water for domestic uses for one family for the remainder of the year, at rates to be fixed by the company, not exceeding $1 per month for each family, but he is not to use water for irrigation during

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these other months, except "with the consent of the company, and upon terms to be fixed by the company. The delivery of water is to be at such point or points as the corporation may establish." And the holders of water-right certificates "have the right of cumulation under the rules and regulations of the company." The water-right holder agrees to pay $2 per year on each water-right, "which payment within the time stated is a condition precedent to the right of the said owner to receive and use water from said corporation; and the failure to make such payment shall forfeit the right of said owner, and the same shall revert to the company."

It does not appear that these water-rights are attached to the lands sold; but it would seem, from the wording of the certificate, that they are sold only with the lands of the Hemet Land Company. They are, however, transferable "with the consent of the company and a written indorsement" entered upon them. No transfer is binding, however, except the certificate be surrendered to the corporation, and a new certificate or certificates be issued therefor; "and no assignment of a water-right shall be valid unless the assignment shall designate and describe the lands to which said right shall be applicable." The use of water under these certificates is limited to one eighth of an inch to each acre of land. It may be used on a less quantity of land, but may not be used on a greater quantity, nor on other lands than those described in the certificate. A violation of these stipulations works a forfeiture of all rights under the certificate.

It will be noticed that these certificates of water-rights are distinct from certificates of stock of the water company. The land purchaser becomes the purchaser of a water-right for his land, and agrees to make an annual payment for the use of the water; he receives no interest partaking of the nature of ownership in the water property or works. But his waters are not indissolubly attached to his lands. They are not made an appurtenance thereto. It is made a simple matter of contract on his part, that he will use the waters under his right on certain specified lands, which with the consent of the company, he may change. Or, with the consent of the company, he may sell his water-right to the owner of other lands to be held for the benefit of such lands, leaving his land without any claim to be served with water. The company has reserved to itself the control of the situation with

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respect to the placing of individual water-rights, and may or may not, in its discretion, consent to their transfer for the benefit of lands not owned or sold by the Hemet Land Company, although the owners of the stock of the Water company are the same individuals who own the stock of the Land company. It would appear that they look to their water stock as a permanent investment, which will yield them a revenue, from the annual payments stipulated for, over and above the amount necessary for maintenance of the work.

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CHAPTER V.—SAN DIEGO[5]; WORKS AND PROJECTS[6].

SECTION I.—*Sundry Small Ditches and Irrigations:*
San Diego and San Dieguito Old Ditches;
San Luis Rey Old Ditches;
Santa Margarita Old Ditches;
San Jacinto Old Ditches;
Windmill Irrigations.

SECTION II.—*Colorado Basin Works and Projects:*
Palmdale Works;
Colorado Desert Scheme;
Colorado Bottom Lands Projects.

SECTION III.—*Artesian Basin and Wells:*
General Statement.

SECTION I.

SUNDRY PRIMITIVE IRRIGATIONS.

EXISTING FARM AND INDIAN RESERVATION DITCHES.

San Diego and San Dieguito River Old Ditches.

The existing irrigation ditches in the county are few in number, and irrigate but small areas. On the south fork of the San Diego river, the Indians on the Capitan Grande reservation irrigate about fifty acres. On the San Dieguito about one hundred acres of bottom land on the San Dieguito ranch are irrigated from a laguna. Higher up in the San Pasqual valley there are some one hundred and fifty to two hundred acres of alfalfa irrigated in winter and spring, and on the Santa Ysabel rancho, about one hundred acres are watered by Indians in a primitive way. On the Guejito branch of the Santa Ysabel some twenty to twenty-five acres are in like manner irrigated.

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San Luis Rey Farm Ditches.

On the bottom lands in the vicinity of the San Luis Rey mission, five miles from the ocean, there is a small area watered in winter and spring, possibly one hundred acres. On the Montserrate rancho a ditch has been in use in former years to irrigate alfalfa fifty to seventy-five acres in area. In the vicinity of Pala, and above the Montserrate rancho, there are five or six small farm ditches used for irrigating corn, alfalfa, and garden produce. The total of this is estimated at two hundred acres.

On the Agua Tibia ranch, about sixty-five acres of orchard, vineyard, and garden are watered from Agua Tibia creek, a tributary to the river from Smith's mountain. Some five miles above Agua Tibia, Pauma creek descends into the valley from the highlands of Smith's mountain. This stream is one of the most permanent feeders of the river, but has never been utilized except by the few families of Indians living on the Pauma ranch, who irrigate small patches of corn and potatoes. Further up on the Cuca rancho, and on Warner's ranch, the Indians irrigate their little fields, possibly fifty acres all told, along the whole river. Total area irrigated about four hundred and ninety acres.

Santa Margarita River Farm Ditches.

Near the mouth of the cañon, and about eight miles from the coast, a ditch is taken out of the river for irrigation on the Santa Margarita ranch, and about three hundred acres of alfalfa and twelve acres of orchard and vineyard are thus irrigated. The main ditch is three quarters of a mile in length, and terminates in a reservoir, covering one hundred and sixty acres, built in 1883 by throwing up an embankment of earth across a flat side valley. This dam is about twelve feet high, one thousand three hundred and forty feet long, and is provided with an outlet near the south end, consisting of a wooden opening four feet four inches wide, reaching from top to bottom, with loose plank four inches thick set one above the other (not inclined) to retain the water and enable it to be drawn off from the top by removing one plank after the other. A part of the diverting ditch is in flume, five feet six inches wide in the clear, and twenty-two inches deep. If the extent of the appropriation is to be judged by the capacity of the flumes, its volume must exceed one thousand inches. August 27,

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1886, the flume was carrying nearly all the water of the stream, and its flow measured one hundred and forty miner's inches.

From the reservoir to the rancho house, one and one half miles, the ditch is about six feet wide on the bottom, two feet deep, with a grade of four feet to the mile. It is carried one and one half miles farther, and has a number of laterals from which water is distributed in checks in the alfalfa field. This is probably the only old irrigation ditch in the county irrigating any considerable area, which has any pretense of a systematic utilization of water, and in this case its use is rather more required for exterminating gophers than as an absolute necessity for plant growth, because the bottom lands on which it is used are naturally moist and sub-irrigated. Besides this ditch there are several exceedingly small works, irrigating in all from seventy-five to one hundred acres in small patches in the water-shed of this river.

San Jacinto River Farm Ditches.

Several small old ditches take water in winter and spring from the San Jacinto river below its cañon, and are generally well supplied until April or May, the upper two until June or July, and the uppermost of all has a constant supply. The Rancho San Jacinto covers all the land irrigable from the river; and as it is riparian to the perennially flowing portion, the question of water-rights as between the several owners is one of priority of appropriation and use. The oldest ditches in use appear to be those having the most permanent water-supply, and serving lands most conveniently located for irrigation. As nearly all the lands that have been irrigated lie within the limits of a moist belt, requiring but little irrigation, there has been no special contest over water-rights.

The ditches described in their order, from the cañon down, are as follows: The Hamler ditch, left bank; Hewitt's ditch, left bank; Estudillo's ditch, left bank; Mission Indians ditch, right bank; San Jacinto town ditch, left bank; Webster's ditch, left bank; McAllister's ditch, right bank.

The Hamler Ditch:—This ditch heads a little way in the cañon, and enters the mesa land in what is called the Florida tract, where formerly some one hundred acres of grain were irrigated. At present the irrigation is confined to the Webster estate, above

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the Florida tract, and comprises fifty acres of alfalfa, and five acres of orchard. The ditch has a maximum capacity of two hundred to two hundred and fifty inches. It was built in 1871–72. Its water-rights have recently been merged into those acquired by the Fairview Land and Water Company, controlling the Florida tract of two thousand nine hundred acres, as elsewhere described.

Hewitt's Ditch:—This ditch was constructed in 1865, and is three and one half to four miles long, with a fall of twelve or fifteen feet per mile. Its capacity is about six hundred miner's inches. Water begins flowing in the ditch in December, but does not reach its maximum flow until about January fifteenth; and thence to March fifteenth there is always an abundance, diminishing to forty or fifty inches in June. The greatest area ever irrigated was four hundred and fifty acres, in grain, corn, hay, and potatoes.

Estudillo's Ditch:—Heads immediately below Hewitt's, but has been abandoned for some years.

Mission Indians Ditch:—This is a very old ditch that has always been used by a settlement of Indians on the right bank of the river for irrigating about one hundred and fifty acres of corn and orchard. It is about two miles long, and heads a little below Hewitt's ditch. Its capacity is about one hundred and fifty to two hundred miner's inches.

San Jacinto Town Ditch:—This ditch is about one and a half miles long, is used in irrigation around the town of San Jacinto, but is small and of little importance.

Webster's Ditch:—This is an old appropriation of winter water, which has been abandoned but was reopened five years ago, and is used to irrigate seventy-five acres of barley. It is about two miles in length.

McAllister's Ditch:—This ditch was constructed in 1882. As it is the lowest on the river, it gets but little water, except in flood, and in some years receives none. When water was available it has been used to irrigate seventy-five acres of barley for hay. Its length is about three miles.

None of these ditches have headworks or dams other than temporary dykes of sand and brush. Besides the ditches mentioned,

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there are three or four smaller ones in the cañon, for irrigation of little patches of ground in cultivation, the total extent of which probably does not exceed fifty acres.

Windmills:—In the lower valleys of the Tia Juana, Otay, Sweetwater, Paradise valley, El Cajon valley, Poway valley, and at some points in the interior, the chief resource for water irrigating gardens and small orchards has hitherto been the pumping power of ordinary windmills, which are to be counted by hundreds. Where the lift is not to exceed twenty to thirty feet, this means of supply is not burdensome in cost, and in some ways convenient, and as much as ten acres are sometimes watered from a single pump and mill. The constancy of the sea-breeze blowing landward gives a tolerable reliability to the supply, and in the absence of any other means is of no small importance. But the cost of maintenance where the lift is greater, and the occasional lack of wind when most needed, here as elsewhere, inclines the farmer to abandon his mills whenever he can get a gravity water-supply, so that wherever distribution has been effected this season from the Sweetwater reservoir, for instance, a surrender of mills and pumps has generally taken place.

SECTION II.

The Colorado Basin Works and Projects.

Palmdale Project and Works.

District and Work:—On the desert slope at the eastern foot of Mt. San Jacinto, the Palm Valley Land and Water Company has secured lands which it has laid out in farm tracts, with a townsite in the center, and connected by a railroad six miles long with the Southern Pacific at Seven Palms station. The lands are to be watered from the Whitewater river, a stream which takes its rise in the San Bernardino mountains, and flows southeasterly down a steep, rocky slope, losing itself in a few miles in the desert. This stream has been diverted and appropriated at a point near the crossing of the Southern Pacific Railroad, and a ditch nine miles in length has been built to the colony. The ditch has a very steep grade, and its cross-sectional area seems small when compared

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with capacity claimed. It is but one foot on the bottom, three feet on top, and three feet deep, paved with stone on the bottom and sides for the whole length. For one mile of the distance the stone is laid in cement. Its capacity is said to be one thousand miner's inches (20 cu. ft. per sec.), and it is expected to suffice for irrigating six thousand acres, with the supplemented supply that may be derived from West and Chino cañons that come out of Mt. San Jacinto in the immediate vicinity of the settlement. The ditch was commenced in 1886–87, and finished during the current year.

Water Supply and Use:—The supply counted upon from Chino cañon is fifty inches at low water, and from West cañon one hundred and twenty-five to one hundred and fifty inches. The company claim that there was flowing June first this year one thousand inches in West cañon, and two thousand to four thousand in Whitewater. Water for the supply of the town is to be piped from West cañon with a head of two hundred feet. The company have planted one hundred and sixty acres of orange trees, which are now irrigated from the ditch. An analysis of the soil has shown results promising great productiveness and lasting fertility, and the company are anticipating success in creating an oasis in the desert with the water supply which they have secured. The dry climate, freedom from frost, sheltered position behind the mountains, and the absence of fogs, are points urged in favor of the locality for the production of early fruits.

Colorado Desert Scheme.

District and Project:—For many years the utilization of waters from the Colorado river on the great desert of the same name, has been periodically and often brought to public attention, and Congress has been urged to grant concessions in various forms, or make appropriations to carry out certain projects for the purpose, as public works. The original idea seems to have been to turn the waters of the river into the great basin, making it a lake, and thereby effecting such a change of climate as would render the country around it habitable and cultivable. Then it was afterwards proposed simply to take out waters in an immense canal for irrigation of extended areas of the desert lands.

Several preliminary surveys have been made for this latter project, in the interest of private enterprise. The State Engineer,

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though, has never been in position to attempt any examinations of it, and has not succeeded in obtaining data from private sources which is considered reliable. In 1875 and 1876 a reconnoissance was made of the situation by a party under the direction of Lieutenant George M. Wheeler, of the United States Geographical surveys. The report of the engineer in charge of the party, Lieutenant Bergland, very clearly and emphatically showed that the river waters could not be carried into the desert basin on a canal route lying within American territory, but that south of our own line on Mexican territory, there existed a route entirely practicable, and along which the waters of the river during the flood of 1862 had actually poured over into the desert basin in vast volume for several months, making a lake, asserted by some witnesses to have been sixty miles in length and nearly twenty miles wide.

The river's low water plane, at the point of this overflow, is about one hundred and ten feet above sea-level. The desert below sea-level is between eighty and ninety miles long, and with a maximum width of near thirty miles. The report says that along the line of overflow, a depression called "New River," the descent is continuous and nearly uniform from the river to the basin, but there is no data given to show the extent of cutting necessary to effect a diversion that could be controlled. It is apparent though, that with due authorization, power, and sufficient means, the possibilities of irrigation from the river in this vast basin are very great—for the area of suitable lands is immense, and the river water-supply, at the season of irrigation, is greater than that of all the utilized irrigation streams in the State combined.

Colorado Bottom-Lands Project.

District and Project:—The same report refers to the extensive and rich irrigable bottom-lands bordering the river in the lower valley of the Colorado below the Needles, but points out the great difficulty of effecting and maintaining diversions for such irrigation, on account of the considerable annual erosions made by the river changing its channel, caving down its banks, and destroying not only headworks, but considerable sections of the canals themselves. Since that time a well known San Francisco capitalist, owning a large area of these lands, attempted their irrigation by such means, but after spending a very large sum of money, a portion of the canal was carried away by the river, and the whole

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project is understood to have failed and been abandoned. Nevertheless, it is believed, that with proper engineering supervision, and with a strong and large organization, the possibilities of irrigation in this field are second only to those of the desert project itself, in the matter of scope of territory which might be artificially watered.

SECTION III.

Artesian Basins and Wells.

The only explored artesian basin in San Diego county is in the upper San Jacinto valley. Here the limits of the artesian belt have been well defined by borings, and comprise about ten thousand acres. There are now one hundred and nine flowing wells in this locality, and as yet the flow of existing wells has been slightly, if at all, affected by the new ones. The characteristics of all the artesian basins of Southern California are here reproduced. The water-bearing strata are six or more in number, and lie at a depth of from twelve to five hundred feet below the surface. They are not uniformly distributed over the area of the belt; that is to say, they apparently follow old river channels whose courses are not clearly traced out, and there is a measure of uncertainty in boring a well as to which of the water-bearing strata will be encountered. The generality of the wells bored are about two hundred feet in depth. Some of them have the strong flow of twenty to fifty miner's inches. The head of pressure forces the water to heights varying from five to eighteen feet from the surface, and it is customary to control the flow by extending the casing or pipe a short distance higher than the water will rise, and tap it again when the water is required, by a valve on the side near the surface, a convenient arrangement. Attempts have been made to strike flowing water on the lower San Jacinto plains, at various places, without success.

Near the mouth of San Diego river the San Diego and Coronado Water Company have experimented in boring in the bottom of their large infiltration pump-wells for the city water-supply. At the depth of eighty feet they obtained a flow which would not rise quite to the natural surface of the ground, but where the casing was cut off near the bottom of the pumping well, some ten to fifteen

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feet below the surface, there was reported to be some flow. In the lower Sweetwater valley, four miles above National City, a flowing well was obtained a number of years ago, but owing to the defective casing or the lack of casing for the lower fifty feet, the well filled with sand, and has not been flowing for two years or more. Artesian flowing water has also been obtained in the Colorado desert on lands below the level of the sea. As yet none of these artesian supplies have been much utilized in irrigation. Data concerning them will be presented, in connection with some general discussion of the subject of artesian wells and water-supply, in a subsequent chapter of this report.

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IRRIGATION IN SOUTHERN CALIFORNIA.

SAN BERNARDINO COUNTY.

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SAN BERNARDINO COUNTY IRRIGATIONS.

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Arts Brillon & Roy, S.E.

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SECTION I.

THE FIELD FOR IRRIGATION.

IN SAN BERNARDINO AND LOS ANGELES.

A General View of the Country.

Mount San Bernardino, with its immediate consort, Grayback, constitutes the primary culminating point in the topography of Southern California. Extending southeast from it are the San

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Jacinto and other mountains composing the chain heretofore described as in San Diego county, and which continues to and beyond the Mexican border. Extending west, the Sierra Madre ranges reach away over a hundred miles as an almost unbroken chain through Los Angeles and into Ventura county. Standing at the point of meeting of these masses of mountains, the San Bernardino peaks are the highest and most commanding objects in the southern counties' landscapes, and play a very important part in modifying local climatic phenomena and regulating irrigation water-supply.

Taking a station on these peaks, at an elevation near twelve thousand feet above the ocean, we would see far south of us the great mountain plateau and coast mesa described in a former chapter as of San Diego. From the northwestern end of this plateau starts out a range of mountains which sweeps westward—following the general direction of the coast. This, locally known by various names, is collectively called the Coast Range, and extends across the extreme southern point of San Bernardino county into Los Angeles county. Along its seaward face, a sloping plain or coast-wise mesa is found; while inside of the Coast Range, and between it and the Sierra Madre chain, lies the great interior cultivable valley of Southern California; which, interrupted by two comparatively low hill groupings, extends away from the very foot of San Bernardino peak, westward, a distance of one hundred and ten miles. The coast-wise lands—which, in Los Angeles county locally lose their mesa-like or bench character, and become a broad, alluvial plain (the former delta of the three principal rivers of the country)—and the interior valley constitute the field of irrigation in San Bernardino and Los Angeles counties.

North from the Sierra Madre chain stretches away to the Sierra Nevada mountains, a distance of over fifty miles, and from the Colorado river on the east to the Santa Barbara mountains on the west, the desert plain of the Mojave, comprising an area of fifteen thousand to sixteen thousand square miles. On this broad plateau there are extensive tracts of rich soil; but from the want of rain they are barren, and from the absence of water-supply they are, except in very limited localities, non-irrigable. The Mojave, then, is not, save in a very much restricted sense, a part of the irrigation field, present or prospective; although, locally, irrigation flourishes there, and many small utilizations of water remain yet to be carried out.

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The Sierra Madre and the Coast Ranges.

The Sierra Madre range of Southern California, in parts known through San Bernardino and Los Angeles counties as the San Bernardino, Cajon, Cucamonga, San Gabriel, and San Fernando mountains, constitutes the mountain wall which, intercepting the drift of ocean breezes and storm clouds, regulates the climate and makes highly cultivable that which we have called the irrigable portions of these counties.

It is a remarkably precipitous and rugged range of mountains. Without outstanding foot-hills, it rises from the plains along its southern face, abrupt, forbidding, and apparently barren. In elevation its crest line holds closely to a plane about six thousand to seven thousand feet above the level of the sea, and its peaks rise to nine thousand, ten thousand, and nearly twelve thousand feet of altitude. Its complete passes are almost none—the one exception, the Cajon—unless we are to recognize the San Gorgonio, between the Sierra Madre proper and the San Jacinto mountains, as constituting a pass through the Sierra Madre.

In appearance on its southern face, it is remarkably destitute of forest growth, and, in fact, of vegetation of all kinds; but this appearance is, in high degree, deceptive, and its reputation as an extremely barren region is, in great measure, undeserved. The peaks and spurs, as a general thing, are without growths, but its cañons and those hidden recesses, not seen from the plains, are frequently well wooded and densely shaded. The high crest line, also, of the mountains top, particularly through San Bernardino county, has much more forest growth than one would suspect from the view had at a distance; and the northern slope of the entire chain on its higher altitudes has limited forest growths of dense character. So that, taken as a whole, although by comparison with mountain ranges of equal altitude in other countries and other parts of California, it is barren and sparsely forested, as compared to the showing it presents to the casual observer from the valley, it is quite well wooded.

It has a secondary culminating point in the mountain known as Old Baldy, situated in the heart of the widest portion of the range, about fifty miles westerly from San Bernardino, and from each of these higher mountains the range gradually lessens in altitude each way—the Cajon pass being the lower point between

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the two. West of Old Baldy there are several lesser culminating points, but north of San Fernando valley the entire range drops to about three thousand to three thousand five hundred feet of altitude, only.

In San Bernardino county the abrupt face of this range is on the southern side, and the longer slope is on its northern, so that the streams running into the San Bernardino valley have short mountain courses, except Lytle creek which comes in from the west from behind the outstanding Cucamonga ridges and peak; and the Santa Ana which comes in from the east between the main range and the San Bernardino peaks. In Los Angeles county before we arrive at the lower portions of the mountains around San Fernando valley, we find the range much wider and the crest line further north in it, so that several of the southern streams have far greater lengths and drainage areas.

The Coast Range, while in some parts precipitous and rugged and attaining altitudes of four thousand or five thousand feet, constitutes much less of a barrier to the incoming moisture-laden clouds; and, although standing outside the Sierra Madre, has comparatively little influence upon climatic phenomena and water supply. It is, however, a regulator of temperature in the eastern end of the great valley, seeing that it closes off the sea breezes which each day invade the neighborhood of Los Angeles, for instance, and the coast plain southeast thereof, and thereby renders the San Bernardino valley a region not only of higher temperature but of drier atmosphere, and thus, it is claimed, better adapted to cultivations by irrigation, regarded of the highest order.

The Interior Valley and the Coast Plain.

The great interior valley is distinctly divided into three local valleys—that of San Bernardino at its eastern end, and San Fernando at its western end, with the San Gabriel intermediate. Including in the term "San Bernardino Valley" all of this great valley which is east of the San José hills, it constitutes by far the largest of these divisions, covering a space of about thirty-seven miles in extreme length; twenty-seven miles in greatest width; and about five hundred and twenty-four square miles in area.

West of and separating it from the San Gabriel is the low irregular range known as the San José hills, between whose south-

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ern edge and the northern foot-hills of the Coast Range is the San José pass, through which is built the Southern Pacific railroad, and between whose northern edge and the face of the Sierra Madre passes the California Central railway also by easy gradients.

The San Gabriel valley is well defined as a basin, but is less shut in from the sea, for in front of this division of the great interior valley, the Coast Range attains to little more than a range of hills, and the pass of the San Gabriel river through them is wide and open in character.

West of the San Gabriel valley are the San Rafael and the Verdugo hills, presenting an exception to the rule, seeing that they are in the nature of a foot-hill range to the Sierra Madre proper, rising to an altitude of several thousand feet at their culminating point. Between them and the Sierra Madre is the Monte Vista or Cañada pass, and south of them is the pass by which the Los Angeles river, draining San Fernando valley, finds an escape around the point of the Cahuenga mountains to the coast plain, and thence to the sea.

The San Fernando valley is, again, a closely walled basin, with the Cahuenga mountains, which here take the place of the Coast Range, on the south, and the San Fernando mountains on the north and west.

The coast plain reaches from the spurs of the Cahuenga mountains, which come down to the sea fifteen miles west of Los Angeles, in a southeasterly direction about fifty miles, and then extends on, with the character more of a mesa and less of an alluvial plain, a distance of over twenty miles farther to the region heretofore described as the coast-wise mesa of San Diego county. Its greatest width is eighteen to twenty miles, and it comprises about one thousand and thirty square miles of territory. Not any of this is within the bounds of San Bernardino county, however. A more detailed description of the parts of the irrigation region thus broadly outlined, which are not in San Bernardino county, will now be left to a chapter in a division of this report referring to Los Angeles county.

The San Bernardino Valley and Basin.

The San Bernardino valley is wholly within San Bernardino county, except a very small corner in its western end, and it constitutes by far the most important part and the great bulk of the

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really irrigable portion of the county. Thus, generally speaking, it embraces not only the San Bernardino valley proper, and which I shall refer to as the San Bernardino basin, but also the Riverside mesa plain, the Jurupa valley and adjacent mesa lands, the great plain extending west of San Bernardino basin, and along the foot of the Sierra Madre range all the way to the San José hills, and which I shall call the Cucamonga plain, and the Rincon basin, which is the moist land district around the lowest point or outlet of the valley into its drainage way—the lower Santa Ana cañon.

The San Bernardino valley proper occupies the extreme eastern and northeastern end of this great valley taken as a whole. Hemmed in on the north by the most abrupt portion of the very abrupt Sierra Madre, overshadowed on the east by the towering peaks of San Bernardino and Grayback, closed in on the south by a high range of hills, extending southwesterly from the foot of the San Bernardino mountains to that of the Coast Range, this San Bernardino valley is open only to the west, and in that direction it is still overlooked by the somewhat abrupt rising edge of the Cucamonga plain.

This valley is a basin filled with a vast alluvial deposit of comparatively recent geological placing. Coming into it from the northwest, at its extreme northwest end, is the Cajon pass. Coming into it at the southwest corner, from the San Gorgonio pass, and by a northwesterly course, is the San Timoteo cañon. Entering at its extreme eastern end, crossing it, and emerging at its southwest corner, is the Santa Ana river. While dropping to its edge on two sides are many cañons, which bring down great winter torrents, and hold their little perennial streams throughout the year. It is the best watered valley in Southern California, and one of the most inviting in appearance. In area, it is about one hundred square miles, of which about twenty square miles are within the known limits of an artesian water-producing basin, which occupies its lowest lands, just above the outlet on the course of the Santa Ana river.

The Riverside Mesa and Jurupa Valley and Plain.

The plain occupying the southern and southeastern portions of the greater San Bernardino valley, the scene of the well known Riverside irrigations, is herein referred to as the Riverside mesa

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plain. Heading at the southwest corner of San Bernardino basin, in a bluff fifty to two hundred feet in height, this long, narrow plain extends southwesterly a length of about eighteen miles, to the Temescal wash, which skirts a somewhat similar mesa at the foot of the northern slope of the Coast Range. For about half its length it occupies the space between the Santa Ana river on the west and the cross range of hills on the east; and has an extreme width of about three miles. For the lower half of its length it lies between the eastern hill range and an outlying group of hills which stand south of the Santa Ana river where it has taken on a western course towards the Rincon region; and in this half of its length the Riverside plain has an extreme width not exceeding two miles.

The Santa Ana river, after its departure from the San Bernardino basin, courses through a low, narrow, bottom-land formation between the edges of the northern and southern mesa plains. The Jurupa bottoms lying immediately west of Riverside, and extending from Slover mountain pass, the outlet of San Bernardino basin, to the Narrows, a distance of about eight miles, is the notable feature, and then there are narrow fringes of low land on each side of the river, on to the Rincon basin.

The Jurupa plain is a mesa-like formation, closely resembling that of the Riverside, and lying immediately across the river from it. On the north it is shut in from the great Cucamonga plain by an intermediate range of hills. Indeed, the Jurupa plain proper bears the character of an irregular mesa at the southern foot of and lying between disconnected masses of this hill formation.

The Cucamonga Plain and the Rincon.

Between the Jurupa hills and the foot of the main range of mountains lies the Cucamonga plain; at this point with a width of about nine miles, and then extending westerly twenty miles. In general character, it is a vast, steeply-sloping deposit of alluvial washings, apparently brought off the mountain face by its torrents and spread out by the shifting waters. Beyond the western point of the Jurupa hills, it slopes away to the lower basin of the great San Bernardino valley, which is known by the general term of the Rincon; and here it attains a width, including the lower plain, of about fifteen miles.

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The Rincon region occupies the southwestern corner of the great San Bernardino valley. West of it lies the Coast Range. Sloping to it from the north is the Cucamonga plain; entering it from the east is the Santa Ana river, and from the southeast the Temescal wash. Bordering it on the south is what is known as the South Riverside mesa, and it is closed in on that quarter by the Coast Range, through which in a southwesterly direction, by a deep cañon, the Santa Ana river escapes towards the sea.

Such, in general outline, is the notable irrigation region, with its surroundings, of San Bernardino county.

SECTION II.

Rainfall and Arterial Drainage.

The influence upon rainfall by an intercepting mountain range could hardly be more distinctly marked than it is in this case. Rain-clouds drifting inland from south and southwest seas are interrupted in their flight by the Sierra Madre, and robbed of their moisture. There is no such gradation in rainfall here—increasing with distance from the coast and increase of altitude—as has been spoken of for San Diego county. The crest line of the Sierra Madre immediately north of the San Bernardino valley is about fifty-five miles from the ocean shore, and intermediate, nearly half way from the coast, lies the Coast Range. This range, in a measure, first holds the clouds, and on its seaward face receives a very considerable downpour. Then comes the valley of San Bernardino across which these clouds move, giving down but a small amount of their moisture, until coming up against the Sierra Madre, they not unfrequently precipitate very great rains, and cover the crest deeply with snow.

Rainfall in the middle of the valley, the records show, may be but six to eight inches for a season, when, against the base of the mountain from five to ten miles away, there will be 80 to 100 per cent more precipitation; and on the mountain's face near the top, 200 to 300 per cent more. In the season of 1883–84 there was the equivalent of about one hundred inches of rainfall in Bear valley, at an elevation of six thousand feet, four miles north of San Bernardino peak, while in the San Bernardino valley there were only

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eighteen to twenty-three inches. It is a known fact that along the upper edge of the plain—at Highlands, near the extreme eastern end of the valley, at Etiwanda farther west, and other places, where observations have been made—the rainfall is about double that which is found on the plains but a few miles away. And so, precipitation is not here affected so much by altitude as by the presence of the wall-like mass of mountains which obstructs the movements of the clouds, and holds them until they bank up to the point of releasing their vapors.

Speaking now only of that portion of the mountains within San Bernardino county: with the exception of the region lying on the sides of San Bernardino peak and Grayback, drained respectively by Mill creek and the Santa Ana river, and the region out of which comes Lytle creek, all of the mountain catchment areas are such as shed their waters with remarkable promptitude. The drain slopes are exceedingly steep, oftentimes, in the main cañons, even, two hundred to three hundred feet per mile; and on the southern face of the range, although in the cañons there is a wooded growth, those accumulations of vegetable molds and soils which are recognized as holding waters, and giving them out in the form of surface drainages, are limited in extent.

At some time in the geological history of this country, it has been subjected to an immensely greater rainfall than it receives at present; such that enormous torrents, comparatively speaking, have come out of these mountain cañons, and piled great masses of bowlders and gravels before them. The principal streams have built veritable ridges far out into the plain in front of their cañon mouths, which slope not only forward but sideways; and looking at the base of the mountain across the valley from south to north, one sees the profile of the plain as it rests against the mountain's base, with hills out upon which the streams come, and valleys in between. The heads of these ridges, next the cañons are, of course, composed of specially permeable detritus, which extends up into the cañons, filling the deep bedrock cuttings with masses of broken matter, ranging from sand grains up to rocks of many tons weight. Into such beds a large portion of the waters of these streams sink, and percolating through the interstices, and running through the openings in the debris, find entrance into the old channels of former streams in the permeable layers under the plain, long since closed over by layers of material less per-

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meable and which have become closely cemented. Such is the source of artesian waters which are found to rise in the bottoms of the basins throughout the country. The San Bernardino valley, or basin as we have called it, is a very well marked formation of this class. Again, the land at the foot of the great Cucamonga plain and resting against the Coast Range, which is herein called the Rincon basin, is another such formation.

Into the San Bernardino basin from the west a part of the waters of Lytle creek find passage through gravels which it has deposited in channels here and there at different periods in its existence, and which are more or less permeable. A large part of those of the Cajon pass stream sink farther up, and find their lodgment also in the artesian strata of this basin. From the east the Santa Ana river comes through a wide cañon, filled, no one knows how deep, with such debris; and a share of its waters contribute also by this means to the artesian supply. While the streams like City creek, Twin creeks, Devil's cañon, and others, which come to the valley at its northern edge, seldom ever course beyond a few hundred yards into the plain, and there sink to the same great receptacle—the subterranean gravel-filled channels.

The artesian basin of the Rincon and Chino is fed by the sinking waters of San Antonio, Cucamonga, and other cañons which run into the upper edge of the Cucamonga plain ten miles or more away, and one thousand feet higher. While the uprising of waters in the neighborhood of Pomona is but their liberation from some old channels and beds of San Antonio creek on their way down under the plain towards the Rincon.

The arterial drainage of this whole country is one everywhere complicated by the artesian feature thus outlined. The Santa Ana river sinks and rises, and sinks again rapidly in its course, and receives tributaries underground, so that it would be difficult to identify waters rising below with those which have sunk at any specified locality above. It is the main drainage way of all this country, however, and the entire arterial drainage output of the great San Bernardino valley, speaking now of the whole region which has just been described, and not of San Bernardino basin alone, is probably by way of the Santa Ana cañon above or beneath its sands, through the Coast Range.

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SECTION III.

Rivers and Streams.

The Santa Ana River.

As already remarked, the Santa Ana river is the main arterial drain of the irrigable region of San Bernardino county, and it is, as well, its chief irrigation feeder. It heads on the north side of the easternmost spur of Grayback mountain, and flows westerly in the high mountain valley, from four thousand to five thousand feet in elevation, lying north of and parallel to the ridge of which Grayback and Mount San Bernardino are the points, for a distance of about fourteen miles, not counting the windings of the stream. Then plunging through a deep, rocky, and tortuous gorge about ten miles farther, it comes out at the eastern end of San Bernardino valley, at an elevation of about one thousand eight hundred and ninety feet, in a wide, open cañon filled with the heaviest debris, resting on grades exceeding one hundred and fifty feet to the mile. Then it runs a little south of west a distance of about fourteen miles, into and across the San Bernardino basin to the pass between Slover mountain and the head of the Riverside mesa, on grade slopes gradually lessening to thirty feet in the mile. Then still more southwesterly on somewhat lesser grades, and through a series of small bottom-land valleys, with the Riverside mesa on the south and the Jurupa mesa and then the foot of the Cucamonga plain on the north and west, to and through the Rincon basin, a further distance of about thirty-four miles in a straight line, to the head of its cañon through the Coast Range, wherein it passes out of San Bernardino county. In general terms, it lies lengthwise through San Bernardino valley taken as a whole, within two to six miles of its southern edge, and from six to sixteen miles from the base of the mountains on the north. All other streams of this basin are its tributaries either above or below ground, and the river itself has a subterranean as well as a surface existence.

The visible Santa Ana river through this valley, with its perennial flowing over a greater portion of the course, is no more all the Santa Ana river there is, than are the nearly-always-dry beds, or washes in the plain, of many of the north and south cañon streams, all there is in each instance of these; and so, while this river loses

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and regains its waters, and acquires other waters on its course, the streams which come laterally into the valley, and are so promptly lost along its edge (through some hidden channels, though much spread out, perhaps, and divided in the underground formation), pass on down the slopes and mingle with those of the subterranean flowings of the Santa Ana, arriving after all at the common outlet of the Lower Santa Ana cañon.

The Santa Ana has an independent mountain drainage area of about two hundred and twenty-three square miles, with the highest mountains in the range flanking it on the south, and almost the next highest ridge bordering it on the north; and, taken all in all, the forest growth in this upper basin is, perhaps, the most dense found in any portion of the Sierra Madre. In both extent and character of drainage area it stands first in its promise of volume and steadiness of flow in supplying irrigation waters—a promise which is fairly well fulfilled.

Because of its excessive grades and low banks through the valley the diversion of its waters are easily accomplished, but on account of the unstable nature of its bed and the violence of its floods the problem of constructing permanent works for controlling such diversion is a difficult one. In its course through the valley it will be further spoken of, with descriptions of local districts and works, and in a later chapter on the subject of water-supply.

Mill Creek.

Mill creek drains the southern face of Grayback and San Bernardino peak, and there is quite a high ridge lying south of it, also; which gives it a water-shed, in character second only to the Santa Ana, whose extent is about fifty-eight square miles, and sufficient to afford it a volume of flow next to that river. Coming out of the mountains about two miles south of the point of opening of the Santa Ana, into a broad, very steep-sloping side valley, its flood escape-way turns to the right, and joins the main river bed about three miles below its cañon mouth. This stream enjoys the distinction of having been the first to yield its waters for irrigation purposes in this valley; and the ditch dug from it for use at a mission station early in the century, had by the time recent occupation made it important, so far assumed the character of a natural channel that it was claimed as such until by extensive litigation it was proven not to be so.

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San Timoteo or San Gorgonio Creek.

The San Timoteo or San Gorgonio creek drains the southern side of the range which stands south of Mill creek, and all of the country down to the mountains that border the San Jacinto valley on the north. While this area is quite an extended water-shed, its character and that of the outlet is such as to render it of much less importance as an irrigation feeder. The clouds appear to have dropped, and been temporarily shorn of their moisture on the ridge southwest of it, and do not gather for another effort, as it were, until they have passed into the Mill creek water-shed, and against the higher mountains of the Santa Ana. Moreover, the San Timoteo water-shed is far more destitute of forest growth and other vegetation than those of Mill creek and the Santa Ana, and of a more evaporative character. The lower portions of the cañon itself filled with deep beds of sand, the stream rarely runs in considerable volume at its entrance into San Bernardino valley, except for short periods after heavy storms. Notwithstanding the fact, therefore, that the San Timoteo has a water-shed about one hundred and fifty square miles in area, it is of but little importance as an irrigation feeder at its outlet to the valley. Some of its tributaries yield useful little streams, and its waters are diverted for local irrigation in the valleys and on the mesas within its own water-shed.

The cañons which come into the San Bernardino valley from the hills which lie between the San Timoteo at the foot of the San Bernardino mountain on the north, and the Temescal which lies at the northern foot of the Coast Range on the south, are of little or no importance as irrigation feeders, although they drain a country whose aggregate area is about one hundred and thirty square miles. They are mere stream washes, of low drainage areas, having no perennial flow except perhaps in some little springs which may be of value to their individual owners.

The Temescal Creek.

The Temescal wash has a drainage area, which, had it a different exposure, would make it quite an important stream, but its high ridge lies south of it, so that storm clouds, ordinarily, have condensed their loosely held vapors over the areas of the coast-flowing streams before they come over that of the Temescal. The

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direct drainage area of the Temescal is about ninety-two square miles in extent, and is not a timbered one. It is claimed, however, to have some feeding from other water-sheds by subterranean percolations, and possibly thus receives an addition to its summer waters from Lake Elsinore, which lies on the plateau above, and has a shed, as already described, in the distant San Jacinto mountains, as well as the nearer Coast Range. The flood waters of the lake flow over into the Temescal, but by no means each year.

City Creek.

City creek is the principal irrigation feeder on the north side of the valley coming from the mountains, and about five miles west of the Santa Ana river, and it is the largest of its class which enters the San Bernardino basin. Its drainage area is about twenty-four square miles in extent, and is exceedingly precipitous—for the creek falls about four thousand feet in eight miles. In form, this water-shed is only two miles in width in its lower course, but, about half way up, the main channel receives two branches, which opening out, give the upper portion of the shed a fan-shaped form. Receiving very heavy falls of rain upon its uppermost portion, it is subjected occasionally to great and sudden floods; and its waters annually run through and join the Santa Ana in a surface current. During the flood of 1861–62, this creek cut a new channel parallel with the Santa Ana river, and about two miles therefrom, on the average, lengthwise through the valley, making a joining with Warm creek on the eastern edge of the town of San Bernardino. This channel is now known as City Creek wash; and its ditches are referred to as the Lower City Creek ditches.

Twin Creeks.

Next in position westerly, as well as in importance in this little group of streams, come the Twin creeks, which bring their waters to the head of the plain on the north side of San Bernardino basin, about five miles northwest of the opening of City Creek cañon. These two little streams, draining an area, measured along the crest of the mountains, about four miles in length, and embracing altogether about eighteen square miles, reach the valley close alongside of each other, and have been named in accordance with this circumstance. In years of extraordinary rainfall they are subject to considerable floods, which cause their waters

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to run down far on the plain, and even through to Warm creek without sinking; but except at extraordinary times, their flood flow seldom reaches more than a mile or two out into the valley. As is the case with streams generally of this class, which do not habitually run through to the main drain, the Twin creeks have piled up a fan-shaped dump or hill of debris in front of their cañon mouths; and looked at squarely in front from across the valley, they appear to debouch upon the top of a ridge; indeed such is the fact, for their waters alternately, at succeeding periods, turn first to the right and then to the left, and again occupy a medium channel. As irrigation feeders they are of secondary importance, for their combined flow at a period of low water, although greater in proportion to their drainage area than City creek, is quite limited.

Devil's Cañon.

Four miles west of City creek, Devil's cañon comes to the plain in a manner quite similar to that described for the Twin creeks. Its dump is not quite so large, because its drainage area is less. The extent of its mountain basin is about eight square miles, and with a length of three or four miles, it falls from an altitude of about five thousand feet to one thousand eight hundred feet of elevation.

West of Devil's cañon for about eight miles, the water-shed on the southern side of the mountains is not more than two and one half miles in depth, and is drained by quite a number of little cañons of no public importance.

Cajon Pass Creek.

We next come to Cajon Pass creek, with its feeder the Swartout cañon, which, from the extent of its drainage area should present a very good irrigation stream; but as a matter of fact, it does not do so, and for the simple reason that its water-shed is situated behind the higher Cucamonga range that intercepts and holds precipitation that Cajon creek would otherwise receive. Cajon creek comes to the western end of the San Bernardino basin diagonally from the northwest, and except in years of great rainfall, when it turns a point of mountain adjoining Lytle creek, it seldom flows farther than the upper edge of the great plain. Its drainage area is sixty-two square miles, of which the Swartout must be accredited with nearly one third.

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Lytle Creek.

Lytle creek is the only stream which enters the San Bernardino basin on the north side, that does not receive waters from the San Bernardino mountains. The northern fork of this stream drains off the eastern side of Old Baldy peak, about fifteen miles northwest in a straight line from its cañon opening; while the middle fork drains off the northern, and the south fork drains off the eastern face of Cucamonga peak; and they all join at a point about five miles in a straight line from the cañon mouth. In area, the water shed is about fifty-five square miles, and of good character for the production of water-supply as compared to many others in this range of mountains, but the fact that it has a north and east exposure, rather than a south and west exposure, tends to detract from it in the matter of extent of precipitation, for reasons already offered. Nevertheless, the stream must rank third as an irrigation feeder in San Bernardino county.

Cucamonga, Days, and other Cañons.

For a distance of fourteen miles from the opening of Lytle Creek cañon, the water-shed of the southern face of the Cucamonga mountains is very narrow. The Cucamonga peak stands back about four and one half miles from its base, at the head of the plain, and with that exception the distance from the foot of the slope back to the crest does not anywhere exceed three miles, so that all of the cañons coming out along this face are of small drainage areas. One of the principal of these is Days cañon, which drains off the southeast face of Cucamonga peak, and being joined by Youngs cañon, with a total catchment of about six square miles, debouches at the head of the plain, about seven miles west of Lytle creek. This cañon has built a remarkably large dump in front of it, such as has been heretofore referred to. Its irrigation supply is large for its drainage area, accounted for by the fact of its having the best exposure to receive the storm clouds, and by the high altitude of Cucamonga peak, which it drains.

Cucamonga cañon comes from the mountains, about six miles west of Days cañon, draining the southwestern and western slope of Cucamonga peak. It has a catchment of about seven square miles, and for reasons applying to Days cañon, the Cucamonga cañon has a water-supply out of proportion to the extent of its drainage area.

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The cañons of any importance, named in their order, commencing from the east, and each of which brings its little irrigation feeder to the head of the plain, are Bozemans, Sansevains, Deer (which is the most important of this smaller group), Youngs or Garcias, Days, Alder, Coon, Sycamore, Water, Horseshoe, and then the Cucamonga cañon itself.

San Antonio Cañon.

Except Lytle creek, which lies back of the entire ridge, the most important of the drains from the Cucamonga mountains is San Antonio creek, which takes its waters on the western end of the Cucamonga range, and the southern face of Old Baldy mountain, and has a catchment area of 24.6 square miles, surrounded on three sides by high mountain ridges. Its exposure, also, is the most favorable to the receiving of storm clouds, being directly to the south, and the volume of its waters is consequently large. The upper portion of its cañons are very steep of grade, but the lower portions are on moderate gradients, it having more the character of a creek than a steep mountain cañon, such as are the most of its fellows. This creek has built up the largest of all the great masses of debris, which have been referred to as "dumps" at the mouths of the mountain cañons. Its waters, except in years of considerable flood, seldom run more than six or eight miles down its wash into the plains, but there is a continuous channel of considerable dimensions extending all the way across the plain, a distance of fifteen miles, joining the Santa Ana river near the head of its lower cañon, which the San Antonio creek, in years of high flood, occupies in big volume. At low water periods, even before its supply was diverted for irrigation, this little stream seldom reached more than two or three miles out on the plain. West of San Antonio creek lies Los Angeles county.

Warm Creek.

The streams thus far described are those which each have an independent, mountain catchment area, and bringing waters down upon or to the margin of the valley, there, in most cases, lose them. Warm creek, on the contrary, has no mountainshed of its own. It rises in the northeastern part of the valley, about two miles north of the Santa Ana river, two miles west of the opening of City Creek cañon, and two miles south of the edge of the

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mountain; and on its course southwesterly a distance of about seven or eight miles to the Santa Ana river, near the lower portion of the San Bernardino basin, it continually receives accessions in volume from springs in its bed, and in arroyos or cienegas which join it. Warm creek is the reappearance of some of the lost waters of the cañon streams from City creek west to Cajon pass. Lytle creek joins it just below the town of San Bernardino, and they thence occupy one channel to the river, half a mile east of Colton. Owing to the fact that Warm creek waters, although rising in the bottom of a basin, command plains still beyond, this stream, from the constancy of its flow, is one of the most important irrigation feeders in San Bernardino county.

Rincon Mill Creek and Chino Creek.

These streams are of the same character as Warm creek. They are uprisings at lower points on the Cucamonga plain, of waters which have sunk at the cañon openings along its high northern edge, ten to fifteen miles away. Chino creek, rising opposite the opening of San Antonio cañon, skirts along the extreme southwestern edge of the alluvial deposit of the Cucamonga plain, next to the hardpan land of the Coast Range, in a southeasterly direction. Being joined by several little spring streams of similar character and by the Rincon Mill creek near its mouth, it joins the Santa Ana river but half a mile above its cañon through the Coast Range of mountains. Rincon Mill creek rises in the plain or basin of the Rincon about two miles from the Santa Ana river, and gathering waters from various cienegas, it joins Chino creek as above explained, after flowing about four miles in an independent channel. From the fact that the lands which the Chino and Rincon creeks command for irrigation being of a moist character, and cultivable without artificial watering, these streams possess comparatively little importance as irrigation feeders.

The Mojave River.

The northern face of the San Bernardino range of mountains is drained by the Mojave river, with its several branches which bring the waters into it from a slope of about twenty-six miles in length east and west, and comprising one hundred and twenty square miles. This is one of the largest drainage areas of good water-producing character in the county, but owing to the fact

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that it has a northern exposure the volume of its output is comparatively small. However, the Mojave is an irrigation feeder not to be overlooked, and one which may, in the course of years, show a very considerable importance. After leaving the mountains it flows away northerly to the great Mojave desert, irrigating in its course a series of small bottom-land patches, and finally losing itself in the sandy waste forty miles away.

SECTION IV.

Tillable and Irrigable Lands: Soils.

The lands of the San Bernardino valley may be classed, and, in general terms, described as follows: (1) The wet and marshy lands of the San Bernardino and Rincon artesian basins, and of the Chino; (2) the moist and semi-moist lands bordering the wet lands of the Rincon on the north, and bordering those of the San Bernardino on the north and east; (3) the moist bottom-lands bordering the Santa Ana river in its course through the Jurupa from the upper to the lower basin; (4) then, going to the other extreme, the bone-dry red mesa lands, which fringe the entire valley more or less completely; (5) the bowlder and cobble-filled alluvions, which form the ancient dumps of the cañon creeks, and which along the base of the main mountain range, to a great extent, take the place of the red mesa lands; (6) the intermediate plains—dry, sandy, frequently gravelly, and with broad "washes," in parts, but in others, with fine, light, rich, and deep soils.

The first two classes of lands are made moist by the uprising of artesian waters, and if properly cultivated from the beginning of planting, do not require irrigation except for vegetables, and except on some sandy ridges to force heavier production, as of alfalfa, for instance.

The river bottom-lands are made moist by percolation of river waters. These are irrigated only to force production of such crops as alfalfa and vegetables. They are irrigated for other crops also, but often needlessly so had there been proper cultivation from the beginning of their orchard or vineyard growths.

The red mesa lands will produce nothing without irrigation; though when carefully cultivated and judiciously irrigated from

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the commencement of cultivation, quite often the small amount of water that is required to keep them moist is astonishing. This, however, is an exceedingly variable quality—with the particular gradation of soil in each case.

The old alluvions, with the "dumps," until quite recently, have been credited with value only for their crops of rocks—good for lining ditches, when one of the more recent "washes" was not sufficiently near to allow of draft on its mass of bowlders and cobbles. But, it has now been found that, cleared of rocks, which is done in building houses, barns, and fences, these lands are cultivable, productive, and fairly well suited to management by irrigation.

The intermediate plain lands are most variable. Thin soils, with a mass of gravel, cobbles, and bowlders within a foot or two of the surface, occupy considerable areas. This is the poorest kind of land and least well adapted to irrigation. Even-surfaced lands without a wash or break, with deep deposits of mellow and absorptive soils, are found in large bodies. These are the best lands for irrigation. And lands whose soils and sub-soils and surface are of every possible intermediate grade between these extremes, are of course to be found; and besides these there is a considerable area on the Cucamonga plain, that may be best described as drifting sand-land.

In the wet lands are found black, stiff adobe, and black, cienega soil (filled with vegetable matter); and these are mixed in all proportions with light alluvions, and in some places they are alkaline. The moist lands next the wet lands are generally fine grained, light brown, or ashen brown loams. The mesa land soils are the fine "red mesa clay" in places nearly pure, but generally mixed in every conceivable proportion, with coarser granitic washings, and sometimes carrying large proportions of gravel and cobble-like bowlders, but nothing like as much as in San Diego county; for the red mesa lands of San Bernardino county, as compared to those of San Diego, are remarkably free from these. As a general thing the soils trace back to granite as a predominating mother rock.

There are no extensive deposits of adobe, except one in a lower part of the Riverside plain, one on the opposite side of the river in the Jurupa rancho, and some in the low lands of the Rincon, and the San Bernardino basins. The ordinary marly-hardpan lands and thin lands on bedrock are unknown. But there are

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thin lands on bowlder and cobble deposits, and, in parts of the Riverside mesa, on a dark clay hardpan.

There are no large areas of level land. Even the surfaces of the basin lands have slopes between twenty and thirty feet to the mile down to their outlets; and the plains have gradients up towards the mountains, which are astonishing when they come to be realized. The bottom lands of the San Bernardino basin are at about nine hundred and fifty feet of elevation above the sea. The general margin of the plain next the mountain, eight to ten miles away, holds closely to the one thousand eight hundred or one thousand nine hundred-foot contour of elevation. With these great slopes in the ground's surface, ranging from thirty to one hundred and twenty feet to the mile, irrigation by "checks," as on the flat plain of the San Joaquin, is of course out of the question.

A great range exists in the matter of ground-waters. On the mesa formations ground-water is seldom found at less than fifty feet from the surface, more often it is seventy-five, frequently one hundred. In the basins ground-water is within a few feet of the surface; sometimes to be found within a spade's turning. On the high alluvial plain its relation to the surface is not governed by elevation above the basins. In some streaks or ranges down the plain it is found within thirty to forty feet of the top; in other places of equal elevation a mile or two away it may be one hundred feet down.

Such are some of the leading characteristics of the irrigable and tillable lands of San Bernardino.

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CHAPTER VII.—SAN BERNARDINO[2]; WORKS AND PROJECTS[3].

SANTA ANA RIVER WORKS.

THE GROUPING OF WORKS AND PROJECTS. CAÑON GROUP[1].

SECTION I.—*North Fork Canal:*
- Highlands and the North Side Region;
- The Canal Work;
- Operation and Maintenance;
- Water-supply and Use;
- History of Work and Water-right.

SECTION II.—*South Fork Canal:*
- Lugonia and the South Side Region;
- The Headworks and Canals;
- Distribution and Management;
- Water-supply and Use;
- History of the Work and Water-right.

SECTION III.—*Redlands and the Judson & Brown Canals:*
- Redlands and other Mesa Settlements;
- The Old Redlands Canal;
- The Judson & Brown Canal;
- Distribution and Management;
- History of Works and Water-right.

SECTION IV.—*Bear Valley Water Company's Works:*
- The Bear Valley Storage Reservoir;
- The Delivery Works;
- History of Project and Operations.

INTRODUCTION: THE GROUPING OF WORKS.

The irrigation works of San Bernardino county, clustered around the Santa Ana river as the chief water-source, will be best understood when described in groups more or less distinctly marked by the characteristics of their water-supply, as these are governed by

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the physical peculiarities of that river, and by the position of the other supplying streams. As already described, the rivers and creeks which come from the mountains, throughout all ordinary irrigation seasons, lose their waters into the gravels of the valley and great plain almost immediately after departure from their several rock-walled cañons, and then the main stream at various points below is started up and added to by rising waters, either along and in its own bed, or those of tributaries springing wholly within the valley basins.

Because of a peculiar interdependence of water-supplies, remarkable differences of elevation within short distances in the irrigable plains, the development of apparently new waters from time to time, and other causes, there is a complication of works in this region, which at first seems to defeat attempt at orderly and systematic description of them. Waters taken from sources north of the river, and within the main basin, are carried over it and out onto the plain of another sub-valley. Waters taken from the south side are brought across the river, in reverse direction, to lands on a lower plain on the north or west side of the stream. The river is repeatedly along its course drained of all its waters, only to receive additional supply from some rising source, to furnish new works. And works from one source boldly carry their waters into districts served by waters from some other source; and, in some cases, mingle them before distribution is effected. Looking broadly at the subject, however, we find a clue to systematization, which is followed in the grouping now presented.

First considering the main stream and the tributaries which reach it the year round—notably Warm creek and Rincon Mill creek—we find:

(1) Several irrigation works diverting from the river at the cañon mouth—before its waters are lost in the gravels of the valley; and these may be called the "Santa Ana Cañon Group;"

(2) A large number of works deriving waters from the main stream or its immediate tributaries after these have risen in the San Bernardino basin; which are properly designated as the "Basin Diversion Group;" and are best considered in sub-groups as hereinafter arranged;

(3) A number of works diverting from the river in the valley next below San Bernardino basin, and which, after the place itself, we call the "Jurupa Valley Group;"

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(4) Those diverting from the stream in its course through the lower valley basin of the country, and which, also, from the local name, we may call the "Rincon Group."

Then—considering the mountain tributaries of the river, and other cañon streams—there are the works which, from the position of their water-sources, are grouped as—

(5) The "South Cañons Group," which divert from cañon streams entering San Bernardino valley on the south side;

(6) Those which, deriving their waters from north side cañon sources entering the valley, are classed as the "North Cañons Group;"

(7) Those deriving their waters from cañons coming out of the mountains west of San Bernardino basin, and which, from their position of delivery, are herein called the "Cucamonga Plains Group."

Finally, to still further facilitate reference to these canals in the course of this report, I shall describe the first, second, third, and fourth groups under a general heading of "Santa Ana River Works;" and the works of the fifth and sixth groups under the general heading of "San Bernardino Valley Works."

Not all of the works classed as Santa Ana River works derive their supplies from the Santa Ana river, but all take their waters either from that river, or from some rising source which feeds, or would if not diverted, feed it.

Not all of the works classed as San Bernardino Valley works are to be found in that valley proper; as, for instance, the works of Temescal wash. These two facts must be borne in mind by those who may turn the pages of this report. Almost all of the South Cañons group, and of the North Cañons group are in San Bernardino valley; and, therefore, it is convenient to thus refer to them.

The Cucamonga Plains group has a name sufficiently distinctive of location; and the works of which are not referred to as of any other grouping.

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SECTION I.

Highlands and Other North Side Irrigations.

The District and Work—The Canal Work and Route: Highlands and the North Side Region; The Diversion and Headworks; The Canal, Route, and Location; The Construction as a Work; The Cost of the Work, etc.; Summarized Data. *Distribution and Management:* Apportionment to Stockholders; Maintenance of Works and Cost of Irrigation; Organization and Administration; Distributing Works; Summary. *Water-supply and Use:* Diversion for Past Eight Years; Extent of Irrigation; Exhibit; Contract with the Bear Valley Company.

History of Work and Water-right—Old Ditches and Claims: The Original Santa Ana River Ditches; The Cram-Van Lueven and North Fork Ditches; The High-grade, Bench-land Canal. *Recent Organization and Present Status:* The North Fork Water Company; Value of the Property; Ownership of the Property; Individual Water-rights.

The North Fork Canal.

District and Work:—Taking its waters from Santa Ana river within the mouth of the cañon, at the head of San Bernardino valley, the canal of the North Fork Water Company is one of the uppermost works of diversion from this important irrigation stream. Moreover, owing to the very rugged character of the hills along whose base the canal courses, making it difficult and very expensive to construct on a materially higher grade-line, and to the fact that a water-supply is not likely to be available for another work, and to the further fact that there is not a sufficient area of irrigable land above the North Fork grade-line to justify such an additional construction, it is likely to retain for all time this commanding rank in relative position on the stream.

This ditch and water-right presents one of the most marked of those curious instances of the evolution of an important irrigation property by gradual and progressive stages from very insignificant beginnings, in which the development of irrigation in California is so replete. Commenced as an insignificant, rough, little earthen farm ditch for irrigation on the lower plain between Warm creek and the river, by half a dozen poor and needy newly arrived immigrants in the early months of 1858, at a position seven miles below its present point of diversion, this ditch has been extended, its point of intake changed, the location of its irrigations shifted, and their area enlarged, and the character of its construction im-

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proved upon, until we now find it quite a permanently made and commandingly placed structure and notable irrigation property.

Owing to the comparatively settled status of its water-right and higher degree of certainty of its water-supply, it may properly be ranked above some other works of more pretention and extent, and thus be placed at this time second only to the Riverside system, in degree of importance among the canal works of San Bernardino county. Located close along the base of the rugged hills, across low points of mesa and intervening cañons and creeks, and then out upon the upper edge of the high sloping plain in the north-eastern portion of the valley, it commands for irrigation the gore between the north bank of Santa Ana river wash and the mountain's edge, where are the clusters of settlements known under the general name of Highlands, and the Harlem plains, below; and by extension might be made to supply a region far westward towards the Cajon pass, behind the city of San Bernardino, and even out upon the Cucamonga plain.

CANAL AND STRUCTURES:—The Santa Ana river comes from its mountain course into the valley of San Bernardino, through a cañon about one thousand feet wide at the extreme points of its opening, and gradually diminishing to half that width at half to three quarters of a mile above. Flanked by precipitous and rugged mountain sides bare of any vegetation, this portion of the cañon is filled in with a vast bed of bowlders, cobbles, gravel, and sand, with small accumulations of earth in patches here and there, through which wind, on gradients of one hundred and fifty to one hundred and seventy-five feet per mile, several low-water and ordinary flood channels of the stream. In extraordinary floods, the waters sweep the wash from cliff to cliff.

At a point something less than half a mile above the extreme lower end of the gorge, one of these low-water channels courses along the base of the northwestern mountain side; then runs away towards the middle of the cañon, and returns to the northwest side again about half way down to the cañon's mouth. At the upper point spoken of is placed a weir, where the waters are divided between the North Fork and South Fork canals—the generally acknowledged claimants of all the low-water flow at that point. At the lower place, where the water comes against a sharp rocky point protruding into the bed of the stream, the North Fork canal proper has its head.

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Headworks and Diversion:—Here the low-water channel of the river is about thirty feet in width, and running almost square against the point, is deflected off at an angle of about 45 degrees from its general course. Through this point of rocks, at a level nearly equal to that of the bed of the stream, a tunnel has been driven, about four feet by six feet in sectional area, and about thirty-five feet in length. At the head or upper end of this tunnel is a sliding regulator gate. Crossing the low-water channel, just below the opening of the tunnel, is a low, rock dam, which holds the water at about an even elevation against the head-gate—the surplus, if any, flowing over and going down the stream.

Canal Location:—I. From the lower end of the tunnel, and hugging close in to the mountain side, the North Fork canal is built. The channel is excavated in the gravel and bowlder bed of the cañon, and then paved with small bowlders on sides and bottom, and cemented as hereafter described. At the lower end of this section of the work, about three hundred feet below the extreme headworks, is built a regulator and waste-way, all of rock masonry in cement mortar.

II. Below this regulator and escape way, the little canal, for about ten thousand feet, hugs close to the foot of the mountain. Following a tortuous course to avoid rugged points and depressions, it is built upon the gravelly and rocky plain, which, sloping away at rates between one hundred and fifty and two hundred feet of fall per mile, as a vast water-spread "dump" in front of the cañon, slopes sideways also around the mountain base. Although as a general thing adjusted in declination to the varied inclinations of this plain, as well as in position to the mountain's footing—on grades between 3 and 5 per cent (but with local extremes of 2 per cent and 16 per cent) and curves as small in radius as forty or fifty feet—at a number of locations, to avoid greater extremes or lessen the frequency of variations from the normal fall of the country, the canal cuts into and along the rugged mountain slopes or through deep points of detritus lodged against them. The route here follows somewhat nearly that of the original Cram ditch taken out in 1859, and as remodeled and paved in 1883, but as now seen it is an entirely new construction, relocated, reëxcavated, enlarged, and repaved during the winter of 1887–88.

III. There is next presented a division of the work nearly a mile in length for the most part located above the plain, along the

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face of a very steep and winding bluff—following around its points and into its ravines with sharp curves and reversals—upon a general grade of 1.6 per cent. In this division the waters are led away from the location of the original ditch (which followed the mountain foot below), and are caused to "climb," as it were, back upon the first low spurs of bench-lands, overlooking the valley. The original earthwork of the new ditch in this section was constructed in the winter of 1881–82 and paved and cemented in 1884, but in the winter of 1887–88 the inside wall was taken out and the excavation very materially enlarged, the bank raised, and the whole structure repaved and recemented where necessary.

IV. Crossing Plunge creek in a flume about four hundred and fifty feet in length and with thirty feet of elevation, the next division of the work—about three thousand seven hundred and fifty feet in length—is located well up against a steep and rugged hillside, upon grades of 2.4 to 3.2 per cent, until, turning sharply about a point, it comes out on the high sloping mesa, and suddenly arrives at the upper end of its zone of irrigation. The ditch was dug through this division in 1881–82, and was thereafter used as an earthen channel up to the fall of 1887. Before paving and cementing it during the past winter, however, it was set further into the hillside—practically, redug.

V. Thus entered upon the bench-lands, the alignment of the work is in much more gentle curves, with intervening, long, straight parts, and a nearly uniform gradient of 2.4 per cent, over good ground for construction, for a distance of about half a mile, to the "Cram Divide," where the waters of the Cram-Van Lueven division of ownership are parted out into a branch that plunges headlong down the mesa's face to the plain below, where were the irrigations for which the original ditch was built in 1859. Through this fourth division of the work an earthen ditch was dug in 1881–82, and used several years, but a wholly new excavation was made parallel to it in 1884–85, and paved and cemented in 1885–86.

VI. Below the "Cram Divide" the work enters a section where, for about a mile in length, right-of-way deeds have not been secured, and where the canal still remains an open, unpaved ditch, excavated in 1884–85. Through this division several flat mesa points are crossed, between which the work winds around the face of deep, steep-sided gulches. There are two or three

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heavy fills, two flumes about three hundred feet in length each, and, finally, having run on about the same ruling gradient of 2.4 per cent, the waters are led by a tunnel five hundred and fourteen feet in length, which is a recently constructed cut-off, on a considerably increased gradient, through a point of mesa and out beyond, again into a completed, paved canal. From the long tunnel mouth the work extends around the gently sloping face of a high mesa with several notable fills, and one long cutting, a distance of about seven eighths of a mile, to where it pierces the opposite rim of the table-land by a tunnel one hundred and sixty feet in length, and thence it drops down the bluff, by a masonry chute, to the head of the "Highland Vineyard" branch canal. The original earthen ditch was dug through this division in 1881, 1882, and 1883, and was partially paved in 1883–84, but the upper six hundred feet was remodeled and repaved in 1886–87, and the remainder in 1887–88.

VII. From the Highland Vineyard branch heading, the main work continues on an excessively heavy grade—being, indeed, a chute in character—around the head of a valley, and thence again on the lighter ruling gradient to the City creek crossing, which it makes by a low flume, several hundred feet in length.

VIII. From this point on, a distance of about a mile and a half, the work is, with the exception of a very short space, located upon excellent ground for construction to its end on the high sloping plain, a total distance of about eight miles from the headworks in Santa Ana cañon.

Canal Construction:—Throughout its length, this little channel is placed entirely in cutting—with no built-up banks to supplement the excavation in forming it, except where carried entirely in fills across depressions, which has been done only at places not easily avoided. Its waters are thus held with their surface plane below the natural level of the ground immediately adjacent, and its lining rests in a solid and unyielding bed. There has never been any engineering supervision or plan of construction on this work, neither has it been instrumentally aligned, for the most part, and its several divisions have been built from time to time and under auspices much varied.

Paring and Cementing:—The excavation having been made to a forming template, the lining work is done by building on either

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side a wall, about eight inches in thickness, of partially rounded small bowlders, which are for the most part granite. The bed is then paved with the same material set firmly. And then the interstices are filled and chinked, and the surface evened off nearly to the plane of the outer projections of the rocks, with a cement mortar forced in with a trowel. The bowlders are such as are in some instances found in the excavation work, but are generally hauled from adjacent torrent or creek channels, and are selected as having bedding surfaces sufficiently flat to make a stable wall, and with a good, even-planed face. The mortar for the sides is made of one part best Portland cement to four of good, coarse, and fine sand, and for the bottom the proportions are one to two and a half, and sometimes, on the surface, very materially richer. The men employed were all ordinary, unskilled laborers, paid at most times $1 50 per day, with board; and the foremen were generally local cultivators, who had attained some knowledge and experience in this line of work from building and "rocking" their own distributing branches of the main work.

The water-way in the tunnel is also thus paved and cemented, and in some instances, where through earth, the sides above the paving and the top are timbered and lagged. The flumes are of redwood—the planking being two-inch—and the newer ones very well put together. Altogether it is a class of work which has thus far stood, and probably will continue to stand well in this climate, where ground freezing and long, protracted, heavy rains are unknown. Where, as along the face of the higher bluffs is for some distance the case, the excavation is made through a conglomerate, or, in other places, a firmly cemented drift, the rock lining is dispensed with and the water-way is cemented immediately on the face of the cutting with a one to three, or four, cement mortar. Where the canal is carried in fill, as at limited localities is the case, the embankment has been given a year to settle and consolidate before the paving was done.

Cross-Drainage Ways:—Except at the creek and large ravine crossings, where flumes appear, and in some cases, where culverts have been provided under the fills, no provision has been made for cross-drainage. In the first two miles of the work the outpour routes of waters from a number of ravines or gorges in the adjacent mountain face are crossed; and at times these have brought torrents of water and masses of detritus into and over the canal.

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but without considerable damage to it or inconvenience other than occasioned by the labor of cleaning away the debris. Owing to the absence of well defined channels for these torrents, they would have to be carried over the canal in some super-passages, but because of their wandering nature, it is difficult to locate such passages so that they might not after one season be abandoned by the waters for some other location. It has thus far proven less expensive to meet and repair damages from occasional cross-washes than to attempt to train the course of these sporadic little torrents, and provide passages for them over the canal, or to build the canal up so as to be able to leave water-ways for them under it.

After leaving the lower plain traversed for the upper ten thousand feet, except where located in the conglomerate or the old drift deposits of bowlders and gravel, the material in which this channel is formed is a fine-grained and, for the most part, chocolate brown mesa soil, which rapidly melts away under running water; so that a break in the canal on steep, sidelong ground, soon results in a washout and considerable disaster to the work, and to cultivations below. Such accidents—owing to the working of gophers—were of frequent occurrence before the paving was done, and even now are a notable source of trouble.

The Work as a Structure:—The commendable points about the work as a construction are the excellence of the rock and cement lining, considering its little cost, and the success of the efforts at good alignment and true grading, made in the more recently constructed and remodeled parts of the channel, considering the conspicuous absence of nearly all professional guidance and supervision.

The notable deficiencies are the absence of structures for regulating, rating, and measuring the flow of water in the canal, and for releasing it into escape-ways at intervals sufficiently near together to prevent disaster in case of breakages, but most of all it is to be regretted that there has been no planning or introduction of partitioners or modules by means of which to part or apportion the waters at main branches, or measure them out in stated streams in distribution to customers. The opportunity to provide for these ratings, measurements, and partitionings of water by local adjustments of grade and sectional dimensions of water-way, and the introduction of overfalls therein was so good,

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because of the great excess of grade at command, that it is to be regretted that the chance to accomplish these much desired ends has been so far lost. Because of the construction of only a simple paved canal—however well formed and successful as a water conduit it may be—on the very heavy gradients found throughout in this structure—causing high velocity of current at all points—it will now be difficult and a delicate and comparatively expensive job to provide the means to control, measure, partition off, and distribute the waters, made requisite as well by the great value of the commodity as the necessities of the irrigators to be regularly and efficiently served with their due volumes at proper points.

The lessons to be derived from the development of the North Fork Canal Company's enterprise are especially found in this. Their importance to the irrigating public will be appreciated in geometrical proportion as years go by. Nevertheless, the work amongst irrigating structures of its class in California is a good one. Its commanding position, the probable high class and value of its irrigations, and the necessity for perfection in distributing from it will—notwithstanding the fact that it has in good part been twice constructed, and in some places three times built—bring about its remodeling, locally at least, and adjustment to a better service than it can now render. Maybe this will come about, in sufficient degree, gradually, guided by the rule of thumb process, which has thus far accomplished, at great expense to be sure, so much that is good on this work, and which has perhaps been made necessary by never knowing one year what the prospect was for the next. But it is to be hoped that the time may come when a really perfect little work may be constructed on well matured plans, in this state, before all such good opportunities and locations for them have been occupied.

Although in the newer portions of the work there has been an intention of adjusting the width of the water-way to the varying grade-slopes and obstructions in alignment, this has not been completely accomplished, and defects will doubtless become apparent when the canal comes to be taxed to its full desired capacity, namely, one thousand two hundred inches, or twenty-four cubic feet per second.

COST OF THE WORK:—Without counting the original ditch construction for the first two miles, which does not at all figure for

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the present work, the cost of the North Fork ditch previous to the incorporation of the company in the early part of 1885, had been well over $20,000, perhaps $25,000. Experience has shown that, as it stood, it could have been replaced at that time for $15,000. The company has since expended in remodeling, rebuilding, and relining it, together with some accessory works, such as drainage outlets, about $35,000, and expects to spend on the main work, independent of such other accessory structures, about $15,000 more.

Under contract with the Bear Valley Land and Water Company, hereinafter referred to, that organization pays one half the cost of rebuilding and completing the main canal as far as it was to be rebuilt, and has the use of it to one half its capacity for conducting its waters, to that extent, to lands beyond. And the Cram-Van Lueven association, under agreement, pay one third of the balance of the cost of the main work down to the Cram divide.

To the North Fork Water Company then, the cost of its work will have been:

Loss on original work, say		$5,000 00
Construction, original		15,000 00
Reconstruction, etc., to date	$35,000 00	
Construction, anticipated	15,000 00	½ 25,000 00
Total cost of work to N. F. ditch people		$45,000 00
Less Cram-Van Lueven proportion		7,500 00
Cost to N. F. Water Co.		$37,500 00

Other expenses, such as right of way, legal expenses, etc., will bring the total to something between $45,000 and $48,000 to the North Fork company, and to $77,500 to $80,000 for the cost to all concerned.

The cost of nine thousand nine hundred feet of new ditch at the head, together with head-works, etc., was about $10,000, the rates going from $10 to $30 per rod. One barrel of cement, costing $5 50, delivered, was used to each two rods of the work. One man's work laid six and one half linear feet of the rock paving, and cemented it, per day.

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Tabular Statement of Grades and Dimensions.

Division.	Approx. Length in Feet.	Grade.	Width in Feet.		
			Top.	Bottom.	Depth.
I. Tunnel to regulator	1,200	. . . .	6	4	2½
II. Along foot of mountain . .	9,700	6% to 8% 2% to 16%	4½	2½	2½
III. Along bluff to Plunge Creek .	5,000	1.6%	8	6	2½
IV. Along hillside to mesa . . .	3,750	2.4% 3.2%	6	4	2½
V. Across mesa to Cram Divide	2,600	2.4%	4½	2½	3½
VI. Through railroad section to tunnel	5,100	2.4%	5	3	3
VII. Lower Tunnel to City Creek .	4,900	. . . .	6	4	2½
VIII. Below City Creek	8,800	. . . .	4½	3	2

Highland Vineyard Company's Canal:—This work is practically a continuation of the North Fork canal. Taking water just below the heavy drop which is made in that canal by the tunnel through the mesa edge above City creek, it continues around the edge of the mountain's base on a higher grade line than the North Fork canal itself, and extends westward a distance of about two and one eighth miles. It crosses City creek and several other cross-channels by means of flumes. Its grade, at points, brings it up against the mountain side, so that it is cut into the face of the steep banks and tunnels through two heavy points. It is two and one half feet wide on the bottom, two and one half feet deep, and four and one half feet wide on top; is paved and cemented as in the case of the South Fork canal, and is so planned that the sides may be raised a foot or a foot and a quarter higher. The ruling grade is five feet four inches per mile, but there are long reaches at double that slope, and some short sections have five times as much grade.

As now constructed there are two tunnels on the line of the work. No. 1 is one thousand two hundred feet in length, and, for the most part, in hard rock. No. 2 is five hundred feet in length, and in conglomerate. Part of No. 1 and all of No. 2 is timbered. There are several flumes whose water-way is four feet wide by three feet in depth, and whose aggregate length is about three hundred and fifty feet. The ruling gradient of the flumes is 0.2 inches per rod, and a capacity for three thousand miner's inches is claimed for them.

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Operation and Maintenance:—The North Fork company distributes water only to its stockholders, in parts of its whole supply proportionate to each one's stockholding or ownership. So that the cost to the stockholder per annum will be his proportionate part of maintenance and administration. Before the canal was rebuilt, paved, and cemented, this cost used to range above two and even three dollars per year per acre irrigated. Now, the annual expense, including pay of secretary and superintendent, comes under $1,600, or 33⅓ cents per share per year, which would be about $1 60 per acre for the area of irrigation in 1888. Including the Cram-Van Leuven interest, the cost is less than, but say $2,000 per year, or $1 43 per acre.

The probable cost per miner's inch per season of irrigation is about $3 to $4. Irrigators apply this amount of water on as great or little area of land as they choose, for there are no water-rights attached to any lands, and each stockholder takes his water-supply from the main canal at any recognized point of distribution he may elect and arrange for. Up to 1882, the rotation period in distribution was ten days; then to 1887, inclusive, ten and one quarter days; and this season it is fifteen and one quarter days.

ORGANIZATION AND ADMINISTRATION:—There are constantly employed a secretary, superintendent, and ditch tender or *zanjero*, and during the irrigating season an assistant on the ditches is necessary. At the opening of the season a schedule for water distribution is made out and a time-table is prepared for each shareholder, naming the day, hour, and minute of commencement and ending, in each period of rotation, at which he is to commence taking and cease taking the flow of the canal. This constitutes his certificate of right to take water, and his guide in preparing to take it. He can use it on his own land or sell its use to others during any part or the whole of his time period. If he is a large cultivator, of whom there are a very few left in the organization, he can use all the stream; if he is a small cultivator he is forced to pool with his neighbors, for he cannot handle the full stream on his land. These pools are made up in advance of the season's schedule, and the time-tables are by request made out to the pools instead of to each individual; and so the irrigators are enabled to regulate among themselves in each pool for the receipt by each irrigator of a small, manageable stream of

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water for a much longer period than that for which any one would be entitled to the whole stream under the company schedule.

DISTRIBUTION:—The distribution works are built by the stockholders, or those who expect to get water from the stockholders; or, under the arrangement with the Bear Valley Company, doubtless it and its customers will, as is understood to be the case already, extend the canal as a leading distributary and build other small ditches or lay pipes for such purposes. The end of the main canal was fixed in the articles of incorporation, where now located, and cannot be changed, nor can any extensions or lateral ditches, except such as may be necessary for the disposal of waste waters, be constructed by the company, unless by unanimous consent of all the holders of the subscribed stock. All gates or distribution outlets along the main work are constructed by the corporation, at the expense of the stockholders whom they are designed to serve, and are thenceforth under the exclusive control of the officers of the company.

Water-supply and Use:—Referring to the table showing the mean low-water flow of the Santa Ana river at the cañon mouth, which is given in another chapter, it will be seen that the North Fork canal, taking half of the flow, had a supply available, during the years 1881 to 1885, inclusive, for the six irrigating months of each, as follows:

FOR THE MONTH OF—	During 1881.	During 1882.	During 1883.	During 1884.	During 1885.
	Inches.	Inches.	Inches.	Inches.	Inches.
June	550	540	570	9,250	850
July	300	423	450	1,550	681
August	350	494	320	1,150	599
September	408	470	322	900	539
October	512	500	420	900	564
November	553	542	535	1,000	580

Under contract with the Bear Valley Land and Water Company having a large stored supply in the mountains above, the North Fork Water Company, the outside owners in the old North Fork ditch and the Cram-Van Lueven branch of the total water-right ownership, are guaranteed, with certain saving clauses as to responsibility, a continuous supply of water as follows: June, five

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hundred miner's inches; July, six hundred; August, six hundred; September, five hundred; October, four hundred and fifty; and November, four hundred and fifty. And this is coupled with the privilege of drawing back in any one month of the first four, and taking the saving in any other month, but so as not to exceed two thousand two hundred and fifty inches in the four months, or six hundred in any one of them. For further explanations of the provision of this agreement, see the article on Bear Valley Land and Water Company.

IRRIGATION:—This North Fork ditch, inclusive of the Cram-Van Lueven division, was reported in 1879 to have about six hundred acres under irrigation. In 1881, it irrigated about seven hundred to eight hundred acres. In 1885, the acreage was one thousand one hundred and sixty acres. In 1888, the total irrigation is one thousand three hundred and eighty to one thousand four hundred acres. In the earlier years named the cultivation was largely of summer crops on lower lands. Now it is about as follows: Citrus orchard, four hundred acres; deciduous fruits, five hundred; vines, four hundred; summer crops, fifty; alfalfa, fifty.

History and Water-right:—The first ditch on the extreme upper Santa Ana river was taken out by Mormon settlers, at a point on the south side several miles east of the San Bernardino rancho line, and, coursing southwesterly, was used for irrigation of some large fields of grain, comprising two or three sections, north and northwest of Old San Bernardino. Originally this was quite a large ditch, and is believed to have been constructed in 1855. It subsequently came into possession of Judge H. M. Willis, who purchased the Bishop Tinney ranch, to which it was appurtenant, and so the ditch was known as the "Tinney Ditch." The next ditch was built and diversions made on the north side below the head of the Tinney ditch, but still some distance above the rancho line. This was known as the "Timber Ditch," from the fact of its bringing water down into the wooded country called the "Timber Settlement." It was constructed in 1857, by settlers not Mormons, and that year irrigated about fifty acres.

In the year 1857 these two ditches took all the water in the river which came to them during the irrigation season. The Tinney ditch was not used in 1858, owing to the breaking up of the Mormon settlements, and the sale of the Tinney property to

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Willis in the winter of 1857, and he not occupying the property until the fall of 1858. During that spring another ditch was taken out on the north side above the Timber ditch, but still below the Tinney ditch, which served water for the irrigation of about fifty acres, by settlers north of the Timber point, and toward the Warm Creek settlement. The owners of this ditch, presuming to have succeeded to the Tinney water-right, apparently supposed to have been abandoned, claimed half the water of the river during the irrigating season, and allowed the other half to flow down to the Timber ditch below. These two north side ditches, taking their waters from the same low water channel of the Santa Ana, and conducting them in common along the same old, natural flood channel, as part of their work, became known to some extent as the North Fork and South Fork ditches of the Santa Ana, respectively—the newer ditch being the northern prong, and the old Timber ditch the southern one.

When Judge Willis took possession of the Tinney property in 1858, finding the ditch in bad condition he repaired it, and during the irrigation season of 1859 attempted its use, but was interfered with by the settlers under the north side ditches, who repeatedly destroyed his work, and turned the waters of the river down the channel to the ditches below. Matters approaching a crisis in this controversy, Willis alone opposed to a number of settlers, and the principal witnesses as to the age of the Tinney ditch having left the country in the Mormon hegira, he consented to a compromise for the time being. To save the growing crops of the settlers on the north side, he consented to their taking all the water in the river for that season, while he took in lieu of his share thereof, for the season also, to save his crop on the Tinney place, the water to which one of the North Fork people was entitled, under another right, from the Mill Creek ditch. Willis then becoming interested in farming another tract farther up on the Mill Creek ditch, and under still another right appurtenant to it, ceased to maintain the Tinney ditch after that year, and the North Fork people thus virtually succeeded to its waters, although not to its priority of right thereto over the Timber ditch.

The Cram-Van Lueven Ditch, and North Fork Ditches:—In 1859, Messrs. Cram and Van Lueven, and others, diverted a part of the waters of the river at a point seven miles above and in the mouth of the cañon, for use in the upper portion of the valley, on the

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north side, just above City creek. This diversion interfered with the supply to the ditches below. A suit was brought, and an injunction on the Cram-Van Lueven ditch was issued. It appearing that the Cram and Van Lueven settlement was contemporaneous with the old North Fork settlement, namely, in 1857, and the ditch having been in construction during the year 1858, at the time the old North Fork ditch was being built, a compromise was effected, and, by agreement, judgment was entered for the defendant ditch owners on June 18, 1861, whereby they, Cram, Van Lueven, and others "do take into their ditch one sixth of the stream of the river Santa Ana, at the point where their said ditch is taken from said river." This left the North Fork ditch people with a claim to two thirds of one half of the stream—the Timber ditch taking the other half. This was the first suit for Santa Ana river waters brought in San Bernardino county.

Several years afterwards the North Fork ditch waters were run through the Cram-Van Lueven ditch, and the original North Fork ditch was abandoned at its head, but taking waters from the Cram-Van Lueven, and enlarging it, became virtually a part thereof. And this resulted in the upper portion of the Cram-Van Lueven ditch becoming known as the North Fork ditch. These old ditches, the Cram-Van Lueven and North Fork, were from time to time extended and new distributaries built, as irrigation increased and water-rights under them were divided and sold to the owners of other lands. In 1865, on the North Fork ditch, there were eight owners of water-rights, each claiming water for twenty-five acres, or a total of two hundred acres. In the same year, on the Cram ditch, there were four owners, irrigating in all about one hundred to one hundred and twenty-five acres. In 1878 there were twenty-one owners in the old North Fork, and still only four in the Cram-Van Lueven division of the water-right.

About this time the value of irrigation began to attract general notice. A new set of people were coming into the country, buying the higher lying lands, hitherto regarded as non-irrigable, and were looking about for rights to water with which to irrigate their holdings. The soils and exposure of these upper lands were specially well adapted to the higher classes of orchard and vine growing. Experience had proven that such bench-lands irrigated were more valuable than the lands of the class upon which the waters of the North Fork and Cram-Van Lueven ditches had been used, and so

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it was sought to purchase rights to water in these ditches to transfer to the higher belt. In April, 1878, the Water Commissioners[1] authorized the changing of the "West Fork of the North Fork of the Santa Ana ditch," meaning the lower part of the old Cram-Van Lueven ditch, to a higher grade line; and in that year the work was constructed from a point near the then existing Cram school house, around the base of the steeper slopes on the north. This new canal commanded lands not before considered susceptible of irrigation, and was the first attempt at carrying waters back on what was known as the "bench-lands."

The High-grade Bench-land Canal:—In that same year some of the old individual North Fork water-rights were bought by parties who wanted to transfer their use to lands lying on the mesa above—the upper slope next to the rugged hills—and for this purpose they were desirous of constructing a ditch, leaving the main ditch several miles still higher up, taking to the hillside and across the points and gulches which lie between City creek and Plunge creek. This was an undertaking which the old North Fork ditch people never dreamed of, and there was much opposition to it; so that it was not until 1880 that sufficient interests were thus relocalized by purchase of rights (theretofore used on the low plain lands) on the part of the owners of the high mesa property, to make the change at all popular; and during that year the proposition was pushed and actively canvassed.

In the spring of 1881 an agreement was entered into between two persons, holding some of the high lying land, and the owners of the North Fork ditch water-rights (exclusive of the Cram-Van Lueven rights) to excavate a high-grade ditch from a point about two miles below the present head of the system, around as far as City creek. This work followed substantially the present line, and as locally remodeled, paved, and cemented, is the canal now in use. The contract price of the original construction was merely nominal ($700), but the work was built during the fall and winter of 1881–82, at a cost to the contractors of about $4,000, and water was first run through it about April, 1882. It was used in the shape in which it was left by the contractors, for irrigating purposes, during the season of 1882 and 1883, but the upper end of the old ditch, between the commencement of the high-grade part

[1] This refers to the County Board of Water Commissioners elected under the law specially relating to San Bernardino county, approved February 18, 1864.

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and the Santa Ana River cañon, was paved and cemented in the spring of 1883. In 1883 the terminus of the main North Fork ditch was established at a point three fourths of a mile west of City creek wash; about two miles of paved and cemented ditch was constructed to reach that point; and in the same winter about one mile of paved and cemented ditch was completed along the line at various localities.

During the summer of 1882, the owners of the Cram-Van Lueven rights, finding their old ditch as used—without the water of the North Fork owners accompanying theirs—incapable of supplying enough water for irrigation purposes (because of a large proportion of loss from so small a stream running in so large a ditch over porous lands), made an agreement with the North Fork owners by which their water should be taken through the new high-grade ditch, as reconstructed and paved in 1882–83, to a point about four miles below the Santa Ana cañon, where they took it out in a branch ditch made by themselves. This point is called the "Cram Divide," and by this arrangement they became part owners in the canal up to it.

The North Fork Water Company:—The work up to this time had been conducted without any binding arrangement between the stockholders; and now finding it very difficult to continue without organization, the North Fork Water Company was, after much negotiation and delay, incorporated in January, 1885, which has conducted the operations from that time. The Cram-Van Lueven people have not incorporated with the North Fork ditch interests, however, but are simply joint owners with the North Fork Water Company in the upper section of the North Fork ditch. In the formation of the North Fork Water Company, those of the owners of North Fork ditch rights who entered it deeded their interests, in trust only, to that corporation, for a fixed period of time, and under certain conditions looking to reversal of the interests to their owners in case the company does not properly carry out its trust.

In the month of June, 1885, an arrangement was made between the North Fork Water Company and other owners in the North Fork ditch, including the Cram-Van Lueven rights, with the Bear Valley Land and Water Company, by which one half interest in the ditch was conveyed to the Bear Valley Land and Water Company for a money consideration, and for a guarantee of a certain

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amount of water, as hereinbefore named, during the irrigating season. Before this agreement with the Bear Valley company was made, however, the settlement of a long mooted question as to the division of the waters of the river between the north side and south side ditches was arrived at.

There had been between 1872 and 1885 a number of negotiations on this point, and the Board of Water Commissioners had several times apportioned the waters in conflicting measures. By the settlement of 1885, however, it was agreed that the south side ditch should take one half the water in the river, and the north side ditch take the other half, of which the Van Lueven interest was to have one third, or one sixth of the whole, in accordance with the original decree of court; and this judgment formed the basis upon which this agreement was made. But, as will be seen by the agreements between the Bear Valley company and the North and South Fork ditches, there has been some modification in these terms as to measure of water to be delivered, depending, however, entirely upon the arrangements between the Bear Valley company and the two ditches respectively, and in no way affecting the rights of the ditches in the water of the river as against each other.

Subsequent to the agreement made between the Bear Valley company and the North Fork company, in May, 1885, the work of construction and reconstruction has been carried on from year to year, as already described, under the supervision of the North Fork Water Company—the Bear Valley Land and Water Company paying one half of the costs, as per the terms of agreement, and the Cram-Van Lueven interest, their share of the other half.

Value of the Property:—From the record of deeds of shares in the original ditch property, where such have been separately conveyed, and where the mentioned considerations, after inquiry, are believed to have been at the ruling rates, and from data of later date in the company's books, the following exhibit of the market value of shares and consequent valuation of the whole property, from time to time, has been made. As it now stands, the share of North Fork Water Company's stock, under the Bear Valley company's guarantee, represents one twelfth of an inch of water flowing during the two or three months of greatest need: two thirds, or four hundred inches, of the six hundred inches guaranteed, being due to the four thousand eight hundred shares in the

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new company, or the equivalent in hours of the old subdivision; the other third going to the Cram-Van Lueven division of the total ownership.

At $60 per share, which is understood to be the present market value of the stock, the inch of water would be worth $720, and the total property of the North Fork Water Company $288,000[1]. The advance in value, from time to time, will be seen by an inspection of the table:

Water-right and Canal: Market Value.

1.	2.	3.	4.	5.
Month.	Number Sales Recorded.	Average Rate per Share.	Resulting Value of Work, 240 Shares.	Value per Inch.
1865	1	$30 00	$7,200	$18 00
1871	1	50 00	12,000	30 00
Novemb'r, 1877.	2	42 50	10,200	25 50
1878	1	36 50	8,760	21 90
January, 1879.	1	35 00	8,400	21 00
April, 1879 . .	2	44 00	10,560	26 40
1880	3	50 00	12,000	30 00
March, 1881 .	1	100 00	24,000	60 00
June, 1881 . .	1	92 00	22,480	. . . .[2]
January, 1882.	4	150 00	36,000	90 00
February, 1882.	1	200 00	48,000	120 00
March, 1882 .	4	200 00	48,000	120 00
April, 1882 . .	2	225 00	54,000	135 00
October, 1882.	2	400 00	96,000	240 00
Novemb'r, 1882.	2	500 00	120,000	300 00
December, 1882.	2	520 00	124,800	312 00
January, 1883.	1	500 00	120,000	300 00
March, 1883 .	5	550 00	132,000	330 00
April, 1883 . .	2	525 00	126,000	315 00
May, 1883 . .	1	550 00	132,000	330 00
January, 1885.	4,800 shares at	30 00	144,000	360 00
July, 1887 . .	4,800 shares at	62 00	. . . . .	. . . .[2]
July, 1888 . .	4,800 shares at	60 00	288,000	720 00

Putting the cost of the canal, to the company, as heretofore estimated, at $48,000, the value of the water privilege alone would be $240,000 for four hundred inches—or $600 per inch. The value of the water-right, inclusive of the Cram-Van Lueven interest, is hence $360,000; and inclusive of works $408,000. This, of course,

[1] This relates to 1888 down to August or September.
[2] These rates are thought to have been abnormal, and are, hence, not carried out.

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covers values of distributaries, and of the Cram-Van Lueven work regarded as a distributary.

For the year 1888 the work and the two thirds of the water-right merged into the company were assessed for taxation, to the company, as a canal twelve miles long, at $5,295 per mile, or $63,440 total.

Ownership of the Property:—The following tabular statement shows the manner in which the ownership of this property has been distributed for most every year from 1865 to the present time. The number of owners, average holding of shares or interests, and maximum and minimum extent of individual ownership are given for each year of which data could be found in the record of the Water Commissioners up to 1885, and thence forward, in the books of the company, to the present season. To 1885 the "shares" or "hours" relate to the old division of the interest as shown in the last column. In 1885, to 1888, the shares relate to the total number (four thousand eight hundred) of the corporation.

North Fork Canal: Share Holdings, etc.

Date.	Number of Owners.	Holdings.			Total Recognized Shares.
		Largest.	Smallest.	Average.	
					Before Incorporation.
1865 . . .	8	25 A.	25 A.	25 A.	200 A.
1871 . . .	11	48 hours.	10 hours.	15.0 hours.	164 hours.
1874 . . .	19	30 hours.	6 hours.	12.4 hours.	236 hours.
1875 . . .	20	30 hours.	6 hours.	12.0 hours.	240 hours.
1876 . . .	19	30 hours.	4 hours.	12.6 hours.	240 hours.
1877 . . .	20	30 hours.	1 hour.	12.0 hours.	240 hours.
1878 . . .	21	30 hours.	1 hour.	11.4 hours.	240 hours.
1879 . . .	22	20 hours.	1 hour.	10.9 hours.	240 hours.
1880 . . .	26	30 hours.	1 hour.	9.2 hours.	240 hours.
1882 . . .	30	30 hours.	1 hour.	8.0 hours.	240 hours.
1883 . . .	24	37 hours.	2 hours.	10.0 hours.	240 hours.
1884 . . .	36	40 shares.	1 share.	6.6 shares.	240 shares.
					After Incorporation.
1885 . . .	47	860 shares.	10 shares.	102 shares.	4,800 shares.
1886 . . .	50	860 shares.	10 shares.	96 shares.	4,800 shares.
1887 . . .	76	860 shares.	10 shares.	63 shares.	4,800 shares.
1888 . . .	64	700 shares.	5 shares.	75 shares.	4,800 shares.

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Individual Water-rights:—The nature of the individual water-rights in the old North Fork Canal association—the measure of control which each owner had over his share of water—before incorporation, gave rise to serious dissensions, and for a time threatened disaster to the North Fork organization. Originally this was a simple association of individuals, without recognized articles of agreement, banded together to build a ditch to take out water of which each claimed an equal part. As in all the very early instances of water diversion in this county, it was tacitly understood in this case that the ditch was a common property, but that each man owned his share of the water in severalty, and might transfer it to another ditch, just as was done in the Timber ditch rights. In later years, however, with the disaster of the Timber ditch, brought on by the gradual disposal of individual water-rights to south side owners, before their eyes, a strong prejudice grew up among the larger owners in the North Fork ditch against the transfer of individual water-rights from that ditch to any other. They foresaw the possible sale of interests to south side people, and a weakening of their association to that extent which would make it difficult to properly maintain their work, and reduce the volume of their stream so as to leave the proportion of loss disastrously great.

In November, 1877, an eight-hour interest in the North Fork having been sold to South Fork people, the Water Commissioners were asked to reapportion the waters from the river, which was formally done on the twenty-second of that month, and instructions given to the representatives of the two associations accordingly. The North Fork people soon protested against this, refused to abide by the reapportionment of the water, and denied the power to transfer individual rights from one ditch to the other. They claimed that each of the ditches was entitled to one half of the water, and that the individual claims related to parts of the water of the ditch, and not to parts of water of the river, independent of the ditch. In December, 1877, the Water Commissioners again considered the matter, heard arguments on it, and concluded that the individual rights were transferable, but that they could not agree as to how it should be done. There were other meetings, and similar conclusions and protests, and threatened injunctions on the part of a large majority of the North Fork water-rights. Finally, this case was settled by one of the North

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Fork owners buying back the eight-hour right, which had been transferred to the south side, and from that time on it appears to have been understood that the North Fork shares of water were not transferable into any other ditch, because the North Fork people would not consent to it, or suffer a reapportionment of their water with any other ditch. The trust deed of all individual rights to the company now, of course, puts that matter at rest so long as its provisions hold.

SECTION II.

SUNNYSIDE OR LUGONIA IRRIGATIONS.

The District and Work—The Water-right and Works: Lugonia and the South Side Region; The Old Sunnyside Ditch; The New Bear Valley Canal; The Present South Fork or Sunnyside Works. *Management and Distribution:* The Association and Basis of Organization; The Principle of Rotation: Administration and Maintenance; Recent Changes in Management. *Water-supply and Use:* Supply Available in Former Years; Supply under Arrangement with Bear Valley Company; Irrigation in 1879, 1881, 1885, and 1888.

History of Water-right and Works—Old Ditches and Claims: The Berry Roberts Ditch; Timber Ditch Water-rights; South Fork and Sunnyside Ditches. *Recent Organization and Status:* The South Fork Association; Agreement with the Bear Valley Land and Water Company; The Lugonia Water Company; Holding of the Property in 1864–1888; Value of the Property in 1872–1888; The Waste-water Controversy.

The South Fork Ditch.

District and Work:—The water-right and work which go under this name constitute the original south side diversion from the Santa Ana river at its cañon mouth—corresponding to the North Fork canal on the opposite side. Diverted at this advantageous location, the South Fork waters are led southwesterly, three miles, and then, for the most part, are distributed westerly, four miles, over a portion of the main south side plain of San Bernardino valley lying next south of the Santa Ana river, about two miles in width, and which district is known as Lugonia.

The story of the gradual development of the South Fork water-right, and final location of the ditch, on the route above referred to, after repeated locations and changes on other routes, is told elsewhere in this report. The ditch thus constructed was the

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Sunnyside ditch, or Sunnyside division of the South Fork ditch, as it was sometimes called. Under the arrangement with the Bear Valley Land and Water Company, entered into by the South Fork owners in 1886, the upper portion of the Sunnyside ditch was turned over to the Bear Valley organization, to be reconstructed for the joint benefit and use of the two companies. This having in a measure been done, the work is known as the Bear Valley canal, so there is now no South Fork ditch out from the river, but the South Fork waters are taken through the Bear Valley canal about three miles, and there, for the most part, are turned out into the old Sunnyside canal to be distributed westward as already spoken of. The Bear Valley canal will be described with other works of the Bear Valley Land and Water Company. As originally constructed the Sunnyside ditch, compared to the paved and cemented canals which are now being rapidly adopted for the larger works in this valley, was a very rude and wasteful conduit; and even yet that portion belonging to and used exclusively by the South Fork association is quite a crude and primitive structure.

CANAL AND STRUCTURES:—The point where the South Fork waters are taken out of the Bear Valley canal is known as the Sunnyside divide. Thence they are led westerly and southerly about a mile, through an unevenly formed and roughly excavated ditch, following the slope of the country, and sometimes apparently but an old natural surface drainway. Then a little rock-paved and uncemented ditch about two to two and a quarter feet wide on the bottom, two to two and a quarter feet deep, and four to five feet wide on top, leads west, along a road, two miles. This, together with about three and a half miles of branch ditch of the same general character, one half to three fourths of a mile of fourteen-inch cement pipe, and about six miles of unpaved branch ditches, constitutes the works of the South Fork association. A portion of the Sunnyside paved ditch was the first work of the kind—the first attempted improvement on a simple excavated channel made in this valley; and, as a pioneer work, it had its merits, and rewarded its constructors by a very great saving of waters and in cost of maintenance. Now it is far behind the times, and by comparison is regarded as a poor ditch, to be at some future time rebuilt. There are no notable structures in this work, and all its outlet

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gates and water partitions are of the simplest and cheapest wooden construction.

Operation and Maintenance:—Until quite recently the South Fork works have been owned and managed by the owners of the three hundred and sixty-nine water shares constituting the water-right, who came together for this purpose, as a simple unincorporated association. This association is one for the mutual benefit of the shareholders. Each owner is supposed to own his water-right. He derived it by separate purchase from an original appropriation. He entered this association to work with others, and to have others work with him for the construction and management of a ditch. His share of the water is to be delivered to him. None is sold except what individual owners may choose to dispose of from time to time as they do not need it themselves.

DISTRIBUTION:—The principle of distribution has been that of periodical allotment of the entire flow of the ditch to each owner in turn, for a part of the period of rotation, corresponding to his proportionate part of total ownership in the property. The period of rotation is fixed at seven days and six hours. The six hours is put on to cause a continuous shifting of times, so that the irrigating shift of each cultivator will be put six hours later each week, and thus he will be gradually changed in time through the whole week, and never twice in succession have his turn come at the same part of the week. This is to give all a fair share of day and night water, and of Sunday and week-day irrigating.

The one hundred and seventy-four hours of the period is divided into three hundred and sixty-nine parts, corresponding to the number of shares in the association. Each irrigator is entitled to the full flow of the canal of supply for a period of time corresponding to one such part of the one hundred and seventy-four hours, multiplied by his number of shares. Thus, one share represents $\frac{174 \times 60}{369} = 28.29$ minutes. Now, there are a number of interests which hold one share or less, and one of the owners has but one fourth share, so that his irrigation turn only lasts 7.07 minutes, with the entire flow of the stream. The inconvenience and waste consequent upon this sort of outcome has led to the practice of "lumping hours" amongst small irrigators, and "dividing the run." But this necessitates harmony and forbearance amongst neighbors, which do not always exist.

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The water tickets are made out at the beginning of each irrigating season, and these, handed to each irrigator, specify the time in hours and minutes for the periods ahead, during which he is entitled to the run of the stream. The schedule is arranged so that, commencing with the irrigators lowest down on the course of the canal of supply, each one higher in position follows his neighbor. At the time the water is turned on to the irrigator whose turn it is, he has to take care of it all, unless he has previously given notice that he does not want the whole or a part of it, or unless he has arranged with his neighbors to "divide the head" during a "lump period of hours."

The *coda del aqua*, as Italian irrigators call it, gives much trouble in this settlement. To whom does the "tail of the water" in the canal, when an irrigator's time ceases, belong? is a question always on the carpet when the supply has been short. It so happens that with two exceptions the irrigators at the extremities of the canals of supply are large users, so that the point does not much concern them; but to small irrigators, the "ditchful" is about all they get, and this question becomes a serious one.

Night irrigation with big heads is another inconvenience of this system. There can be no such thing as turning on a small and manageable head in the evening, and letting it flow down the furrows until morning. There are but few irrigators who have sufficient shares to have their turn extend through a night, and even these have to bestir themselves the entire time with lantern, spade, hoe, and extra help to receive and apply the water. A "turn" may come in the middle of the night, and only extend for an hour, and the water must be taken and used then. And the "head" is such that it requires constant attention. Formerly the low-water supply of this canal varied between three hundred and fifty and five hundred inches at the Santa Ana "divide." About one fifth of this goes to Redlands, and about one fifth may have been lost in delivery. Hence, the irrigating heads under this system might be as much as three hundred inches, which the irrigator would have to receive and handle. During past years, when the supply was short and the system more rigidly adhered to, there was much complaint and wrangling over this system. For several years past the supply has been abundant, and irrigators have been allowed to take it in more manageable quantities. Nevertheless, it is

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intended to radically change the system so soon as the reorganization elsewhere spoken of is perfected.

ORGANIZATION AND MANAGEMENT:—The South Fork association has had a president and the other usual officers of a corporation, but none of these have been salaried. A *zanjero*, or watermaster, actively employed during four or five irrigating months, has received a compensation, ranging from $40 to $60 per month. Since the diversion was made up by the cañon mouth, the flumes constructed, and the main ditches paved, the annual work of repairs and clearances has been light. The total cost of operation and maintenance, and including all contingent expenses, has usually been met by an assessment of $1 per share on the three hundred and sixty-nine shares, the highest having been in the present year, when the rate was $2 per share, not over half of which was needed, however, for ordinary current expense. In July, 1887, a portion of the owners of the South Fork shares, comprising not quite half of the whole, entered a corporation known as the Lugonia Water Company, as elsewhere explained, and the property is now managed, apparently by tacit consent of all concerned, upon the same old principle, and in substantially the same manner, and with the same force and expense as formerly, by this company, though, even yet, less than half the "hours" or "shares" of the old association have become identified with it.

Water-supply and Use:—The water-supply for this diversion during months of greatest demand has been in past years the same as that already noted for the North Fork canal—the two associations equally partitioning the available flow of the river at the "divide." Under the agreement with the Bear Valley Land and Water Company, the South Fork association is now guaranteed, subject to certain conditions, a water-supply, delivered from the Bear Valley canal, at the Sunnyside divide, of four hundred and sixty-six and two thirds inches continuous flow from May to October, inclusive, for each year. And this is coupled with the privilege of taking less in any one or more months of the six named, and receiving the saved amounts in any others of the same six months, provided that the amount shall not exceed six hundred inches flow for any one month, and that the demand for such change shall be made before the twentieth of April of the year in which it is wanted. For the other six months the associa-

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tion is guaranteed at least three hundred inches continuous flow, with certain other conditions more fully noticed in the account elsewhere written of the Bear Valley company's rights and obligations.

IRRIGATION:—Summer irrigation may be said to have fairly commenced in the district commanded by this ditch in 1876, but it was not until 1878 that all the water shares making up the right were transferred from the old north side work to this of the south side.

In 1879 there were twenty-seven owners of shares in the South Fork ditch, of whom twenty-six cultivated by irrigation a total of three hundred and thirty-four acres of land.

In 1880 there were twenty-eight owners, of whom twenty-seven were actual irrigators. The largest holding was eighty shares of the three hundred and sixty-nine, and the smallest, one share. There were 554.5 acres irrigated, of which 237.5 were cultivated in deciduous fruit tree orchard, with a very few citrus fruit trees, 208.5 acres were in vines, 61.25 in alfalfa, and 47.5 acres in summer crops.

In 1885, of the three hundred and sixty-nine shares of this water property, sixty were held for lands in Redlands, and the water due these and fifteen other shares, or seventy-five shares in all, was used with other waters in that settlement. The remaining two hundred and ninety-four shares were held for land in Lugonia, and, to a very limited extent, in Old San Bernardino, and the waters due to them were there used, as shown by the following table:

CLASSIFICATION OF OWNERSHIP.	Number of Shares Held.	Number of Acres Irrigated.	Number of Acres in Ownership.
Individual irrigators:			
44 resident, 193½ shares) 10 non-resd., 14 shares[1])	207½	1,216½	2,025
Brockton Fruit Company	20	190	200
Real estate firm	64½	....	1,224
The Lugonia Church, and the Fruit Drying Company	2	....	....
Totals	294	1,406½	3,449

[1] The ten non-residents for whom one piece is held and farmed are counted as one individual in making up total of irrigators for a table which follows.

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The 1,406½ acres irrigated were planted as follows: Citrus fruits, 139½ acres; deciduous fruits, 1,049½; vineyard, 282¾; alfalfa, 30; summer crops, 4¾ acres.

The resident land holding irrigators numbered 44, owning 193½ shares of the water property, and 1,885 acres of land, of which 1,081¼ acres were irrigated, and planted in citrus orchard, 136½ acres; in deciduous fruit trees 637¼ acres, in vineyard 272¾ acres, in alfalfa 30 acres, and in garden crops 4¾ acres. Of these irrigators, one irrigated over 170 acres (mostly cultivated as vineyard), two irrigated between 70 and 100 acres, and the balance less than 25 acres each—the smallest irrigation being two acres in area.

In 1888 there are 91 owners, the largest holding 50 shares, the smallest $\frac{1}{10}$ share, the average 4.05 shares, and there are in all about 1,535 acres irrigated.

History of Work and Water-right:—On March 10, 1869, Berry Roberts posted and filed a notice that he claimed "the surplus waste-water running in the Santa Ana river," the ditch to divert it commencing on the south side of the river "where the old 'Tenna' (Tinney) ditch was taken out."

Berry Roberts Ditch:—On the nineteenth of February of the same year the Water Commissioners located this ditch, to be known as the Berry Roberts water ditch, "the water claimed being the water of the Santa Ana river," at the point named. There were two owners between whom it was to be equally divided—Roberts and Suverkrup. This was practically a relocating of the old Tinney ditch, which has been described in the previous section. The water-right thus claimed was united by Roberts and Suverkrup, with the asserted right to use the waste waters of Mill creek, and these were brought together by two small ditches. On petition the river ditch was allowed to be enlarged in April, 1870, it being still only a waste-water ditch, and acknowledging the prior rights of the Timber, North Fork, and Cram ditches, on the north side, to all the water of the river they could divert, which meant all the summer supply.

Timber Ditch Water-rights:—In 1872 Suverkrup bought about a tenth or twelfth individual interest in the Timber ditch water-right, and wanted to transfer it across the river to the Berry Roberts ditch. At a meeting of the shareholders of the "South Fork

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of Santa Ana water ditch," by which name the Timber ditch was called as elsewhere explained, held February 15, 1873 (as recorded in the Water Commissioners' records), the water was apportioned among eighteen claimants, for the irrigation of an aggregate area of three hundred and sixty-eight acres, held in tracts from five to forty-five acres each. Of this number, six owners holding rights for one hundred and forty-eight acres, were south side, or "Sunnyside" people, and the balance being residents of the "Timber" country on the north side of the river. At this meeting it was resolved that the apportionment of the individual water interests for that year should be final, and the signatures of the claimants to this agreement appear on the Water Commissioners' books. It was further agreed that the shareholders, after having signed the agreement, should "have the power to sell and transfer their water-rights, without any question or hindrance whatever."

During the year 1874, several owners of land in the Sunnyside, now Lugonia, neighborhood, some of whom had bought water-rights in the Timber or South Fork ditch, apparently conceiving the idea of getting hold of a large number of those rights, let a contract for the construction of a ditch on the south side, from a point in the cañon mouth, where the North Fork and Cram-Van Lueven ditch was then diverted, and which they called "the South Fork of the Santa Ana ditch." The route proposed for this south side ditch started from the "divide" and kept around the hills, on lighter grade, above that of the present South Fork or Sunnyside ditch, and during the season of 1874 it was constructed nearly as far as the Mill creek wash, and here the work was stopped, and this idea seems to have been abandoned.

On February 1, 1875, the Water Commissioners apportioned the summer waters of the Berry Roberts ditch to two persons, for thirty-four acres, with a separate apportionment for the spring waste-waters. It thus appears that at that time thirty-four of the three hundred and sixty-eight rights of the South Fork or Timber ditch had been transferred to the Berry Roberts. It was also made of record at that meeting that five parties owning rights to water for sixty-two and a half acres were applying "to put their water in our (Berry Roberts) ditch." This was the commencement of a series of transfers by purchase of these individual rights from the "Timber" or "South Fork of the Santa Ana ditch," on the north

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side of the river, to the Berry Roberts ditch on the south side, which went on through the years 1875 to 1877, by which time the major part of the water-right as a whole had been transferred, and with it the name of "South Fork of the Santa Ana ditch."

At a meeting of the Water Commissioners, held April 20, 1876, the summer waters of the Berry Roberts ditch were apportioned among twelve owners, holding rights for two hundred and twenty and a half acres altogether, which, of course, were transfers from the Timber ditch. This year the old Tinney ditch was reopened for its full length, by the Sunnyside people, from the Berry Roberts ditch southwesterly into the Sunnyside settlement, now included in the Lugonia neighborhood, and most of the waters were there used. There thus arose three interests in this association: the Sunnyside division interest, the remaining South Fork interest, and the original Berry Roberts ditch interest—the two former being successors to the Timber ditch, or South Fork perennial water-right, and the latter holding the waste-water right under the location of 1869.

South Fork and Sunnyside Ditches:—At a meeting of the County Water Commissioners, held May 13, 1877, a petition from fourteen owners in the Berry Roberts ditch was received, asking to have the point of diversion changed to a location higher on the river, and the route of the ditch changed to one to be pointed out by members of the association, and on the seventeenth of May, the board, viewing the route, authorized it to commence "at the mouth of the Santa Ana cañon, below or near the South Fork of the Santa Ana ditch," and following a line apparently over the route proposed, and of partial construction, for the ditch named, in 1874. This work was "to take the waters belonging to the said Berry Roberts ditch," and it was ordered that "said new ditch shall be known as the South Fork of Santa Ana ditch."

On the first of February, 1878, however, "a majority of the South Fork ditch of the Santa Ana river, as located May 17, 1877," and comprising the same persons who signed the petition of May thirteenth, petitioned the Water Commissioners to relocate their ditch, commencing at a point in the cañon "four hundred yards above the present diversion of the North and South Fork ditches, and running about one hundred and fifty yards southeasterly of said point," thence by a natural channel back into the river, at a point below, and so on down the channel to "its junc-

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tion with the Berry Roberts ditch." This petition was signed by nineteen persons, the owners of two hundred and twenty-four and one half of the three hundred and sixty-nine "acre" rights in the ditch, and the waters were thus conducted to, and, as they were before, distributed through the Berry Roberts ditch, for the first part of that season of 1878. This was the "South Fork" ditch—the ditch from the old head of the Berry Roberts ditch up to the cañon, and with the Berry Roberts ditch enlarged.

On July 5, 1878, the Water Commissioners received the following petition: "We, the undersigned, own water-rights in the Santa Ana river amounting to two hundred and thirty-three and one fourth shares or acres, out of a total of three hundred and sixty-nine shares, respectfully request your honorable body to locate a water ditch for the conveyance of said water, on or near the location as intended by your order in the location of the South Fork ditch of the Santa Ana river, of May 17, 1877, for the uses and purposes therein set forth, viz.: For irrigating and other purposes, said water ditch having been constructed and nearly ready for use for said purpose." And on that day the route of construction was viewed and recorded by the Commissioners as the "South Fork of the Santa Ana River—Sunnyside Division." This is the present Sunnyside or, sometimes called, South Fork ditch, except as locally modified in repairs or reconstruction, as the Bear Valley canal, for joint purposes. During the latter part of the season of 1878, some water was run through it, and in that of 1879 nearly all of the summer waters were transferred to it, from the old South Fork and Berry Roberts ditches, although these have been annually used for South Fork waters since, at least as late as 1886.

This is another instance of a water-right being transferred from a low lying ditch to one out from a higher point of diversion, and around on a higher grade-line, for the benefit of a better class of lands. A recital of the struggles which were gone through over this point among local irrigators would be instructive, but it would occupy too much space of this report. On February 22, 1879, the waters of the "South Fork of the Santa Ana river" were, on report of the watermaster, apportioned by the County Board of Water Commissioners to twenty-seven owners holding in all the entire number of three hundred and sixty-nine shares. On January 12, 1879, the Board of Water Commissioners met at the mouth of the Santa Ana cañon, by request of the owners of the

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South Fork of the Santa Ana ditch, for the purpose of dividing the waters between it and the North Fork ditch. The South Fork people claimed, under the old Timber ditch claim, five ninths of all the water under the apportionment of May 29, 1872, and the North Fork people claimed one half of the whole supply. The Commissioners divided the waters equally between them, and the South Fork people entered a protest. On February 4, 1884, the waters of the "South Fork ditch (Sunnyside division) of the Santa Ana river" were apportioned to forty-eight shareholders, having from one quarter to sixty-five and one half shares each, and all holding the total of three hundred and sixty-nine shares. And in February of the next year the apportionment was made with substantially the same results. This was the last apportionment made of South Fork water by the Water Commissioners.

The South Fork Association:—The old organization was a simple association based upon an agreement of the holders of the water-rights to work together in the construction and management of a ditch. A number of attempts have been made to incorporate and put the interests into a stock company, but these, until about a year and a half ago, uniformly failed. Each owner in the property has considered that he owned his proportion of the waters in severalty; he could sell his right to the North Fork company for instance, or himself divert his share of the water into another work. In practice, to be sure, there would be deterring inconveniences in such a move, there would be vigorous protests by his coöwners against such an action; and he would, of course, lose his interest in the works of the association, which are a common property, but he felt an independence in owning his water-right separately, and independently reflected that he might draw out of the association with it if, at any time, he saw fit.

This spirit has been a potent opponent to incorporation, but others have been more so. A large majority of the individual water-rights are owned and the water used on lands in Lugonia, while an active and irrepressible minority holding is located in the rival settlement of Redlands. Although lying side by side, there is a considerable depression in topography between the two, such that water from a ditch down on the Lugonia side could not conveniently be carried across and up to the Redlands tracts—it would have to be brought in a separate ditch around the head of

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the depression, as it now is, being apportioned some miles above, and carried in the Redlands Water Company's ditch. The Redlands owners of South Fork rights, therefore, being the Redlands Water Company, and some individual residents of Redlands as well, refused to incorporate with the Lugonia majority upon any other basis than that the corporation work should be limited to that part of the line of conduit, etc., above where the waters are divided, and to this the Lugonia owners did not accede, and the Redlands owners were well satisfied to continue holding their rights to some extent free from the control of a rival majority. And so incorporation of all the South Fork interests has been defeated.

Lugonia Water Company:—The Lugonia Water Company was formed by owners in the South Fork ditch, and was incorporated on July 21, 1887, with a capital stock of $369,000, divided into three thousand six hundred and ninety shares of a par value of $100 each. It has for its object the acquirement of the property of the South Fork or Sunnyside association, together with the water-rights of its members, and the management, maintenance, and improvement of the same. Under the articles of incorporation, the owners of the shares in the old association, by simple grant deed, convey their water-rights to the new company, receiving in exchange therefor an equivalent number of shares of the company's stock, of which ten are given for each one of the old three hundred and sixty-nine South Fork shares. Of the three hundred and sixty-nine shares in the old association, between one hundred and sixty and one hundred and seventy have thus far become identified with the new company. These represent nearly all of the irrigators resident in the Lugonia neighborhood. The Redlands Water Company own fifty of the three hundred and sixty-nine shares, and the Domestic Water Company own thirty-one and three fourths shares, and will not merge their interests into the Lugonia company. There were several large owners also still holding out because of complications which, it is said, will in time be done away with. With these exceptions, those who have not yet come into the organization are non-residents, or those whose stock is in such position with respect to mortgage that it is not yet known whether its status can be changed for the present. There are now fifty-six shareholders in the new company, the largest holding being thirty shares, and the smallest one share.

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South Fork Canal, Share Holdings, etc.

Date.	Number Owners.	Share Holdings.			Total Recognized Number of Shares.	Name of Ditch.
		Largest.	Smallest.	Average.		
1864 . .	17	25	5	11.88	202 acres . .	. . . Timber.
1865 . .	19	30	5	14.89	283 acres [1] .	. . . Timber.
1866 . .	20	45	5	15.65	313 acres . .	. . . Timber.
1868 . .	17	40	5	19.58	333 acres . .	. . . Timber.
1871 . .	18	45	5	20.16	363 acres . .	. . . Timber.
1872 . .	18	45	5	20.50	369 acres . .	. . . Timber.
1873 . .	18	45	5	20.50	369 acres [2] .	. . . Timber.
1874 . .	4	40	5	22.50	90 acres . .	Berry Roberts.
1876 . .	12	40	2½	18.37	220½ acres .	Berry Roberts.
1878 . .	19	40	2½	11.81	224½ shares .	. South Fork.
1879 . .	27	60	2	13.66	369 shares .	. South Fork.
1880 . .	?	?	?	?	369 shares .	. South Fork.
1881 . .	?	?	?	?	369 shares .	. South Fork.
1882 . .	?	?	?	?	369 shares .	. South Fork.
1883 . .	?	?	?	?	369 shares .	. South Fork.
1884 . .	47	65½	¼	7.85	369 shares .	. South Fork.
1885 . .	48	50	¼	7.68	369 shares .	. South Fork.
1886 . .	48	50	¼	7.68	369 shares .	. South Fork.
1887 . .	85	50	¼	4.33	369 shares .	. South Fork.
1888 . .	91	50	1/10	4.05	369 shares .	. South Fork.

"Largest"=Highest number of shares held by one person.
"Smallest"=Smallest number of shares held by one person.
"Average"=Mean number of shares held by one person.

[1] This apportionment was made under an agreement to make a ditch to be known as the "Main Ditch;" the shareholders agreeing to form themselves into a company or association for that purpose.

[2] By resolution of the owners of the ditch, the apportionment at this time was made final and permanent. It appears, also, from the minutes of the meetings of the members of the South Fork Association, that the Timber ditch was under the control of this association; and there was a watermaster elected for the Timber ditch at a meeting of the owners of the South Fork of the Santa Ana ditch, held in February, 1873. At this same meeting they resolved, also, that thereafter the owners of the water-rights might sell them without hindrance.

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South Fork Canal Valuations.

Month.	Number of Sales.	Average Rate per Share.	Resulting Value of Work.	Resulting Value of the Inch.[1]	Name of Ditch.
June, 1872 .	1	$9 75	$3,600 00	$6 00	. . . Timber.
Aug., 1872 .	1	11 11	4,099 59	6 83	. . . Timber.
Sept., 1873 .	1	20 00	7,380 00	12 30	. . . Timber.
Mar., 1874 .	1	31 00	11,439 00	19 06	. . . Timber.
Nov., 1874 .	1	28 33	10,453 77	17 42	. . . Timber.
Dec., 1874 .	1	30 00	11,070 00	18 45	. . . Timber.
Jan., 1877 .	1	30 00	11,070 00	18 45	. . . Timber.
Jan., 1877 .	1	30 00	11,070 00	18 45	. . . Timber.
Mar., 1877 .	1	111 00	40,959 00	68 26	. . . Timber.
Mar., 1878 .	1	30 42	11,225 50	18 70	. . Sunnyside.
Apr., 1879 .	1	200 00	73,800 00	123 00	. . Sunnyside.
Feb., 1880 .	1	66 66	24,597 54	40 99	. . Sunnyside.
May, 1880 .	1	114 25	42,159 00	70 26	. . Sunnyside.
June, 1880 .	1	250 00	92,250 00	153 75	. . Sunnyside.
Nov., 1882 .	1	700 00	258,300 00	430 50	. . Sunnyside.
Oct., 1882 .	1	500 00	184,500 00	307 50	. . South Fork, Sunnyside Div.
Feb., 1883 .	1	800 00	295,200 00	492 00	. . South Fork, Sunnyside Div.
Feb., 1883 .	1	1,000 00	369,000 00	615 00	. . South Fork, Sunnyside Div.
May, 1887 .	1	1,000 00	369,000 00	615 00	. . South Fork, Sunnyside Div.

For the present year the South Fork property and water-rights are assessed for purposes of taxation, to the individual holders of the three hundred and sixty-nine original shares, at the rate of $200 per share, or a total of $73,800.

Agreement with the Bear Valley Company:—In February, 1886, an agreement was entered into between the South Fork Ditch Association and the several owners of South Fork water shares with the Bear Valley Land and Water Company, similar to that between the North Fork Water Company and the Bear Valley company. Its provisions as they affect the water supply of this company have already been explained, and more will be said of them in an article concerning the Bear Valley company.

The Berry Roberts Ditch Controversy:—This work, already described as a primitive canal of diversion from the river, made in

[1] The valuations of the inch in this table are upon the basis of a 600-inch supply. Under arrangement with the Bear Valley company this basis is less, as will be elsewhere seen.

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the very earliest times of Mormon occupation of the valley, afterwards sold to Gentile settlers, and abandoned about 1859, then taken up by Roberts in 1869 and used as a waste-water ditch, then enlarged, extended, and used as the South Fork summer-water ditch from 1875–76 to1885–86, and then partly abandoned as a summer-water ditch by the South Fork association, is now believed to be owned by the South Fork association, but is claimed by the owners of the waste-water claims, and kept up by them for their use. When taken by Roberts it was used only during winter and early spring months for the flooding of grain lands. During the first few years of use as a summer ditch by the South Fork people, it was recognized as having two distinct claims attached to it—the one for summer waters to the extent of its capacity, the other for waste-water when the irrigators did not want or use summer waters. In apportioning its flow to irrigators, during this period, the Water Commissioners made two apportionments—the one for waste-waters which was recognized as running until the first of June, and the other for summer waters which took exclusive effect thereafter. But the waste-water claim has been lost sight of for a number of years.

There is a suit entitled Isaac L. Hewitt vs. Warren Story et al., now pending before the United States District Court for the Southern District of California, the complaint in which is the assertion of the waste-water claim of the Berry Roberts ditch, as against the Bear Valley Land and Water Company, primarily, and the North and South Fork ditches, and others, secondarily. It is claimed that the Berry Roberts ditch is entitled, to the extent of its capacity, to all the water in the Santa Ana river at the cañon mouth, over and above the original capacity of the North and South Fork ditches, and that the operations of the Bear Valley company in storing water above are without sanction of law, and in a very material degree detrimental to the rights and privileges of the Berry Roberts waste-water claimants.

The controversy involves the right to catch and conserve flood waters, and then, in time of low flow in a stream, to permit them to flow down its course, and reclaim and divert them. The question as to whether or not in this case the reservoir operation diminishes the flow of the river during the times of the year when this waste-water ditch was usually supplied, is one of fact. And, of course, it is a question of fact also, whether the alleged enlarge-

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ment of the North and South Fork ditches, and diversion of all the natural flow of the stream, as well as the extra flow due to the Bear Valley reservoir waters at low periods, deprives the Berry Roberts ditch of water at times when it otherwise would have received it. On the other hand, while specifically disputing the claims of the Berry Roberts ditch to water at all, under the circumstances, after the early spring months, the defendants allege that the entire waste-water claim, even, has been long forfeited by not having been used; and this is also a question of fact. It will perhaps be difficult to show that a ditch can have been a waste-water ditch for ten years to itself, which itself diverted during that period all the water it could carry, or all it could get to carry, under a summer-water claim.

SECTION III.

REDLANDS AND OTHER SOUTHSIDE IRRIGATIONS.

The District and Works—The Old Ditches and Development Works: Redlands and the Southern Mesa; The Redlands Ditch; The J. & B. Ditch; The Development Tunnel; The Yucuipa Reservoir. *Operation and Maintenance:* The Redlands Settlement Basis; The Works of Distribution and Measurement; Apportionment of Water to Stockholders; Organization and Management; Rules and Regulations; Cost of Maintenance and Operation. *Water-supply and Use:* Eight Acres to an Inch; Four Acres to an Inch; Present Water-rights; Extent of Irrigation in 1885 and 1888.

History of Works and Enterprise—The Redlands Colony Settlement: Agreements of its Projectors; Troubles about Water; The Tunnel Development Project. *The Redlands Water Company:* Increased Water-supply Necessary; Arrangement with the Bear Valley Company; Present Water-rights.

The Redlands Water Company's Works.

District and Works:—The Redlands ditch and the J. & B. ditch, as originally built, together formed a continuous channel from the opening of the Santa Ana river cañon southwesterly across the eastern end of the southern plain of San Bernardino valley, and out upon the southern bench lands to a small reservoir in Yucuipa road cañon, a total distance in a straight line of about five miles, and were constructed for the purpose of irrigating a large portion of the sloping mesa on the southern side of the valley, known as Redlands.

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THE REDLANDS DITCH:—The Redlands ditch, the lower portion of this work, was, at first, a branch or continuation of the then new South Fork or Sunnyside canal. Leaving it at the point where, after a southwesterly course, extending about half way across the plain, it delivered its waters into a sort of natural channel that ran westerly to Lugonia, the Redlands canal continued in an almost due southwest course, completing the passage of the valley plain, crossing Mill Creek zanja, and thence skirting around the upper edge of the mesa to the reservoir site just mentioned. The upper mile and a quarter of this work was quite direct in alignment, and, considering the time it was built, was well paved with rough stones of the neighborhood, and partially cemented. The lower portion was exceedingly tortuous, and, because of this, was of small capacity for its sectional dimensions, and gave much trouble in maintenance. This whole work is now done away with, however, under an agreement with the Bear Valley Land and Water Company, whereby this latter organization has undertaken to build it anew for the joint benefit of the Redlands Water Company and themselves, from the Sunnyside junction to the Yucuipa reservoir, as hereinafter described.

THE J. & B. DITCH:—The J. & B. ditch obtained its supply from the waste-water of the river, just below the "divide" between the North Fork and South Fork ditches; from a small stream developed in Morton cañon, a tributary gulch near at hand; and from the drainage derived from tunneling into the gravels of the river cañon bed, at a point several hundred yards below the "divide." Starting at an elevation less than that of the Sunnyside, but having less grade, the J. & B. ditch was constructed on a very tortuous alignment, southwesterly, until it intercepted the Redlands canal about a quarter of a mile below its head on the Sunnyside ditch. This work is still in existence and use. It is roughly constructed, in part paved, but not cemented, and has capacity for about four hundred miner's inches of water. For about half or three quarters of a mile it is built, in leaving the river bed for the plain, along the face of a bluff, and has several short pieces of flume, but there are no works or classes of construction noteworthy as compared to others in the valley and herein described.

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Water Development Tunnel:—The feature worthy of remark in connection with this work is the water development tunnel in the cañon bed. At this locality the bed of the cañon is filled with cobbles and gravel, has a slope of about one hundred and fifty feet per mile. The idea of this attempted development was that a material portion of the waters of the stream found passage through these gravels, percolating most freely along or near the bedrock of the cañon, and that if a tunnel were driven up stream, at a low grade, sufficiently far, it would intercept this bedrock plane and drain these waters out to the surface. This work was commenced in 1881, and has since been carried on with some interruptions, and often a good many discouragements and obstacles. A tunnel was first driven one hundred to one hundred and fifty feet from the south wall of the cañon, commencing just above Morton cañon junction, which struck bedrock at nine feet of depth, and followed along it six hundred feet to twenty-one feet of depth. This result was not considered favorable—in that the bedrock pitched rapidly towards the center of the cañon, and not much water was developed. This tunnel was then lined with bowlder masonry in cement, leaving frequent inlets, and with the bottom of the walls laid dry; was left in the form of a culvert about one and a half by three and a half feet opening; and has since delivered about thirty miner's inches of water.

Another tunnel, with a long open cut of approach, was commenced out in the middle of the cañon mouth, seven hundred or eight hundred feet north of the first. This has now been driven somewhat more than one thousand three hundred feet, which, with the open cut, makes over one thousand six hundred feet of work; and there is also a diagonal branch about six hundred feet in length from near the commencement of the work off toward the northern wall of the cañon. At about one thousand one hundred and fifty feet in from the tunnel's mouth, a point or ridge of bedrock was passed through at a depth of near fifty feet below the surface of the gravels; and at about one thousand two hundred feet the work passed under the present low water channel of the river, about forty-five feet beneath its waters. The work is run from shafts located at intervals varying between two hundred and three hundred feet, and is timbered as it goes. When a new shaft is opened, the section of the tunnel between it and the shaft below is lined up in rubble masonry as described for the smaller tunnel,

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leaving a culvert channel about two feet wide and four feet high. This tunnel delivers a stream of about one hundred and thirty miner's inches of water. The two tunnels, producing one hundred and sixty inches, have cost about $25,000, or about $156 per inch of water obtained, not including perhaps $5,000 expended in other prospecting works and cuttings in the neighborhood, but now abandoned. The work in the long tunnel is now being prosecuted by contract at $9 per linear foot over all costs and materials. The extreme sectional size of the work before lining is about four by six feet. It does not appear that any special examination or study has been made of the situation with the view of laying out and conducting this work on just the best plan to effect the purpose. Thus far it is simply considered that the end has justified the means.

Operation and Maintenance:—Each land owner in Redlands for each acre of land held has one share of the stock of the Redlands Water Company, which entitles him to receive waters at the rate of one miner's inch to every four acres of land. Neither the water nor the works are attached as appurtenances to the lands. The Water company's stock is held as personal property by the land owners, disposable at will. But it is yet, so far as known, still held as originally apportioned—one share to the acre—except as to that part formerly held for lands now within the town of Redlands, and no longer requiring agricultural irrigation, which right has been merged into the Crafton Redlands and Lugonia Domestic Water Company.

The Redlands Water Company's stock constitutes a right to receive a proportional part of the water at the disposal of the company. The company does not sell water to anybody. During the first year of the organization, water was sold to the stockholding irrigators, after the Riverside system, by measurement, on orders for so many inches of night or day water; but the plan has now been changed. Nevertheless, and although it is the idea that water is not sold to irrigators, but that an irrigator is only to receive his proportionate share of the supply, in practice some irrigators use much more than others, and these have thus far been allowed to receive as much as they called for, seeing that the supply is abundant. And, hence, the method of distributing waters as called for by orders is still adhered to. In giving orders,

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the irrigator must state the place he wishes the water delivered, time at which desired, quantity in inches, and the duration of flow required; and he must hand in his order three days in advance of the time specified for the commencement of the delivery. There are no stated rules or regulations formally adopted by the company. But the superintendent or *zanjero* makes those which are considered reasonable by the directors, and consented to by the irrigators. There has thus far been no trouble on this account, which is doubtless due to a system of distribution works that render efficient service, and to the fact that thus far the water supply has been abundant.

DISTRIBUTION AND MEASUREMENT:—All the water for the Redlands supply now comes through the Bear Valley canal from the junction of the J. & B. ditch. About one tenth or one twelfth of the whole is delivered at points above the Yucuipa reservoir. About twenty-five to forty inches are delivered below the Yucuipa reservoir, and the balance goes into that reservoir, and is thence delivered through the settlement. The distribution works in this settlement are entirely of cement pipes, ranging from fourteen inches in diameter down to five inches. The main lines are generally fourteen, twelve, ten, and eight inches; the laterals five and six inches in diameter. They are laid on the grade of the country, which one way ranges between fifty and one hundred feet to the mile, and have large capacity for their size. They are not under pressure, but are used simply as open channels, although buried under ground. The main supply is brought from the Yucuipa reservoir through two fourteen-inch cement pipes. The total length of all the pipes in the district is about fourteen miles.

The measuring and partitioning of the water is effected and the head in the pipes is broken or prevented from accumulating by the introduction of small concrete chambers, from five to six feet square, at short intervals and at heads of branches. The water running by the supply pipe enters such a chamber, fills it, and, rising, falls over weirs in a partition wall, thus being measured and divided to the pipes which go on beyond from other compartments of the chamber. The irrigators' delivery is made over a little weir in such a chamber, which is two to three feet square, at the highest corner of each ten-acre tract. This pipe system has worked remarkably well, after it was once properly put

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in, which was only after repeated changings and replacings in part made necessary by the doubling of that basis of water delivery on which the colony was at first projected.

The cost of operation of the water system of this company is, indeed, insignificant. The matter of maintenance is a trifling item, the works being of a character that require hardly any cleaning, and but little repair. There is a Superintendent who is paid $1,100 a year, and a Secretary who is paid $50 per year. The annual assessments cover the expense of maintenance, and represent the cost of the water to the irrigator. In 1885 the assessment was 75 cents on the share; in 1886, $1; in 1887, $1 50 on the share, which provided for payment of an assessment levied by the Bear Valley company on its stock, some of which is held by the Redlands Water Company; and in 1888 the assessment was $1 per share. At the latter figure the irrigator is served with water at $1 per acre per year.

Water-supply and Use:—The Redlands settlement was started upon the basis of an irrigation duty of eight acres to the miner's inch of water. This was afterwards found or believed to be insufficient, and additional water-rights were secured as elsewhere explained, to afford one inch to each four acres of land. As it now stands there is a supply available at this rate for the one thousand five hundred acres of land in the settlement; a small part of this, namely, one hundred and eight shares, has been transferred to the Domestic Water Company, and there are but one thousand two hundred acres irrigated, which makes the available waters three hundred and fifty-two inches—equivalent to an inch to 3.41 acres. As a matter of fact, however, the Bear Valley company are delivering to the Redlands Water Company, during the test month of August, 1888, about four hundred and sixty inches, and which is being used, thus making the duty of the water 2.61 acres per inch.

IRRIGATION:—Irrigation may be said to have commenced in Redlands in 1882, though there was little accomplished until 1883. In 1885 there were fifty-five irrigators in the settlement, owning in all seven hundred and sixty-seven and one half acres of land, or an average of 13.9 acres each; the largest holding being fifty-three acres, and the smallest two and one half acres. These irrigated five hundred and seventy-six and one quarter acres, of which one hundred and ninety-nine and three quarters were

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planted in citrus fruits, two hundred and seventy-five and one half in raisin vineyard, one hundred and seventy-five acres deciduous fruits, and the balance in alfalfa and garden crops.

History of Enterprise and Work:—The settlement of Redlands was made upon a body of one thousand five hundred acres of land, which, under the terms of the sale made by the projectors, originally, was to receive one inch of water, constant flow, to each eight acres of land. The tract was divided into ten-acre pieces. These projectors bought fifty shares of the South Fork canal waters, representing, say ($\frac{400 \times 50}{869}$), 54.2 miner's inches, as a part of the requisite supply, and commenced tunneling into the great wash of the Santa Ana river, near the mouth of the cañon, for the development of water, sufficient (133.3 ins.) to make up the 187.5 inches necessary.

ORGANIZATION:—They organized the Redlands Water Company, turned over to it the fifty shares of South Fork waters, and made a contract with it to drive the tunnel, which they had commenced, to bedrock, agreeing to furnish enough water by this means to afford the requisite one inch to each eight acres of the one thousand five hundred acres of land which were to be put in the operation. This company was organized with one thousand five hundred shares of stock, or one share to each acre of the original settlement. It issued shares to the projectors of the enterprise, who, in selling their lands, attached one share to each acre of land sold. The development of water in the cañon tunnel was not sufficient to give the requisite supply under the contract, so the projectors of the settlement turned over to the Redlands Water Company six hundred and forty water certificates of the Bear Valley Land and Water Company, which, together with the water due the fifty shares of the South Fork stock, and the developed water in the tunnel, would make a sufficient volume to supply the one thousand five hundred acres at the rate of one inch to eight acres. After the sale of nearly all the property in the Redlands settlement by the original projectors, and when by far the greatest portion of the Redlands Water Company's stock had passed into the hands of cultivators, it was found that one inch of water to eight acres would not be sufficient for their irrigations.

Water-rights:—The Redlands Water Company then secured enough stock in the Bear Valley Land and Water Company's

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enterprise to give them control of water to the extent, altogether, of one inch to four acres. They also made arrangements whereby the tunnel work was to be continued and turned over to the Bear Valley company for prosecution; and they secured a small supply of water, amounting to about eight inches from Morton cañon, a little tributary ravine to the river near the opening of the main cañon. Hence, at this time, the Redlands water-supply consists of three hundred shares of Bear Valley Water Company's stock, giving it control of six hundred water certificates, and six hundred and forty other Bear Valley Company water certificates received from Judson and Brown, each representing one seventh of an inch of water; of one hundred inches coming from the main cañon tunnel; eight inches from Morton cañon, and fifty three hundred and sixty-ninths of four hundred and sixty-six inches which constitutes the South Fork supply, in all making up the equivalent of three hundred and seventy-five inches, or one inch to four acres of the one thousand five hundred acres in the Redlands settlement. Of this amount, the Redlands, Lugonia, and Crafton Domestic Water Company, a corporation organized to supply the settlements with domestic water, own that due one hundred and eight of the one thousand five hundred shares, which is taken out of the Redlands ditch a mile above the settlement, and there conducted into a paved and cemented reservoir, for distribution in pipes.

The Redlands Water Company was incorporated October 27, 1881, with a capital stock of $1,500,000, divided into one thousand five hundred shares, of a par value of $1,000 each. The present market value of the stock is $120 to $130 per share, and within the year past it has been $140 per share. These works are not assessed for purposes of taxation, but are considered as part of the property they serve in irrigation, and that property is rated higher, because of them, than it otherwise would be.

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SECTION IV.

GENERAL WATER-SUPPLY PROJECT.

Water Storage and Delivery—The Storage Reservoir: Bear Valley and Bear Creek; Water-shed and Precipitation; Dam and Outlets; Reservoir Space and Water-supply. *Delivery Works and Projects:* Commanding Lines for Delivery; The North Side Canal; The South Side Canal; Distribution Works; Possibilities and Projects.

History of Project and Operations—The Bear Valley Land and Water Company: Organization and Management; Water Certificates; The North Fork Water Company Agreement; The South Fork Ditch Association Agreement; The Redlands Water Company Agreement; Water Claims and Rights; The Waste-water Controversy.

Bear Valley Land and Water Company's Works.

Bear Valley and Bear Creek:—Immediately north of the San Bernardino peak and Grayback mountain, extending in an easterly and westerly direction, at an elevation from four thousand five hundred to five thousand feet, lies the valley of the upper Santa Ana river. Overlooking this and bordering it on the north is a long rugged mountain ridge, whose crest line holds seven thousand two hundred to seven thousand seven hundred feet of altitude, and which I shall call the central ridge. Next north of this, with its axis in the same direction and about four and one half miles from the main mountains on the south, we find Bear valley, a remarkably large and flat mountain basin, about six thousand two hundred to six thousand three hundred feet above the sea, and twenty-one miles in a straight line from San Bernardino.

STORAGE RESERVOIR:—This valley has the appearance of once having held a lake whose waters, at an elevation of one hundred and twenty-five feet above its bottom, overflowed at the east end into the head of a cañon which leads away into the Colorado desert. Now, however, we find a deep and narrow rock-bound gorge leading out of its other extremity, and, cutting southerly around the west end of the Central mountain ridge, before mentioned, joining the cañon of the Santa Ana river about ten miles above its outlet into San Bernardino valley. This gorge holds Bear creek, at whose point of departure from the valley a dam has been built, whereby the basin has been made, or remade, a lake.

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The bottom plane of the valley is twelve miles long, and varies between a few hundred yards and a mile in width. Its lower end was narrow and rock-bound; then, a couple of miles or more above the dam site, it opened out into a couple of beautiful meadows, whose level plains, seven hundred to eight hundred acres in area, were thirty to forty-five feet above the outlet; and at the upper end of the valley is another such flat, covering about eight hundred acres, and twenty to thirty feet still higher. At sixty feet of elevation above the base of the dam a water-plane would reach 5.9 miles up the valley, and have an average width of 0.6 of a mile, covering two thousand two hundred and fifty-two acres in area. At one hundred and twenty feet of elevation the length would be 11.5 miles, the mean width 1.1 miles, and the area submerged seven thousand eight hundred and fifty acres.

Water-shed and Precipitation:—The water-shed tributary to this valley is forty to forty-five square miles in area. On the south lies the central ridge already described, and heavily timbered on its slope towards Bear valley. North and west is a well timbered but not abrupt mountain one thousand to one thousand five hundred feet above the valley. Northeast are rolling hills—five hundred to seven hundred feet above the valley, and sparsely timbered; while the east end is closed in from the desert slope by a comparatively barren range of hills, whose altitude ranges from two hundred to five hundred feet above the valley.

The rock of the country is, for the most part, granite, of which huge bowlders and massive ledges crop out around the slope, particularly near the western end. Limestone is found near the eastern end, and some good lime has been there burned. Although the country is much broken and shattered in its rock formation, there is a good layer of soil over most of it, and the bottom of the valley itself is well clothed in this respect, as attested by the rich meadows which ordinarily remain moist and green the year round—receiving little streams from the wooded hillsides, and having some springs along their margins. It was feared in some quarters that the reservoir would not hold water—that it would escape in enormous quantities through the rock rifts and seams. But this fear has proven groundless.

Bear valley is in the midst of the heaviest downpour belt in Southern California. The clouds collect around and bank up against the high peaks of San Bernardino and Grayback, and spread over into the Bear Valley water-shed. Holding so great an

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altitude, its precipitation is largely received in the form of snow, which, in the wooded and shaded portions of its sides, lies for several months. The data of local rainfall will be given in a division of this report devoted to Water Supply in Southern California.

Bear Valley Dam:—The dam is at the extreme western end of the valley, at the head of the narrow, rock-bound gorge, which drops rapidly away. Founded on granite, where the channel was sixty to seventy-five feet wide, and abutting against granitic mountain sides, at the top line it is about three hundred feet in length, in the form of an arch, having a radius of three hundred and thirty-five feet; and it is sixty-four feet in height from extreme base to top of coping.

In cross-section it is remarkable. The top is but 3 to 3.2 feet wide; the lower face vertical for 48 feet, and the upper face battered so that 48 feet down the structure is 8.5 feet thick. At this plane there is an offset up and down stream—the dam increases in thickness to twelve or thirteen feet—and thence has a slight batter on both faces, so that at the extreme foundation it has a thickness of twenty feet.

This structure is of granite, rough-ashlar masonry on both faces, and broken coursed rubble in the interior, all laid in a cement mortar and grouting. The square stones show dimensions ranging from three to five feet in length, one and one half to two and one half feet in width, and one to two feet in thickness, with others, of course, smaller. Its total volume is about three thousand three hundred or three thousand four hundred cubic yards.

At the time construction commenced, in the fall of 1883, there was no water running out of the valley, and but little was encountered in sinking three or four feet for the dam foundation, so that small difficulty was had in this work. That season the wall was brought up to the level of the bench, sixteen feet above the extreme foundation plane, for about half of its length. It was desired to make some show of impounding water the first year and to test the water-producing capacity of the shed; so a temporary earthen dam was put across the valley just below the wide marshes, about two miles above the main dam site. This embankment was five to six feet high, and was calculated to bank water over five hundred to six hundred acres, to an average depth of three or four feet. The move was quite a fortunate one, for the water thus held back during the winter of 1883–84 furnished

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a supply, which being gradually let out from this temporary reservoir, during the summer, enabled the constructors to keep a lake surface of sufficient depth and extent behind the new wall to afford, by means of flat-boats, an economical way of transporting stone from the quarries.

The rock was quarried from the outcropping masses of granite along the edge of the valley, and near the level of the proposed lake, from one hundred yards to three quarters of a mile above the dam site. That for the first season's work was obtained near at hand and delivered on sleds, but that for the second season's work, comprising the great mass of the dam, was transported on flats and put into the work by means of derricks on large rafts floated close against the upper face of the wall.

At the north end the dam foundation was cut into the loose, sloping mountain side, to a bedrock base. The south end abuts against a massive, nearly perpendicular ledge, or point, of granite standing near one hundred feet out into the cañon. This point in reality forms a part of the dam. Over it a flood escape-way has been cut twenty feet in width, and with a plane 8.5 feet below the level of the extreme crest of the dam coping.

Through the bedrock immediately below the foundation plane, about one third of the length of the structure from the southern end, about 9.5 feet above its extreme base plane, is a cutting which forms a culvert 3 by 3.5 feet in aperture, opening out below into a masonry pool, from which it was expected to measure the water over a weir. This culvert gradually becomes narrower towards the upper end. On the upper face of the structure the culvert is closed with masonry, to a gate-opening of 20 by 24 inches, over which is an iron sliding gate, on brass bearings, worked by a screw at the top of an iron rod, which extends up through the water, in a six-inch lapwelded pipe serving as a guide, to a wooden platform built out from the coping of the dam. Subsequently this culvert opening was lined over a movable mold with concrete, so that the opening is now 2 by 3 feet, with an arched top. There is no gate tower; no provision for drawing water at less pressure; no safeguard or regulator on the one outlet provided other than the one gate.

In the matter of abutment, the dam for about twenty to thirty feet at each side is gradually made thicker, so that it rests against the rock of the country at 1.5 to 2.2 times its normal thickness. The coping stones are three feet long, generally one and one half

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feet thick, and two to two and one half feet wide, resting lengthwise across the top of the structure. The finish work and coping stones have not been put on for the full length, so that for more than half the length the top is three to four feet below the intended plane of completion.

The first year after construction, with the water plane at forty to forty-five feet, there was a little leakage at the south end, near or under the base, which it is claimed came through rifts in the granite point against which the structure there rests; and there was a remarkably free sweating and efflorescence of lime on the lower face over the whole structure, nearly up to the water line. It is understood that the sweating phenomenon has now to a great extent ceased. There has been some expansive movement to the structure—attested by the reported fact that the cope stones which do not extend all the way across show a separation at some of the joints, to be accounted for only as the result of expansion and subsequent contraction. Otherwise the structure appears to rest just as placed, and thus far serves its purpose; the water having been for a time within a foot of the finished part of its top, and having constantly stood well up on it for a considerable period, as hereinafter written.

The company, desirous of securing greater reservoir capacity, has in contemplation an enlargement of this work. Indeed, it is proposed to provide for storage to the one hundred-foot plane above the present foundation, which, successfully and permanently done, would make this a truly notable reservoir and very valuable property. There have been no plans or definite ideas, even, as yet put forward for the enlarged work. Engineers familiar with such construction will see that, under the circumstances, it is a problem not without much embarrassment and grave responsibility.

Reservoir Space and Water-supply:—This reservoir site was surveyed preliminarily by the State Engineering Department in 1880, and it was reported that a dam forty-five feet in height would impound water over an area of about one thousand five hundred acres, to a volume of about six hundred and fifty million cubic feet, and that a dam sixty feet in height would create a reservoir space about two thousand three hundred acres in area, and about one thousand eight hundred and fifty million cubic feet in volume. The dam subsequently built is not exactly at the location where the section of 1880 was made, so that the figures of the later and

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more detailed survey made by the Bear Valley company do not tally precisely with those of the preliminary reconnoissance; but they are close enough to prove each substantially correct.

At different elevations of the water plane the areas of reservoir surface and capacities of reservoir space are as follows:—

Elevations of Water Plane.		Corresponding Areas of Reservoir Surface.	Capacities of Reservoir: Totals Above Ground Surface.	
Above Base of Dam.	Above Outlet.			
Feet.	Feet.	Acres.	Cubic Feet.	Mill. Galls.
(1)	(2)	(3)	(4)	(5)
5	. . . . .	0.75	65,000	.48
10	0	4.95	631,000	4.72
15	5	10.23	2,271,000	16.99
20	10	34.93	6,921,900	51.78
25	15	141.36	17,898,450	133.87
30	20	294.54	67,850,660	507.52
35	25	427.79	145,808,450	1,090.65
40	30	1,060.01	312,153,521	2,334.91
45	35	1,425.02	581,855,607	4,352.28
50	40	1,691.41	920,824,487	6,887.77
53	43	1,858.99	1,152,729,883	8,622.41
55	45	1,960.49	1,307,277,775	9,778.44
57	47	2,069.26	1,482,801,898	11,091.36
60	50	2,251.50	1,763,166,320	13,188.38
65	55	2,532.00	2,283,791,020	17,082.76
70	60	2,812.00	2,834,253,750	21,199.22
80	70	3,300.00	4,161,190,000	31,125.70

COST OF THE WORK:—The dam cost about $68,000, which, together with expense attending the management, and collateral costs during its construction, brought the total to about $75,000. There were upwards of one thousand six hundred barrels of cement used, all of which had to be hauled by wagon from San Bernardino over seventy miles of rough and heavy road, away round the mountains and up the desert face of the chain to Holcomb valley, and thence down Bear valley from the east, although the dam itself is not over twenty-one miles from San Bernardino in an air line. This transportation cost over $10 per barrel, and the cement in all cost over $20,000. This circumstance of heavy transportation and inaccessibility of location made all rates high, and the cost excessive for its bulk. Under these circumstances it seems that another kind of dam might have been constructed to advantage.

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The question of water-supply will be discussed in a division of this report devoted to Water-Supply in Southern California.

Bear Valley Canal Works.

DISTRICTS AND WORKS:—The waters of Bear Valley reservoir being liberated, come down Bear creek and the Santa Ana river. The character of the river channel is such, and loss in it so very great after leaving the cañon, that it is desirable to take waters out of it at as high a point as possible. The Bear Valley company found the North Fork and South Fork ditches in possession of the point of advantage—the highest place at which diversion could be effected without extraordinary expense and cost for works, which would have to be located on rough cañon and mountain sides. After long and wearisome negotiations, agreements have been effected under which the Bear Valley company have secured right of way for its waters out from this point, and through the North and South Fork ditches.

The North Fork ditch has already been described, as reconstructed or in process of reconstruction, in carrying out the purposes of this agreement. The Bear Valley company is a joint owner in that work, at present up to half interest, and has the privilege of further increasing its size and capacity. Thus, the company have secured an outlet for its waters around the northern rim of the basin, and which could be prolonged to reach far out upon the Cucamonga plain, lying to the west.

Under an arrangement between the Bear Valley company and the owners of the shares of the South Fork Ditch Association, the Bear Valley company have taken possession of the old South Fork ditch, have partly rebuilt it, and are to complete its reconstruction for the joint service of the two companies. And, under a further agreement between the Bear Valley company and the Redlands Water Company, the Bear Valley company is reconstructing the Redlands ditch as a continuation of the South Fork ditch, thus making a continuous line out from the "divide" at the Santa Ana cañon, around on the southern plain and mesa, which contains the settlements of Lugonia, Redlands, West Redlands, Old San Bernardino, and some others. On this side also, an extension of the works would give command of the bench-lands lying back of Mound City, and even those of the high mesa of Riverside, above the Gage canal.

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The Bear Valley Canal.

CANAL AND STRUCTURES:—The work as it now is may be described as follows: Commencing at the "divide," the waters flow down a natural channel-way through bowlders and gravels for somewhat less than half a mile; thence they are led partly in a natural channel, and partly in artificial cuttings still through the same river-wash, about a quarter of a mile farther, to a place that may be called the southern face of the cañon mouth.

Flumes; Paving and Cementing:—Here they are taken into a flume forty-eight inches wide and thirty-two inches deep, and carried around the base of the southern bluff for a distance of two thousand six hundred feet, gradually coming out upon the first bench-land south of the river. Thence the canal is constructed across three flat points of bench-land, crossing in its route two deep arroyos or barrancas, a distance of two thousand six hundred and fifty feet to the great barranca known as Mill Creek wash. This work is in the form of a paved and cemented canal, two feet wide on the bottom, five feet on top, and three and a half to four and a half feet deep. The paving and masonry walls were put in by line, in mortar, and cemented over the whole surface. It was constructed in the spring of 1885. Its grades are eight inches and twenty inches in the one hundred feet, and its capacity is placed at three thousand inches. The flumes across the two arroyos mentioned are three hundred and sixty feet, and two hundred and ninety feet long, respectively, and are mainly supported on trestles, but with a truss bridge support, over the main channel-way, forty-five and twenty-nine feet high, respectively, about the central part of each. Across Mill Creek wash is a flume forty-eight inches wide, twenty-four inches deep, and two hundred and forty feet long, supported on trestles. This is a work of the old Sunnyside or South Fork Ditch Association, and was constructed about 1878. It is now in dilapidated condition, and is to be replaced.

From Mill Creek wash for one and a half miles in a southwesterly direction, the work follows in quite a direct line, and over the route of the old South Fork or Sunnyside canal. As originally constructed, this was simply an excavated ditch, following the uneven grades of the ground's surface, with a cobble and gravel bed, three and a half feet wide on the bottom, five feet on top, and

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two feet deep. During the past spring the Bear Valley company reconstructed three thousand two hundred and ninety-five feet of this ditch, making it a paved and cemented ditch two and a half feet wide on the bottom, five feet wide on top, and three and a half feet deep. This lining work was partially guided by mold-boards instead of a line; and the mortar was applied in the form of a thin grout. The rock was near at hand. The work cost $1 35 per linear foot, for the masonry. At about a quarter of a mile above the lower end of this section is what is known as the Sunnyside "divide," where the waters of the Sunnyside canal are turned into the old channel, which takes them westerly into the Lugonia district, as elsewhere described. At the lower end of this division of the Bear Valley work, the J. & B. ditch joins it, having come around on a lower grade-line, west of the Bear valley's course.

Thence the Bear Valley canal follows on nearly the old alignment of Redlands ditch, which was first constructed in 1881, almost on a due southwest course, to and across the Mill Creek *zanja*. As built, this was nearly a straight piece of ditch, and was roughly paved and partly cemented; was about two and a half feet wide on the bottom, two feet deep, and five feet on top, being very irregular, however, in form as well as in grade. Of this old work during the past spring, about five hundred feet were reconstructed, set deeper in the ground, and repaved and cemented. The bottom being two and a half feet wide, top seven feet, depth three and a half feet, and the grade 0.2 in 100. This portion of the ditch was lined as follows: After making the excavation to a determined form, mold-frames and boards were set in it, leaving an annular space of about one foot in thickness between them and the sides of the excavation. Into this space, on each side, and so as to thoroughly fill it, sides and bottom, small stones and cobbles were put in layers of about one foot at a time, and then into the interstices of each layer, a thin lime mortar, one part of lime to nine of sand, was poured, which thoroughly filled the space. This, setting, made quite a firm concrete, presenting a smooth surface after the form was removed, about four to five days afterwards; then a three to one cement plaster, half an inch thick, was immediately put on, and the whole was kept wet for ten days or more. This work thus far has stood well, there having been no cracks or checks in it. It cost (rock hauled some distance) about $2 per linear foot for, the masonry works complete.

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Across Mill creek *zanja* there is a flume four hundred and thirty feet in length, three feet wide, two and a half feet deep, on a grade of 0.3 in 100, all of redwood and well constructed. This brings us into the fifth division of the work, which extends from Mill creek *zanja* to the Yucuipa reservoir of the Redlands Water Company. Following the general line of the old Redlands canal, as constructed in 1881–82, the new work here is gradually getting back on to the comparatively high bench lands and nearing the foot-hills of the southern range. As originally constructed, the old canal was about ten thousand feet long through this division. It was very crooked and of irregular grade and cross-section, but generally two and a half feet on the bottom, four to five feet on top, and two feet deep. During the spring of 1888, the Bear Valley Water Company have reconstructed this ditch for a total length of three thousand eight hundred feet of paved and cemented work and six hundred feet of fluming. This new work commenced about two thousand five hundred feet from the head of the division, and from being straight in alignment has shortened the channel about nine hundred feet. The original Redlands ditch was very roughly paved and cemented. The reconstructed part for two thousand eight hundred feet has been paved, but is awaiting settlement to be cemented next year. Of this the bottom is two and a half feet wide, top seven feet, and depth three and a half feet. About one thousand feet of the new work is two and a half feet on the bottom, three feet deep, with side slopes of one to one. This part is lined on the sides to a thickness of one and three quarters inches with a cement plaster, made of one part of cement to four of river sand, put directly on to the dressed earthen sides of the excavation with a trowel; and on the bottom, with a concrete made of fine gravel screenings and river sand (four parts to one of cement) and tamped in place. This whole lining was then brushed over with a thin grout of cement. The plaster and concrete work cost about $1 per linear foot of canal over all, and thus far has done well, although some cracks have made their appearance.

DISTRIBUTION WORKS:—The Yucuipa distributing reservoir is at the end of this section, and into it the waters of the canal are led, and taken thence, as described under another heading, into the pipe distributing system of the settlement of Redlands. Across the arroyo, in which is the dam for the reservoir, and just below

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the dam, the Bear valley waters are led in a twenty-two-inch wrought iron, riveted, pressure pipe, one thousand two hundred and twenty-five feet in length, with a maximum head of pressure of fifty feet, and a hydraulic gradient of one foot in one hundred. Thence, flowing still westerly, around the extreme upper edge of the mesa, and sometimes on the steeper hillsides, the waters are led in a thirty-inch cement pipe, laid in a trench and covered. In laying this pipe, it was plastered with cement on the inside and outside; its length is two thousand three hundred and seventy-five feet, and grade 0.3 feet in 100. This is the end for the present of the Bear Valley main work on the south side of the river, and here is placed a concrete chamber into which the waters are received, and from which they are apportioned out over weirs to four pipe lines. Of these, one supplies a portion of the Redlands colony water; another furnishes West Redlands and Terracina; the third extends to Gladista and the Drew tract; and the fourth skirts the valley, and crosses San Timoteo creek to Mound City.

POSSIBILITIES OF THE PROJECT:—The Bear Valley company's reservoir site and water-supply, and its command of advantageous lines of delivery for its waters, constitutes the basis of a property which could be made of inestimable benefit to a great area of rich and fruitful lands, favorably situated in one of the most important irrigation regions of the State. Putting out of view the works by which the purpose has been, or is sought to be accomplished, and concerning which this report only states facts without comment, the work is one of importance to the irrigation interests of the state. Fully and properly accomplished, this conservation of water supply might be made not only to greatly extend irrigation in San Bernardino county, but to save the irrigation interest from disaster in years of drought which are sure to come.

History of the Work and Organization:—During the summer of 1880 a topographical survey was made of Big Bear valley, as a reservoir site, under the direction of the State Engineer, for the state, and it was reported upon as one of the best locations for the purpose found in Southern California. In May, 1883, it was visited by F. E. Brown, a young civil engineer, in company with Hiram Barton, who was familiar with the San Bernardino mountains. Brown had heard of the survey and report on the reservoir site, and Barton had seen the place. Both had become impressed

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with the advisability of storing the flood waters of the Santa Ana river, from experience in irrigation and water development works, in the neighborhood of Redlands and old San Bernardino. Returning to San Bernardino, a company was formed. This organization was at first in the nature of a partnership, in which there were thirty-six parts or shares.

A purchase was made from Los Angeles owners of three thousand eight hundred acres of the land, and seven hundred acres were obtained from the Southern Pacific Railroad Company, and from the government, which all cost in round numbers, about $25,000 to $30,000, and which embraced all of the reservoir site desired, and part of the water-shed. Work was begun on the dam on September 27, 1883, and continued until November seventeenth, when the winter's near approach compelled its stopping for the season, and the retreat of the force to the lower valleys. An excavation for the foundation was made, and about two hundred and fifty cubic yards of masonry were put in place during this short season. On July 3, 1884, work was resumed and pushed forward during that summer until about the last of November, when the dam, so far as projected, was completed, except a part of the coping and flood escape-way.

ORGANIZATION:—The Bear Valley Land and Water Company was incorporated in September, 1883, with a capital stock of $360,000, divided into three thousand six hundred shares of $100 par value each, of which the whole amount was taken by eleven local subscribers, in lots ranging from fifty to one thousand shares each. The principal place of business was named at San Bernardino, and term of incorporation fixed at fifty years.

Thirty thousand dollars were at once paid up, and to this time, July, 1888, $180,000 have been paid in by the stockholders, in the way of original payment and subsequent assessments. Each share of stock was intended to represent one inch of water flowing throughout the irrigating season of six months. The price of this stock gradually increased. In the spring of 1884, it had cost the holders $4 50 per share, and was selling at $25 per share; and in the summer of 1887, it had cost the holders $45 per share, and was selling at $225 to $255 per share. In addition to stock certificates, the company has issued water certificates to its stockholders, which are transferable independent of the stock shares,

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and which are in the nature of water-rights in the Bear Valley water-supply.

Water Certificates:—Such certificate entitles its holder to receive a continuous flow of one seventh of an inch of water to the acre of land, to which the said certificate may be applied, for the six summer months, in each year, specified in the contracts of the Bear Valley company with the North Fork and South Fork companies. The holder of such certificate may elect to cumulate the water under it in any one or more months of the six mentioned, receiving in any one month not to exceed one fourth of the whole for that six months. The holder is also entitled to his proportion of the six months' winter-water, accruing under the contracts with the North and South Fork ditches, in the proportion that his certificate, and those that may hereafter be issued, bears to the whole of such benefit.

Notable conditions of these certificates are contained in the following: "This issue or award of water is adopted as a method of distribution and of the use of the same to the company's stockholders, in consideration of the covenants contained in the indorsements hereon; and the interest represented by this certificate shall not become appurtenant to or pass by voluntary act or by operation of law, with any land upon which the water represented may be used; and a transfer hereof shall only be made by surrender of this certificate to the company and the issuance of a new certificate, and upon the signature of the concurrent contract upon the records of the company."

The holder of the certificate is required to sign a contract, wherein he agrees, in consideration of benefits accruing to him by his right to the use of the waters, and "in payment for the water which the certificate entitles him to receive each year," from said corporation, "in accordance with the provisions of the certificate," that he "will, without notice or demand, pay" to the Bear Valley company "annually hereafter, at a certain stated time, each year, the sum of $1 per year for each water certificate," and if he does not make this payment as specified, his water-right will become "null and void, and all rights thereunder will be forfeited," etc.

The share of stock representing one inch of the supply, there may be seven water certificates issued for each share or inch. The basis of this arrangement is, that the waters of the reservoir

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are to be used in the ratio of one inch flowing during the irrigation season to seven acres of land; and that when the water-supplying capacity of the water-shed and reservoir are fully developed, the company will be able to deliver three thousand six hundred inches for six months during each season. Only two certificates per share have been thus far delivered, and another is now ordered issued. But it is the intention of the managers of the company not to issue the full number until the capacity of the work is more fully demonstrated by the experience of rainfall in succeeding years. These certificates sold during the summer of 1887 as high as $80 each, which fixed the value of the water-right as a whole, as represented by the two issues at $576,000, supposing that the company thought itself safe in issuance up to that time. The receipts from the third issue, which is probably the last that will be put out for some time, are expected to be $360,000, and this amount will be held for a construction fund.

The North and South Fork Companies' Combination:—Under agreements made with the North Fork Water Company, and others, owning interest in the North Fork canal, and with the owners of the South Fork water-right and ditches, the Bear Valley has secured right of way for its waters through these North and South Fork canals, and has thereby secured an outlet for them on each side of the river—around the margins of the valley—so as to command the whole region which may naturally look to these waters for irrigation. The North and South Fork associations, be it remembered, claimed, and had done much to firmly establish the right to all the water flowing in the river at the mouth of the cañon, up to the diverting capacity of their ditches, which capacity of each had been for a number of years about one thousand to one thousand two hundred inches. Their combined capacity for diversion, say two thousand to two thousand four hundred inches, exceeded the ordinary low-water flow of the river at that point. Almost every year there was a great deficiency of supply to fill the ditches during the months when water was needed most. The seasons of 1881, 1882, and 1883 had presented exceptionally meagre supplies, as shown by the following table deduced from many measurements at the point in question:

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Mean Daily Flows for Months Named.

Month.	1881.	1882.	1883.	Average.
May	1,200	1,200	1,200	1,200
June	1,100	1,140	1,140	1,106
July	1,000	900	900	782
August	700	640	640	776
September	816	644	644	800
October	1,024	840	840	954
November	1,106	1,070	1,070	1,086
December	1,122	1,088	1,088	1,108

Although the companies had probably never economically conducted and utilized so much as six hundred miner's inches each—on account of great loss in mains and distributing ditches—they had probably made good, as things have gone in such matters, a claim to full one thousand inches each, and would have had the right to improve their works to have taken in that amount each, at all times when in the river, and to have saved all theretofore lost in transit through their works. But, although there would be a supply in many seasons during the low-water months, sufficient to yield each canal six hundred inches, periods like that of 1881 to 1883 were sure to come when the flow would be much less—when about three hundred and twenty to three hundred and fifty inches for each work would be the controlling supply, and to that delivery practice would inevitably limit the measure of irrigation by each ditch.

It was feared there would be some difficulty in determining just how much water there was due in the stream naturally during the low-water periods, at the point of diversion—and to which these two canals would be entitled—and what amount might be due to the current Bear Valley delivery. The natural supply varying from day to day, there being also a very material diurnal variation in the flow, and the proportion of loss in flowing through the cañon, under varying conditions, being even in a greater degree variable and largely unknown, an everlasting series of agreed observations and hourly adjustments of the division would, it was foreseen, become necessary, to avoid conflict.

Moreover, the two canal companies claimed that the Bear Valley dam had cut off a large portion of the low-water flow of the stream, which was an unknown portion. The Reservoir company denied

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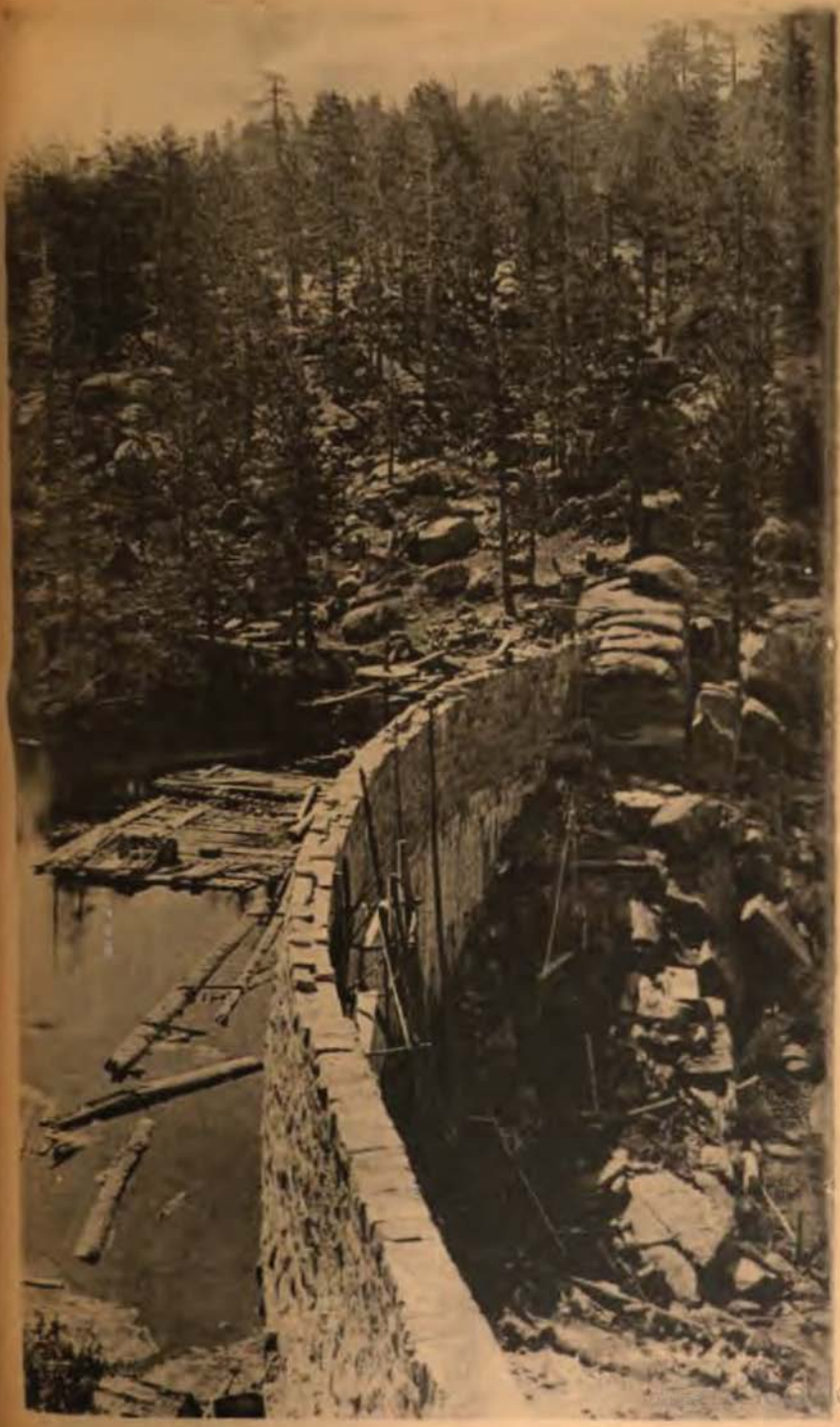
this; alleged that there had been no flow whatever out of Bear valley during low-water season; and claimed that the great lake above would probably in time, by forcing percolation through the rock seams, start and maintain springs in the lower cañons, and thereby add to the low-water supply of the stream. Because of these and other uncertainties and impending conflicts, all parties concerned were desirous of some equitable adjustment which would simplify and establish the terms of division of the waters, and provide for the administration of the agreement, whatever it might be.

North Fork Agreement:—The adjustment was effected with the North Fork company during 1885, to take effect June 1, 1886. The following is an abstract of the agreement: For purposes of carrying out the terms of the arrangement, the control of the water-supply is accorded to the Bear Valley company, and the North Fork company relinquishes to the reservoir company all claims to water beyond the supply specifically agreed to be furnished it, the canal company, by the reservoir company, which is as follows: June, a continuous flow of five hundred inches; July, six hundred inches; August, six hundred inches; September, five hundred and fifty inches; October, four hundred and fifty inches; November, four hundred inches. The canal company reserving the right to call for and receive the maximum supply of six hundred inches for either of the four months first named, provided the total supply to it for those months shall not exceed two thousand two hundred and fifty inches. During the remaining six months in the year, one fourth of all the water flowing at the point of division, exclusive of additional supply contributed from the reservoir, is "to belong to and to be delivered to" the canal company by the reservoir company.

The reservoir company purchased a one half interest in the North Fork company's canal for $4,000, and the two companies join in enlarging, reconstructing, and paving their canal, so as to make it a well finished structure, capable of carrying one thousand five hundred miner's inches of water, each paying one half the expense of such work, and agreeing to pay one half of the expense of future maintenance. Beyond this, either company may further enlarge the work—at its own cost and risk, however.

By failure to comply faithfully with the terms of the contract, and supply water to the canal company as specified, the reservoir

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company would forfeit all the rights accorded it, under the agreement, by the canal company. But mere technical failure or temporary failure attributable to accident to the company's works, or to the act of God or nature, beyond the control of the company, shall work only an equally temporary restoration of the primitive rights of the canal company independent of the reservoir company.

By this agreement the North Fork company has secured for every year, including controlling years of short supply, six hundred inches in place of four hundred inches flow of water, during the two or three months of greatest demand. By which, although it will receive a less amount during other months, it is claimed that its power of irrigation is practically increased 50 per cent. It also has the coöperation of the Bear Valley company in improving and maintaining its canal, which is a measure of present saving, and economy for all time; and it thereby secures a water-way capable of carrying for it all the way through, seven hundred and fifty inches of water, which amount it expects to secure as its share of the river flow during early spring months.

On the other hand, the Bear Valley company controlling a supply unaffected by the current flow of the streams, and commandable to the full extent for every month of the year, has, on the basis, for instance, of the average monthly flow for the three years 1881–1883, agreed to furnish in six months three thousand one hundred inches in place of two thousand nine hundred and fifty found in the stream; and for the difference, one hundred and fifty inches flow for one month, it has secured a right to a much greater flow during other seasons of the year which can be utilized for delivery to its customers in place of water from its reservoir. Moreover, it has secured control of the situation, adjusted conflicts which might have proven embarrassing, and has the cooperation of the North Fork company in constructing one of the two necessary main canals for the delivery of its waters.

South Fork Agreement:—The agreement between this company and the South Fork Canal Association is, in principle, as affecting water-supply, substantially the same as that with the North Fork company. There is no such close and unavoidable community of interests in the matter of canal construction, however, as there is on the north side; and, moreover, the South Fork people not

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being so well organized and harmonious, were not in a position to agree on terms in this regard which would bind them to share in expensive work.

This agreement is substantially as follows: In consideration of the grant of rights or claims to all surplus waters of the river which the association or its members might have, over and above those amounts named in the agreement, the Bear Valley company agreed to furnish to the South Fork association during the months from May to October, inclusive, for each and every year in the future, a continuous flow of water equivalent to four hundred and sixty-six and two thirds miner's inches. The South Fork association, however, reserves the right to lessen the amount taken by it in any one or more of these months named, in any year, and to add the amount thus saved in any month to the amount to be delivered in any other one of these months, provided the total amount taken during any one month shall not exceed six hundred inches of continuous flow, and provided that this request shall be made prior to April twentieth of the year in which it is desired to make the change.

Beyond this, the companies agreed to divide the waters of the river, available for the South Fork ditch in the other six months of the year, namely, April to November, inclusive, in the following proportion: The Bear Valley, to deliver at least a continuous flow of three hundred inches to the South Fork. If, after the delivery of these three hundred inches to the South Fork, there is a supply of water greater than six hundred inches in the river, due to the Bear Valley company, then one half of the excess above six hundred inches up to and sufficient to make six hundred inches in all, shall be delivered to the South Fork association. On the contrary, if, after the delivery of three hundred inches to the South Fork, there is available under this agreement for the Bear Valley company less than six hundred inches, then one half the deficiency shall be deducted from the three hundred inches, and only the remainder be furnished to the South Fork association. It is provided that the South Fork ditch, as compared to the North Fork, shall always receive as great a part of the river water in the future as it has ordinarily received in the past.

As to the construction of new ditches: it is provided that the Bear Valley company may enlarge, construct, or extend the South

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Fork ditch at its own expense, but if it does so it shall thereafter keep it in repair and operate it. In case that the Bear Valley company does reconstruct and rebuild the ditch, and at some future time fails to perform its contract, then the South Fork people may, in their discretion, buy the ditch at an appraised value, to be fixed upon the basis of a capacity not to exceed two thousand inches.

If, however, the South Fork association does not wish to purchase the ditch so constructed, then it shall have a perpetual right of way for a maximum of six hundred inches of water through the ditch down to the Sunnyside divide—the excess of capacity and the ditch, to belong to the Bear Valley company.

Should the Bear Valley Company fail to comply with the terms of the agreement with respect to the delivery of water-supply, it is to forfeit all of the rights and privileges which it acquires under this agreement. But a mere temporary or technical failure, beyond the control of the Bear Valley company, is not to work such forfeiture. The waters to be furnished under the agreement are to be measured out at the Sunnyside divide, near the point known as the Sycamore tree, at the head of the old Redlands ditch.

Bear Valley Branch Works.

From the end of the Bear Valley main four pipe lines extend, as already enumerated. These may be briefly described as follows:

Gladista and Drew Line.

This main distributary is a twelve-inch cement pipe, extending down the mesa, through Redlands; and thence diagonally in a northwest direction across the plain, a total distance of about three miles, to the Gladista tract, which is west of Lugonia; and thence ten-inch and eight-inch cement piping is laid westerly through this tract to Drew tract, which is next north of Old San Bernardino. These settlements are only about eighteen months old.

Mound City Main.

From the end of the Bear Valley south side main conduit, a wrought iron riveted pipe, thirteen inches in diameter, is carried across the West Redlands settlement; thence across San Timoteo cañon, and out on to the bench-lands still westerly to Mound City, a total distance of five and one half to six miles.

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East Redlands Water Company.

District and Work:—A tract of four hundred and fifty acres in area lying adjacent to the northeast end of the Redlands settlement, on the same bit of mesa, and commanded by the old Redlands ditch, now the Bear Valley canal, is known as East Redlands. It is a colony settlement very much on the plan of Redlands, and its irrigations are effected through works owned and controlled by the East Redlands Water Company. These works are mere distributaries of waters from the Bear Valley canal, and consist of three fourths mile of twelve-inch, one and a half miles of eight-inch, four miles of six-inch, and three miles of five-inch cement concrete pipe, laid and arranged on the same general plan as those of the Redlands system. The total expenditure on works has been about $10,000.

Operation and Maintenance:—The promoters of this enterprise owned the land, and had Bear Valley water certificates as water-rights for use thereon. They organized the East Redlands Water Company and placed in it one thousand certificates, which call for one seventh of an inch of water each from the Bear Valley supply, taking the stock of the company in return. In selling the lands they transferred one share of the water stock with each acre. The works are in charge of a *zanjero*, and are operated upon the same principle as those of Redlands. The colony being quite new, there are no developments of interest in this connection.

Water-supply and Use:—The water-supply is represented by that of Bear Valley, in the proportion of certificates held. There are at the present time one hundred and fifty acres under cultivation, chiefly in citrus fruits and raisin grapes, owned and irrigated by about twenty irrigators.

History; Organization:—The East Redlands Water Company was incorporated in September, 1886, with a capital stock of $100,000, divided into one thousand shares. Its purpose is to supply water to stockholders only.

West Redlands Water Company.

District and Work:—Lying immediately west of the southeast end of Redlands colony lands is a tract of one thousand acres of

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similar red mesa formation, which has been placed in the West Redlands colony enterprise. The West Redlands Water Company is organized for its irrigation service. The works, taking their supply from the Bear Valley canal, consist of about two miles of fourteen-inch, one mile of twelve-inch, one and a half miles of eight-inch, five miles of six-inch, and four miles of five-inch concrete cement pipe, laid and planned on the same principle as those of the original Redlands. The cost thus far has been about $15,000.

Operation and Maintenance:—This is an exactly similar organization to that of East Redlands, with similar water-rights and same relation between the company and its stockholders as water customers; and it is operated and maintained in the same way. Each share of stock represents a right to the water due one Bear Valley certificate, and the right to have it delivered through the pipe system of the company, and there is a share conveyed with each acre of the tract sold. Distribution is in charge of a *zanjero*, and is made upon orders received from the irrigators, and arranged in rotation by the watermaster.

Water-supply and Use:—As explained above, the lands have a Bear Valley water-right of a seventh of an inch to each acre. There are about one hundred and fifty acres irrigated by about fifty irrigators—this being the first year of cultivation.

History; Organization:—The West Redlands Water Company was incorporated in April, 1887, to supply water to its stockholders, with a capital stock of $100,000, divided in one thousand shares. Its life has been too short to have afforded much opportunity for a notable career.

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CHAPTER VIII.—SAN BERNARDINO[3]; WORKS AND PROJECTS[6].

SANTA ANA RIVER WORKS.

THE BASIN DIVERSION GROUP[2]. THE RIVERSIDE MESA SUB-GROUP[a].

SECTION I.—*Riverside Water Company's Works:*
The District: Lower Part of the Mesa;
The Three Canals and Pipe-line;
Operation and Maintenance;
Water-supply and Use;
History of Works and Water-right.

SECTION II.—*The Gage Canal:*
The District: Higher Part of the Mesa;
The Canal and its Structures;
Distribution and Administration;
Water-supply and Use;
History of Works and Water-right.

SECTION III.—*Vivienda Water Company's Project:*
The District: Highest Part of the Mesa;
Proposed Pipe-line and Flume;
The Sources of Water-supply.

THE RIVERSIDE MESA IRRIGATION WORKS.

Those works which serve or are intended to serve the lands of the Riverside mesa, or plain, have been referred to as constituting sub-group (*a*) of the San Bernardino Basin Diversion group. They are the Gage canal, the Riverside Warm Creek canal, Riverside Old Upper canal, Riverside Lower canal, Riverside pipe-line, and the projected pipe-line of the Vivienda Water Company. Strictly speaking the two old canals of the Riverside company do not divert or obtain water within the San Bernardino basin proper, but at points just at and below its outlet. Nevertheless, receiving waters from rising sources in the river, and delivering them out upon the Riverside plain, they are conveniently classed in this group.

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SECTION I.

THE RIVERSIDE COLONY ENTERPRISE.

The Riverside Water Company's Works:—Field and Works. *The Lower Canal:—District and Work;* Canal and Structures. *The Old Upper Canal:—District and Work;* Canal; Dam and Headwaters; Flume. *The Warm Creek Canal:—District and Work;* Canal; Paving and Cementing; Flume and Trestle, Tunnel Work, Culvert, Wasteway; Cost. *The Canal System:*—Independence of Works; Conservation of Waters; Paving and Cement Canals; Water Power; Connecting Canal; Waste-water Canal; Summary of Works; Summary of Cost. *The Riverside Pipe-line System:—Domestic Service;* Artesian Water-supply; Main Pipe; Distribution.

Operation and Maintenance: Organization and Management; Water Distribution and Measurement; System in Distribution; Service and Sub-districts; Pipe Distribution; Maintenance; Cost. *Revenue and Expenses:* Water Rates, 1880; Irrigation Water Rates, 1872–88; Expenses and Receipts; Revenue, 1885.

Water-supply and Use: Available Supply and Progress of Diversion; Canal Capacities and Appropriations; Diversion and Use, 1871–88; Use of Water, 1886–87; Progress of Irrigation Cultivation; Irrigation Statistics. *History of Enterprise:* The Old Companies Operations; The Water-rights and Rates Conflicts; Progress Under the New Regime.

The Riverside Water Company's Irrigations.

Field and Works:—The works of the Riverside Water Company consist of three main canals and diversions, an extended irrigation distribution system, and a main pipe-line, and branches for the delivery of water, chiefly for domestic purposes. These take supplies from the Santa Ana river and Warm creek, and from artesian wells in the San Bernardino basin, and deliver them to an extensive district along the lower edge and towards the farther end of the mesa plain, which reaches south and west from the southern border of San Bernardino valley, to the Temescal wash.

Riverside Lower Canal.

District and Work:—At a position about a mile and a half below the California Southern railroad crossing of the Santa Ana river, just south of Colton, at the head of the Jurupa valley, the Riverside Lower canal takes water from the left or east side, and thence carries it southerly and nearly parallel to the stream, only very gradually leaving it and getting back upon the lower portion of the sloping mesa on which is Riverside and its surrounding cultivations. From the point of diversion to the extreme

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lower end, where it is dropped, as a distributary, to irrigate lands down on the plain, is 11.40 miles in a straight line, and the canal itself is 13.50 miles long between these points. For the first half of its length it does not get over a mile or a mile and a half from the river, and more than half the narrow strip thus commanded is moist bottom lands, not regarded as desirable for the local horticultural cultivations. At about half way along on its course, however, the plain commanded by the canal widens out, so that its total available district without extension embraces about six thousand acres; not all of which, however, is within the Riverside settlement, as defined by its surveys and the old land company's ownership.

CANAL AND STRUCTURES:—The canal heads on a flat, sandy, river-bottom formation, and takes water out by a long, straight cutting, running for nearly a mile parallel with the stream, and but a short distance from it. The diversion is facilitated by a brush dam which partially washes out each season of flood. At about a mile and a half from its head the work gets out on to firm bench-land formation. It is built almost entirely in cutting for its full length; the original dimensions having been eight to ten feet wide on the bottom, four feet deep, and fourteen to sixteen feet wide on top. Commencing at the river, elevation eight hundred and fifty-three feet above the sea, it is one thousand four hundred feet to the upper headgate, and one thousand nine hundred and sixty-two feet in all to the lower regulator and sand box. This lower regulator is built in a rocky point of hill at the edge of the second bottom-land formation. Thence to Tequisquite flume is twenty-seven thousand feet on a uniform grade of 0.076 per 100; and from the lower end of this flume the grade varies between 0.07 and 0.08 per 100. At one hundred and fifty feet below the lower regulator the Lower canal receives through a chute the waters now diverted by the Old Upper canal. At eight hundred and ninety feet below the regulator the Trujillo ditch receives its waters through the canal's right bank. At 4.72 miles the Twelfth-street cross canal, coming through Riverside from the Upper canal, is received. At 12.92 miles from the lower regulator it is joined by the Upper canal, which is rapidly dropped at its lower end, where the normal grade would carry it back upon rough foothill ground. With the exception of the Tequisquite flume,

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elsewhere spoken of, there are no notable structures on the line of this work. The intake water-flow is controlled by two regulators and escape-ways; one an ordinary light wooden structure, and the lower a new work in heavy timber and masonry.

It may be said of both these canals, that they course diagonally through the mesa: commanding the narrowest possible strip at its upper end—they dominate at their lower termini its entire width, except some recesses between hill points.

Riverside Old Upper Canal.

District and Work:—Commencing about a mile above the lower canal, where the river runs close against the base of a rock point on its south bank, the Riverside Old Upper canal was built around the western face of a rocky hill, a distance of about two and three quarters miles, to the western edge and northern end of the mesa, and thence, in a general course, southerly and diagonally, through the length of this plain, a total distance of about 15.32 miles from the point of diversion. Starting at an elevation 31.5 feet above the head of the lower canal, the upper work holding a higher position on the sloping mesa, commands for irrigation an additional and very irregular strip of territory lying between the two, which is generally about half, and nowhere exceeds three fourths, of a mile in width, and contains about three thousand acres, of which a large portion covers the choicest lands.

Canal and Structures:—The ruling grades of the Old Upper canal are: From upper waste-way, near the head, to junction of Warm creek waters, mean 0.049 per 100; thence, through the recently reconstructed section to the Twelfth-street canal crossing to the Lower canal, 0.059 per 100. The old part above the Warm Creek junction is eight feet wide on bottom, ten to fourteen feet on top, and three to three and one half feet deep. Following the completion of the Riverside Warm Creek canal, and its junction with this work, the old canal was enlarged from the point of joining, eighteen thousand nine hundred and twenty feet below its head, a distance of seventeen thousand and ninety feet, to the outtake of the Twelfth-street cross canal in Riverside, as hereafter described. This enlarged section is claimed to have capacity for five thousand miner's inches. As now used, the Riverside Old Upper canal diverts waters as formerly, conducts them a distance of nine thousand feet, and there drops them by a chute into

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the Lower canal. From this point of dropping, on to where the Warm Creek canal waters are brought in, a length of nine thousand nine hundred and twenty feet, the Old Upper canal is not now used, but is kept in order and ready for use.

Dam and Headworks:—The diversion is effected by means of a brush dam carried from a rocky point, up the river and parallel with the rocky bank of the south side, for about two hundred and sixty feet, and then diagonally across to the other bank, a total length of four hundred and fifty feet. This dam is one of the best structures of its kind in the southern part of the state. It is three to five feet above the bed of the river on the lower side, and twelve to fifteen feet in width, being composed of brush with the feather ends up the stream, sloping downward in that direction and laid diagonally with respect to alignment of the dam, in alternate layers crossing each other, the whole being pinned down by rough poles, or stakes of willow, three to five inches in diameter and from seven to eight feet in length, driven with a hand maul into the sandy bottom. The current at this point carries a large amount of fine sand which banks up against this dam, thoroughly filling it and making it nearly water tight. A similar dam at this point withstood the annual Santa Ana floods for four or five years, but was washed out by the high floods of 1883–84. The present structure, though not washed out, sinks some every year, and has to be added to each spring as the water recedes. The canal takes water in a cutting against the rocky hillside, with its head-gate located on rock. About five hundred feet below the extreme opening there is a regulator, escape-way, and sand-box to relieve it of the sediments and surplus waters. These structures are all of wood. Thence it is cut along the face of the hillside in rock for the most part—an expensive construction—for about two and three fourths miles, when it comes out on the mesa and courses around on that plain. At points where the Upper canal is on the steep hillside, the lower canal, thirty-one feet below, is at the foot of the bluff hill—horizontally not more than fifteen feet away. The Upper canal has yet a small number of flumes, but as originally built it had a large number, and has been much more expensive in construction than the lower one, in proportion to its capacity, for this reason and others made apparent, it is hoped, in this report.

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Flumes and Trestles:—The high flumes on the old Riverside canals across Tequisquite arroyo, for a long while were the most notable works of their class in Southern California. The one on the Lower canal was built in 1876, but it is now giving away from age, and will soon be replaced by a new one. In building, all of the joints of this work were made with mortise and tenon, and these have been the first parts to rot out. In recent years, it has received frequent and expensive repairs. The flume on the Upper canal across the same arroyo was built in 1878, without mortise and tenon framing, and as yet has shown no serious signs of decay. Both of these flumes were lined with asphalt, which is considered by those in charge of the works to be indispensable. The Upper flume has on various occasions been dry for several weeks at a time in summer, and has not leaked when water was turned in again. This is accounted for by the belief that the asphalt, filling the cracks, is expansive, and, as the wood shrinks, it maintains a solid surface between the planks. The following exhibit brings the data of the chief ones of these structures, on the old canals, within small compass:

Names.	Total Fall in Length of Flume.	Dimensions.			Highest Trestle.	Drop at End.
		Width.	Depth.	Length.		
	Feet.	Feet.	Inches.	Feet.	Feet.	Feet.
Old Upper Canal:						
Garcia Flume . . .	0.2	6	30	90	22	0.5
Spanishtown Flume .	0.9	7	30	528	26	0.5
Tequisquite Flume . .	1.3		30	512	34	0.5
Lower Canal:						
Spanishtown Flume .	. .	10	32	25	. .	. .
Tequisquite Flume . .	3.4	8	30	850	42	0.76

Cost of the Old Works:—The following is an authoritative statement of the cost of the original Riverside canals (Old Upper and Lower), from the time of the commencement of the work in 1870, to the time of the sale of the canal property to the present Riverside Water Company in 1885:

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Earthwork	$125,391 50
Flumes, 2,400 feet main flume (this includes the renewal of two flumes)	25,280 00
Culverts of wood and brick	4,755 00
Bridges, of wood	7,260 00
Head-gates (2); Sand-gates (2); Waste-gates, of wood; Regulators.	5,775 00
Measuring boxes, of wood	4,825 00
Dams (2), of brush (rebuilt in part each year)	24,975 00
Superintendence (includes portions of officers' salaries for first year)	17,000 00
Engineering	6,500 00
Right of way	3,750 00
Total[1]	$225,631 50

Total lengths, to end of 1884, main canals, 28.8 miles; laterals, 46 miles.

Riverside Warm Creek Canal.

District and Work:—The purpose of the Warm Creek canal is to carry a large portion of the Riverside irrigation water-supply, on the shortest practicable route from the upper point of control of it, through to the region of distribution already commanded by the other canals, with a minimum amount of loss. Although commanding a large area of the mesa lands not covered by the other works of the Riverside Water Company, it cannot be used for their irrigation. It is simply a supply canal to the old works. This work takes water from Warm creek a little more than a quarter of a mile from its mouth, and at 932 feet of elevation above the sea, carries it around to and across the Santa Ana river, through the northern rim of the Riverside mesa, and to an arroyo out on that plain, a total distance of twenty-one thousand seven hundred and fifty feet, where it drops and then extends to the Old Upper canal—a total length of twenty-three thousand six hundred and eighty feet.

Canal and Structures:—It consists of (1) an open earthen canal ten feet wide on the bottom, four and a half feet deep, with side slopes of one and a half to one, leading from the point of diversion at the foot of the bluff bank of Warm creek to the old Matthews or Meek mill, where a drop of six feet furnishes water power. Its length to this point is two thousand two hundred feet, and the total fall one foot six inches for the channel and six feet

[1] The sum of the figures in this accounting is not equal to the total here given, but they are all presented as obtained, and it is not known whether the summing up is wrong or figures in the column above.

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for the drop; (2) a paved and cemented canal, nine feet wide on the bottom, four feet deep, with side slopes one on one and a half, leading thence around the bluff bank of Warm creek to the river bank below the creek's mouth, a distance of one thousand four hundred and fifty-five feet; (3) a flume on pile trestle-work, across Santa Ana river and adjacent bottom lands, with water-way eight feet wide and four feet deep, to a point of the bluff on the northern face of Riverside mesa—distance six thousand seven hundred and thirty-three feet; (4) a paved and cemented canal of the same dimensions given in (2), around the face of the mesa bluff, one hundred and forty-four feet; (5) a tunnel, lined and timbered, as hereafter described, through a point of the bluff, seventy-five feet; (6) a paved and cemented canal, as already described, around an arroyo in the face of the bluff, and partly in fill, to the face of the main bluff, three hundred and three feet; (7) a tunnel, lined and timbered, as hereafter described, through the edge of the mesa out into an arroyo on its southern slope, three thousand two hundred and seventy-one feet; (8) an open canal, in portions paved and cemented, nearly all in deep cutting, nine feet wide on the bottom, minimum depth four and a half feet, side slopes one on one, from the tunnel mouth out along an arroyo to the face of the plain, and thence around on the plain to the north edge of another arroyo, where a drop of forty feet is made, length seven thousand six hundred and fifty feet; (9) an open canal, in portions paved, etc., nine feet on bottom, four and a half deep, slopes one and a half to one, grade 0.057 per 100, around the side of an arroyo in the mesa, to the Old Upper canal, a final length of about one thousand eight hundred. The total length is twenty-three thousand six hundred and eighty feet, or 4.48 miles from the dam of diversions in Warm creek to the junction with the Old Upper canal. Divisions (2) to (8), inclusive, have a uniform grade of 3.52 feet per mile; (1) and (9) differ from this somewhat.

Excavation:—The excavation in that portion of the work north of the river was in a light, sandy, alluvial deposit, in many places so loose as to have little consistency as a bank. South of the river throughout the open cuttings, the excavation was in heavy mesa soil and subsoil, making costly work. Some of these cuttings were quite deep and in hardpan, which constituted fully one half of the material of the south side, so that blasting was continually

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resorted to. The total excavation, exclusive of tunnel work, cost $5,990.

Paving and Cementing:—The lined portions of the canal were paved with limestone rubble from six to eight inches in depth, set in lime mortar with a little cement in it, and covered with a plaster, one of cement to three of sand, with some lime, and then washed over with a thin grout of pure cement. The cost of this paving and cementing ranged from $2 to $3 per linear foot of the ditch, according to the distance the stone had to be hauled; the average haul being about one and three fourths miles, and the average cost $2 75 per linear foot.

Flume and Trestle:—The plan of the flume is quite similar to that of the San Diego Flume Company, already fully described. It rests on piles driven to an average depth of about ten feet. The driving was easy, in sand and light alluvial soil; in some parts no firm bottom was reached. The maximum height of the trestle above the river bed is twenty-eight feet. Nearly the entire work is of redwood, which cost, selected, $29 to $30 per thousand, and, rough, $19 to $20 per thousand. The pine cost $17 to $18. The inside of the water-way is thoroughly pitched or tarred with a prepared material. The cost was at the rate of about $3 33 per linear foot for all the woodwork, and 10 cents for the caulking and tarring.

Tunnel Work:—The long tunnel is excavated for full seven eighths of its length through a sort of hardpan resembling a marl, which required blasting. One streak of quicksand for three to five feet in thickness was encountered, which gave much trouble in passing. All except the sand, and about one tenth of the whole additional which was through a friable soil, stood without timbering and lagging. The cost of excavation of a portion of the tunnel (said to have been under bad management), by the day, was about $3 per linear foot. The remaining work was afterwards contracted at $1 45 per foot; and the average throughout was about $2 per linear foot. In lining it, eight-inch square, brick piers were built at four-foot intervals, each being set in a recess excavated about one half of its thickness back into the sides of the tunnel. These piers rise to the spring of the top, and upon them rest the roof timbers, of six by eight redwood of the best quality. Over all is a lagging of two-inch redwood. The floor is

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concreted to a thickness of three inches, and the sides between the piers filled in with concrete four inches thick, up to the spring of the top timbers. The completed tunnel cost at about the rate of $5 50 per linear foot. The work on the short tunnel was of the same character, but cost somewhat less.

Culvert and Waste-way:—At one point where an arroyo was crossed south of this tunnel, a stone culvert to carry the drainage water under the canal was constructed. Considerable trouble was had in getting a foundation for this work. There is combined with it a masonry waste-way, and the total cost of the whole was about $700.

COST OF THE WORK:—The total cost of the Warm Creek canal, as described, has been:—

Brush dam at the head, and the reconstruction of the earthen canal thence to the mill	$4,520 18
The long flume with some other short pieces of flume, at lower points	30,132 74
The tunnels, excavated and lined as described	23,833 32
The open canal, excavated and lined in portions as described	10,767 27
Right of way	3,630 20
Total	$72,883 71

The engineering of the work having been done by the executive engineer in charge of all the works of the company, its cost has not been ascertained for this work alone.

Riverside Canal System.

The Three Canals:—The Warm Creek canal has now become the principal conduit of the Riverside water-supply, although the brush dams and heads of both the old canals are still maintained, and the water is diverted into them to the extent of the requirements of irrigation over and above the amount supplied by the Warm Creek works, or, at periods of low water, to the extent of the available supply which reaches them. The Old Upper canal, as elsewhere explained, is now used only as a feeder to the Lower canal, seeing that it turns its supply into the lower work within a short distance below the point of diversion. Nevertheless, the upper work is kept in repair and ready for use all the way around to the junction of the Warm Creek canal therewith. The object of turning the water diverted by the old upper into the lower work is to concentrate the flow, and save loss in the portion of the

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Old Upper canal around the face of the hill, where percolation has been exceptionally great.

Conservation of Water-supply:—It is estimated by the engineer in charge of the work that there was formerly lost, between the mouth of Warm creek and the heads of the two old canals, at periods of least flow in the river, one thousand miner's inches, and in the upper portions of the old works about six hundred miner's inches. According to this estimate the new work should save as much as one thousand inches, though it has not been shown as yet that this is the case; and the prevailing opinion among its managers is that they have, by the expenditure of $73,000 to $75,000, saved about five hundred to seven hundred and fifty miner's inches of water, which amount practically added to the supply, has thus cost them $100 to $150 per inch.

Paving and Cementing Canals:—The question of lining the entire main canal system with rock and mortar paving, faced with cement, as heretofore described, is one that is being continually agitated among Riversiders. It is claimed by their engineer that this work would save as much as one thousand inches of water now lost. The cost would be about $370,000, or $370 per inch saved. The saving effected in cost of maintenance—that is, cleaning and repairing—would be about $1,000 per month, or nearly one third per cent on the cost. The expected revenue from the increased sale of water and the saving in the expense have, together, been estimated at about 7 per cent on the cost of the work. The great market value of the additional water-rights made available, when attached to other lands owned by the company, would, however, constitute the chief incentive for the outlay.

The Water-power Drop; Warm Creek Canal:—At the forty-foot drop in the Warm Creek canal, since the original construction, there has been built a special work designed for the utilization of the waters in creating power, and which is now used in part by the electric light works, serving a portion of the towns of Riverside and Colton. The total cost of this water-power structure, exclusive of machinery or buildings, was $3,467. The waters are carried out from the bank of, and nearly across, the arroyo, in a flume two hundred and seventy feet long, eight feet wide, and four feet deep, and there dropped through a six and one half-foot iron

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pipe upon a double turbine wheel whose casing rests upon three piers of ashlar masonry six feet above the tail-water; thence the water from the wheel is discharged through two tubes into a concrete basin below the bottom of the canal itself, which, for some distance forward, is paved and cemented. There are other flumes arranged as chutes, to drop the stream by degrees to the canal across the arroyo when the water is not in use for power purposes. It is stated that this plant is calculated for three hundred and fifty horse-power.

Twelfth-street Connecting Canal:—On the line of Twelfth street, in Riverside, a connection has recently been made between the Lower and Upper canals, which will serve as a waste-way from the Upper over into the Lower, and also, by the arrangement of the plan, enable the flowing waters, of which a moderate stream will always be kept in the work, to create a valuable water-power in the heart of the town. The total fall is about thirty feet.

Tequisquite Waste-water Canal:—This work has been carried out within the past year or eighteen months for the purpose of providing a waste-way to take surplus waters, or if need be, the entire flow of the canal, and conduct them harmlessly across a highly improved portion of Riverside cultivated lands, to the Santa Ana river. It was necessary, to guard against the consequences of a possible break in the canal or of the flume at the Tequisquite arroyo, to provide for turning the waters loose somewhere in this neighborhood and getting rid of them without ruining highly improved places. The work is one and one fourth miles long, three feet wide on the bottom, three and one half to four feet deep, and is lined throughout with stone laid in hydraulic mortar. It is on very heavy grade, and consequently, of large capacity for its size. Its total cost was $13,911.

SUMMARY OF WORKS:—The total length of the main canals is about 33.3 miles. The total length of distribution ditches reaches to fifty miles, of which about twenty miles may be regarded as leading works. Usually the capacity of these larger ones is about one hundred to three hundred inches each; and their average grade frequently as high as fifty feet to the mile, but with drops introduced at intervals, although there are a few cases where a grade as low as five feet per mile is in use. The lower canal is claimed

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to have a capacity of five thousand inches all the way through. The Upper canal is claimed to have a capacity, on the Warm creek route, through to the Old Upper canal, and thence on as far as Eleventh street, in Riverside; from there on to the middle of Arlington, about three miles, it is rated at a capacity for three thousand inches; and thence, to the end, at about two thousand five hundred inches. It is in contemplation, within the near future, to extend the Lower canal about one mile, and to build a reservoir covering about twenty acres at its terminus. This will be an earth work, designed for the purpose of receiving and controlling water that passes beyond all the colony irrigators, and to keep it from flowing, unregulated, over the country below.

SUMMARY OF COST OF WORKS:—As now described, the Riverside irrigation canal and distribution system has cost, according to the accounts of the companies, about $373,000, distributed as follows:

Original construction of old works, down to 1885, part inclusive . .	$225,000 00
Recent improvement on old canals	25,000 00
Cost of the new canal	73,000 00
Other works and additional parts	50,000 00

In this statement only round numbers are used, because it is impossible to get an absolutely accurate accounting, and these sums are probably as close as any figuring would be if adherence were made to odd dollars and cents. Details of many of these sums are given elsewhere in this report, and the authority for them stated. This accounting does not include any part of the domestic pipe-line cost, or cost of artesian lands for that supply; and probably does not include other costs, as of legal expenses and incidentals of late years, which should in part be charged up to first cost of works.

Riverside Pipe-line System.

Domestic Service:—The Riverside pipe-line works, of which the main parts have recently been put in, and of which the principal distributaries are now in construction, are intended primarily for domestic water-supply, but they also will serve in irrigation several hundred acres of land which lie too high to be reached by the canal water distributaries.

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ARTESIAN SUPPLY:—The water-supply for the pipe-line works is derived and expected to be derived from artesian wells in the San Bernardino basin, at a point three quarters of a mile south of the river bank, and about one and a half miles east of Warm creek mouth. The ground elevation here is about nine hundred and ninety-five feet above the sea, about one hundred and fifteen feet above the highest point in, and one hundred and eighty feet above the general elevation of the central portion of Riverside town. Here, on a plat of seven and one half acres, just within the recognized lower limit of the artesian basin, and near to the famous Hunt artesian spring, seven artesian wells, each eleven inches in diameter, have been bored, six of them to depths varying from one hundred and eleven to one hundred and twenty feet, and one to a depth of two hundred and fifteen feet. Their flow ranges from eighteen to twenty-eight miner's inches to the well, and the total supply is one hundred and sixty-three miner's inches. The work of boring other wells is in progress, and it is intended to continue it until a flow exceeding two hundred and twenty-five miner's inches is secured. The wells are located at fifty-foot spaces, in two diverging lines, fifty to two hundred feet apart. Their waters, received into a little cement basin around each well, are collected by means of small flumes into a shallow, masonry lined, circular reservoir, thirty feet in diameter, across which is an overflow weir, and over this the water drops in a thin sheet, thus becoming somewhat aerated before entering the pipe.

PIPE MAIN AND DISTRIBUTARIES:—The pipe is taken thence westerly three fourths of a mile, to the river bottom lands, and then extends away in a straight line through these low grounds south of the river and parallel with its course, to and through the pass at the head of the mesa, occupied by the California Southern railroad, and thence down the mesa to Riverside town. From the receiving basin to the top of the pass, the twenty-two thousand five hundred feet of pipe is seventeen inches in diameter, thence to a point in Riverside, twenty thousand three hundred feet, it is sixteen inches in diameter; made of four-pound and four and a half-pound sheet iron, double riveted and double dipped. This line of pipe cost, laid (with slip joints where under light pressure, and cement bands where pressure is heavier) exclusive of excavation and backfilling of trench, and also of many small accom-

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panying works, about $72,600. At a point where the pipe crosses the Upper canal in Riverside is a pressure gauge and regulating escape-way. To this time the pipe-line works have cost without any distributaries, but including the artesian land, the wells, basin, etc., pipe, trenching for and covering the pipe, about $110,000. The company have just let a contract for about forty thousand one hundred feet of the same class of pipe, for main distributaries, ranging in size from six to twelve inches, and to cost in the aggregate about $35,000 for the pipe and laying.

Riverside Canal System (Continued).

Operation and Maintenance:—ORGANIZATION AND MANAGEMENT:—The President of the Riverside Water Company is its business manager. The engineer is, as he should be, the general supervisor of construction, and is constantly engaged in extending and protecting the company's water-supply interests. But there is a superintendent who has immediate charge of works of construction and maintenance and of the force engaged thereon. The *zanjeros*, or watermasters, have to do only with the distribution of the waters. The regular payroll shows as salaried employés, the president, civil engineer, secretary, superintendent, clerk, surveyor, two surveyor's men, four watermasters, three men at head works (one at head of each canal), and one watchman at the tunnel. Extra men are employed for all clearances and repairs.

WATER DISTRIBUTION AND MEASUREMENT:—The original idea of the projectors of the first colony enterprises on this site, as elsewhere narrated, was to sell their lands and retain their waters as a permanent revenue-yielding investment; and hence they adopted the plan of measuring the waters as the surest way to control, use, and obtain returns on capital. Water is measured in flume boxes, usually eighteen to thirty inches wide, with a fixed bar at the outlet, four inches high, and raised two and a half inches above the floor, and with a slide running in from the side, beneath the bar, to regulate the length of the opening left under it. The water held to the level of the bar flows through the opening under a four-inch pressure. It is supposed for each square inch of opening through which the water passes, under pressure thus regulated, there is one miner's inch of discharge.

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System in Distribution :—Water has always been distributed in Riverside in quite small streams as thus measured out to the irrigators. The heavy nature of the soils, and nature of the cultivations formerly compelled the use of very small irrigation heads or volumes of flow, to economize or prevent waste of waters, and even damage to cultivated grounds by washing. With better preparation of grounds and distributing appliances larger heads are now handled. A twenty-inch head is about as much as one man can tend on the heavier soils and smaller tracts, but on tracts of twenty acres, or upwards, and where the distribution works are properly arranged, heads of thirty to fifty inches are ordinarily handled by one irrigator; and on the best prepared grounds fifty to one hundred-inch heads can be taken care of by division into a multitude of little rills between the planted rows. The heads actually delivered to individual irrigators in the town are generally ten miner's inches each. Cultivators of large tracts take heads ranging up to one hundred and fifty inches.

Service and Sub-districts :—Distribution is made upon orders which have to be handed in at least a day in advance. These come to the general office, are there grouped as they will have to be supplied through the several main distributaries, and memoranda for the guidance of the *zanjeros* are prepared accordingly. The order states the time, when, and volume and duration of flow desired by the irrigator, but each order is filled with respect to time, only as nearly as possible in accordance with the order. The *zanjero* turns on and turns off the stream, and the irrigator has nothing to do with the distribution boxes. This system is substantially the same as that originally adopted by the first operators of the works. But in May, 1883, when water had been very scarce for two seasons, and was likely to be even more so that year, the Riverside Canal (the old management) company determined to sub-district the area served by their works—cutting the colony across into three parts, and serving water within each such sub-district to the exclusion of others, until the irrigations were there effected. The reason given was a good one—namely, that concentrating the flow would economize both the supply and the labor of distributing and saving it. There was much opposition to this, however, and the present management have gone back to the old system, for the convenience of irriga-

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tors who do not wish to be compelled to wait over to stated times for water. The company will not deliver water in less than ten-inch streams, and for these the charge is at the rate of 7½ cents per inch for twenty-four hours.

Pipe Distribution:—In one of the laterals where the delivery is made in pipes the charge is $5 per acre per annum, and no restriction is placed on the irrigation as to time. This, it is expected, will be the universal system when all the distribution is effected through pipes, and when the works have reached that state of development, their maximum of convenience, and it is hoped efficiency, will have been reached. Those who irrigate from the one existing pipe distributary, say that they can accomplish more with much less water than by the open ditch system. In using ditches they were compelled to take a given quantity of water for a stated length of time, and the inevitable result with them always was that they had to hurry the water over the ground to dispose of it, and much of it inevitably ran to waste without soaking in or doing good. The smaller stream of the pipe system soaks away slowly, and none is lost or wasted.

MAINTENANCE OF WORKS:—The Riverside canals have been expensive to maintain and operate. There being two main canals for the service of a district which might have been served by one (except for the loss of some water which rises in the river bed below the head of the old upper work and is caught by the lower one), the cost has been in some respects doubled over what it might have been. Now there are three main canals; three points of diversion to look after. Aside from the cost of operation of the works during the irrigation season, the current expenses have been chiefly those of repairing the brush dams, clearing the canals of silt lodgments, and keeping them clear of weeds and aquatic grasses which here have grown with the greatest vigor and rapidity.

Maintenance and Operation; Cost of:—The following exhibit shows the cost of administration and maintenance for a number of years under the old regime, and that which succeeds gives similar data for recent years under the management of the new company—the citizens themselves:

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OPERATION OF WORKS UNDER OLD R. C. Co.

Cost of Maintenance and Management: 1880 to 1883.

CLASSIFICATION.	1880.	1881.	1882.	1883.
Labor	$7,356 15	$9,929 80	$9,609 24	$8,131 91
Lumber, brick, etc.	920 35	1,862 43	2,511 80	815 90
Feed	783 18	1,360 48	1,866 47	1,930 24
Salaries	3,050 00	3,355 35	3,518 75	3,856 00
Legal expenses and taxes	790 41	1,011 53	1,442 05	1,308 28
Wagons and blacksmithing	389 81	501 34	667 20	486 54
Hardware and tools	389 16	163 44	486 60	104 89
Harness and stable expenses	122 53	168 73	237 58	145 87
Stationery, advertising, and postage	237 69	156 50	261 91	100 00
Office rent, and expenses	153 73	87 75	120 82	240 40
New work	358 49	2,440 43	1,240 09	1,508 33
Totals	$14,551 50	$21,037 78	$21,902 51	$18,628 36
Water distributed — Domestic	$1,509 50	$1,842 36	$1,382 50	$1,455 55
Water distributed — Irrigating	9,058 95	10,540 02	14,831 90	18,101 38
	$10,568 45	$12,382 38	$16,214 40	$19,556 93

NOTE.—This account is given exactly as found of record in a report of the president of the company. There are some things about it which are not clear.

OPERATION OF WORKS UNDER THE R. W. Co.

Cost of Maintenance and Management: 1886, 1887.

CLASSIFICATION.	1886.	1887.
Interest	.....	$4,292 83
Printing	$74 00	107 50
Advertising	18 00	129 20
Salary	4,053 77	3,772 25
Stationery	39 35	142 75
Office rent and sundry expenses	448 10	579 55
Postage	66 05	63 70
Breaks in canals	69 75	256 15
Repairs	2,117 40	1,669 03
Cleaning canals	7,253 75	10,286 28
Night watch	547 60	613 40
Zanjero's wages	4,664 65	5,170 75
Totals	$19,352 42	$27,083 39

NOTE.—This account is given just as furnished by the secretary under the present management.

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REVENUE AND EXPENSES; WATER-RATES:—The question of revenue and water-rates has been a sore one in Riverside. The cost of maintenance for the year 1878 was $9,300, which included, to be sure, some new work on the distributaries. The receipts were $7,677, about the same amount as the year before. The charge for water was 2½ cents per inch for a daylight flow, and the rate was then raised. In 1880 the company fixed rates for all purposes, as follows:—

(1) For all persons who have purchased lands from the Land company or stock from the Canal company:

Ten-acre lots, a 2½-inch stream, per year, payable monthly	$48 00
Domestic water, taken from canals or lateral ditches	12 00
Extra water, by the day, per inch	04
By the day and night, per inch	06
By the night, per inch	03

(2) For all other persons:

A 2½-inch stream, payable monthly, per year	$72 00
Domestic water, etc.	18 00
Extra water, by the day, per inch	06
By the day and night, per inch	09
By the night, per inch	04½
Town blocks, a domestic stream per year	24 00
Hotels, restaurants, stables, laundries, etc., per year	48 00
Domestic water taken from canals or lateral ditches, or to fill cisterns or reservoirs	12 00
An irrigation season, whole block	20 00
Single lot, per year	6 00
Each additional lot, per year	3 00

Irrigation Water-rates, 1872–1888:—The following is an exhibit of water-rates which have ruled in Riverside in the years mentioned:—

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Year.	Explanation.	Rates per Miner's Inch.		
		Day.	Night.	24 hrs.
1872.	Established by the S. C. C. A.	2½	1½	4
1873.	Established by the S. C. C. A.	2½	1½	4
1874.	Established by the S. C. C. A.	2½	1½	4
1875.	Established by the S. C. C. A.	2½	1½	4
1876.	Maintained by the R. C. and I. Co.	2½	1½	4
1877.	Maintained by the R. C. and I. Co.	2½	1½	4
1878.	Maintained by the R. C. and I. Co.	2½	1½	4
1879.	Maintained by the R. C. Company	2½	1½	4
1880.	Established by the R. Canal Company . . .	4	3	6
1880.	Established for persons not their grantees .	6	4½	9
1881.	Fixed by the Board of Supervisors	5	3	7½
1882.	Fixed by the Board of Supervisors	5	3	7½
1883.	Fixed by the Board of Supervisors	5	3	7½
1884.	Fixed by the Board of Supervisors	. . . .	. . . .	7½
1885.	Maintained by the new R. Water Co. . . .	. . . .	. . . .	7½
1886.	Maintained by the new R. Water Co. . . .	. . . .	. . . .	7½
1887.	Maintained by the new R. Water Co. . . .	. . . .	. . . .	7½
1888.	Maintained by the new R. Water Co. . . .	. . . .	. . . .	7½

Expenses and Receipts, 1869–1883:—The following exhibit presents suggestive comparisons between the cost of maintenance, etc., and the receipts from the work:

Period.	Construction and Maintenance.	Construction.	Maintenance and Administration.	Receipts to August, 1879. Water Charges August, 1879, to December, 1883.	Deficit of Receipts and Charges Compared to Cost of Maintenance.
	(1)	(2)	(3)	(4)	(5)
Sept., 1869–Aug. 1, 1879 . . .	$253,603 42	$188,000 00	$65,603 42	$45,220 81	$20,382 61
(5 months), 1879	3,823 48	. . . . .	3,823 48	4,232 58	. . . . .
1880	14,551 50	358 49	14,193 01	10,568 45	3,624 56
1881	21,037 78	2,444 43	18,593 35	12,382 38	6,210 97
1882	21,962 51	1,240 09	20,722 42	16,214 40	4,508 02
1883	18,628 26	1,508 33	17,119 93	19,556 93	. . . . .

Note.—The above figures of columns (1) and (4) are taken from report of the Riverside Canal Company to Board of Trustees of the city of Riverside for 1883. Those of column (2) for 1880 to 1883, inclusive, are taken from detailed statements in same report, the items being termed "new work," which doubtless means "construction." The President, however, in the complaint of the Riverside Canal Company vs. Citizens Water Company, puts total construction account for same period at $38,000. The cost of construction for 1869 to 1879, inclusive, is taken from complaint Riverside Canal Company vs. Citizens Water Company. The figures in (3) column are made up by deducting (2) from (1), and those of (5) column by deducting (4) from (3).

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Water Delivery and Revenue, 1885:—The following exhibit shows by periods of three months each, the sales of water during 1885:

Period.	Number of Twenty-four-Hour Inches Delivered.	Amount Received in Payment.
January to March, inclusive	38,845	$2,860 95
April to June, inclusive	82,375	6,258 44
June to September, inclusive	86,170	6,684 58
October to December, inclusive	41,980	3,168 67
Totals	249,370	$18,972 64

Note.—This accounting was furnished by the secretary of the Riverside Canal Company.

Water-supply and Use:—During those three months which test the irrigating capacity of works, speaking generally, the water-supply apparently available for the Riverside canals, and which could have been had by the present improved works, has ordinarily ranged from three thousand three hundred to three thousand six hundred miner's inches; it has in other years fallen below three thousand inches, and in some years has exceeded four thousand five hundred inches. During other months of the year, the supply has been exceedingly variable, ranging from the minimum quantity stated, up to a mighty flood stream in the river.

Diversion and Use, 1871–1888:—The data of the exhibit which here follows show, approximately, the progress of canal construction, of the appropriation of waters, and of the expansion of irrigation, from year to year, under the Riverside canal system from the first year of diversion to the present season, 1871–1888:

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Number of Canals.	Year.	Capacity of Canals. Miner's Inches.	Low Water Diversion. Miner's Inches.	Ordinary Flow. Miner's Ins.	Extent of Irrigation. Acres.
1	1871	450 U. C.	300	. . .	15
1	1872	700 U. C.	500	. . .	100
1	1873	1,000 U. C.	. . . .	. . .	. . .
1	1874	1,200 U. C.	750	. . .	500
1	1875	1,200 U. C.	. . . .	. . .	1,050
2	1876	2,500 U. C. 4,000 L. C.	3,000	4,000	2,000
2	1879	2,300 U. C. 3,800 L. C.	2,800	3,700	3,150
2	1880	2,100 U. C. 3,600 L. C.	2,700	3,800	3,633
2	1881	2,000 U. C. 3,400 L. C.	2,500	3,300	4,075
2	1882	2,000 U. C. 3,200 L. C.	2,300	3,100	4,326
2	1883	1,800 U. C. 3,000 L. C.	2,000	2,800	. . .
2	1884	1,900 U. C. 3,000 L. C.	3,500	4,500	. . .
2	1885	2,000 U. C. 3,100 L. C.	3,100	3,800	5,768
3	1886	4,500 U. C. 4,500 L. C.	3,000	3,600	6,580
3	1887	4,500 U. C. 4,500 L. C.	3,200	3,700	. . .
3	1888	4,500 U. C. 4,500 L. C.	3,100[1]	3,500[1]	6,850[1]

Water was diverted and used in 1871 through the Upper canal. The Lower canal came into use and the upper work was completed in 1876. In that year these works were brought to the greatest capacity which they have ever attained until added to and enlarged in 1885–86. It is thought to be possible, not probable, that the capacities from 1876 to 1879 are somewhat understated; authorities and data are conflicting on this point. In 1880 the canals had the capacity here accorded them. In later years, to 1883, their conditions were at times so bad as to reduce their working capacity below the figures given. At the present time it is claimed that their capacity is for five thousand inches each. This is when they are in first class condition—immediately after cleaning—and a work does not remain long in such a perfect condition.

The measure of low-water diversion up to 1876 was limited, not by the extent of water-supply, but by the low demand for water, and the lack of facilities for caring for it in the lower reaches of the work, and distributing it in irrigation. From that time forward, except in 1884, and perhaps in one or two other

[1] These figures (for 1888) at the time of going to press are subject to revision on the basis of data expected, which should it come to hand will be utilized in correcting for the summarizations in the closing chapters of the report.

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years (to a limited extent), the least amount of diversion for each year has been governed by the quantity of water available. This is particularly true of the years 1881 to 1883, inclusive, and 1886 and 1887, probably also 1888. The least diversion, and ordinary diversion for 1876, per contra, is shown to be less than 1886; but this is not to be taken as indicative of there being less water-supply in the former year, but that the facilities for obtaining or diverting it were not so great formerly as now.

The measures of "ordinary" flow are to be taken as expressive of about the amounts of diversion for the greater portion of each irrigation season. No attempt has been made to show the maximum extent of diversion for each year. Doubtless, except for the year 1883, and possibly one or two others when the supply was very short, both canals have diverted up to their full capacity at some period each season. The statements as to extent of irrigation for the years 1879, 1880, 1881, 1882, and 1885, are based upon observations and statistics made and collected specially for or by the State Engineer. The figures given for earlier years are based on statements of persons so connected with the work and operations as to have made them familiar with the facts, and on the sworn testimony of a number of such persons, given in cases before the local courts, as reported in transcripts on appeal and other documents of record.

Use of Water in Irrigation:—The following exhibit shows the data of extent of use of water during the several months of 1886 and 1887, and affords a striking instance, by comparison of the figures of the first four months of the two years, of the effect of late rains on irrigation demand:

Miner's Inches Delivered.

Month.	In 1886.	In 1887.
January	2,385	18,679
February	1,575	4,025
March	515	17,850
April	2,630	33,100
May	33,160	40,010
June	51,955	43,748
July	50,795	44,800
August	45,105	44,255
September	29,523	35,665
October	21,330	15,489
November	12,780	15,315
December	9,045	1,945
Total inches	260,798	314,881

Irrigation Cultivation:—There is next presented a statement whose data show in detail the progress for several years of culti vation by irrigation in Riverside. These figures are from specia. statements made up for the State Engineer on the basis of obser-vation made and statistics especially collected for this purpose.

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Year.	Land Holders.	Acres Owned.	Acres Irrigated.	Citrus Trees.	Deciduous Trees.	Vines.		Alfalfa—Acres.
				Number.	Number.	Number.	Acres.	
1880	222	....	3,650	2,592 acres.[1]		.....	637	390
1881	227	5,134	4,075	140,301	63,089	419,730	....	...
1882	269	5,206	4,326	238,023	90,072	496,035	....	...
1885	386	6,223	5,768	286,898	101,806	.....	1,318	245
1886	...	....	6,580	.....	.....	.....	....	...

Irrigation Cultivation Statistics, 1885:—There is next presented a statement showing some interesting details of irrigation statistics, taken from the results of the State Engineer Department inquiries of 1885:

Total number of irrigators	386
Total area of lands owned by irrigators (acres)	6,223
Average holding each (acres)	16.12
Maximum holding (acres)	196
Minimum holding (acres)	1
Average of 10 maximum holdings (acres)	99.5
Average of 10 minimum holdings (acres)	1.2

Total area irrigated (acres)	5,768¼
Average irrigated holding per irrigator (acres)	15
Maximum individual irrigation (acres)	196
Minimum individual irrigation (acres)	1
Average of 10 maximum individual irrigation (acres)	87.5
Average of 10 minimum individual irrigation (acres)	1

Total number of citrus trees	286,898
Total number of cultivators of citrus trees	356
Average number of trees per cultivator	805.9
Maximum number of trees per individual cultivator	8,500
Minimum number of trees per individual cultivator	20
Average of 10 maximum holdings (trees)	4,745
Average of 10 minimum holdings (trees)	31

Total number of acres of vines	1,318¼
Total number of cultivators of vines	254
Average number of acres per cultivator	5.2
Maximum number of acres per individual cultivator (vines)	172
Minimum number of acres per individual cultivator (vines)	½
Average of 10 maximum cultivators (acres)	43.9
Average of 10 minimum cultivators (acres)	.65

[1]This number of acres is for both citrus and deciduous orchards.

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Total number of deciduous trees	101,806
Total number of cultivators of deciduous trees	302
Average number of trees to cultivator	337
Maximum number of trees per individual cultivator	11,800
Minimum number of trees per individual cultivator	10
Average of 10 maximum cultivators (trees)	2,770
Average of 10 minimum cultivators (trees)	2.15

Total number of acres of alfalfa	245.75
Total number of cultivators of alfalfa	93
Average number of acres per cultivator	2.6
Maximum number of acres per individual cultivator (acres)	40
Minimum number of acres per individual cultivator (acres)	¼
Average number of 10 maximum holdings (acres)	10.4
Average number of 10 minimum holdings (acres)	.5

History of Enterprise and Water-right:—THE OLD COMPANIES' OPERATIONS:—*The Silk Center Association:*—In November, 1869, the "Silk Center Association" of Southern California was organized for the purpose of colonization, and the local promotion of a raw silk producing industry, and it was intended to cultivate the variety of mulberry tree suitable to furnish silkworm food, by irrigation. An arrangement was made to purchase five thousand or six thousand acres of the Jurupa and Rubidoux ranchos, covering the present site of the town of Riverside, and one thousand four hundred acres of Government land adjoining was also taken up for the company. A preliminary survey was made for a canal, a notice of water appropriation was posted, and some work of construction done near the present head of the old upper canal for this association in the spring of 1870. But consequent upon the death of the leading spirit and expert, withal, of the enterprise, its operations suddenly came to a standstill.

The Southern California Colony Association:—During the same spring other persons examined the neighborhood and lands, with the view of colonization, and the promotion of general horticulture and viticulture by irrigation. These determined, in June, to negotiate for the lands temporarily held by the silk company, and the purchase was made in the middle of September, 1870. In the meantime a survey for a canal line had been commenced in July. The settlement of Riverside, under the name of Jurupa, was made about the middle of September by camping on the ground, and the "Southern California Colony Association" was immediately formed in camp, having for its objects the purchase of the Silk

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Center Association's lands, water-rights, franchises, etc., and other properties, the appropriation of water, and the construction of canals to irrigate forty-five thousand acres of land, and the colonizing, cultivation, and sale thereof.

The stock of this association was held—a majority by C. N. Felton of San Francisco, and the balance by Mr. Hamilton and M. W. Childs of Los Angeles, J. H. Steward and Dudley Pine of San Bernardino, and W. J. Linnville, J. W. North, Dr. J. P. Greves, and Dr. K. D. Shugart of the settlement. North was elected President, Greves Secretary, Shugart Treasurer, and T. W. Cover, who had been interested in the Silk Association, was made superintendent of canal construction. The canal surveys were made by Higby and Goldsworthy of Los Angeles. Work of construction was commenced October first. The name Jurupa was changed to Riverside in December.

Upper Canal, Original Projection:—As originally projected the canal was eight feet wide on the bottom, twelve feet on the top, and three feet deep, and with a grade of 52.8 inches per mile, or one inch per hundred feet. The work was prosecuted continuously during the winter and spring of 1870–71, but the excavation was not made uniform in width, and in places not taken down to grade. It was very crooked—running far up into the arroyos or depressions before crossing them, and skirting outside of many low points in the plain, instead of cutting through them.

There were thirteen flumes, for the most part short ones across the heads of ravines, constructed in the line between the head down to the ravine just below and close to the Pachappa hillocks, a mile and a quarter below the town of Riverside, to which point the work was finished, as above described, early in July, 1871. Water was brought in the ditch as far as the Spanishtown flume early in May, and it reached the Pachappas about the tenth of July. Owing to irregularities in grade and deficiencies in width, the ditch had at this time a capacity of about seven hundred to eight hundred inches, down to the Spanishtown flume. Below that the width and grade were both less at points, so that the working capacity did not exceed five hundred to six hundred inches. The cost of the work to this stage has been variously stated at $50,000 to $62,000 to the Pachappa arroyo.

In this year (1871) about one thousand five hundred inches were taken into the headworks, but most of this was wasted at a

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point near at hand; four hundred to five hundred inches were brought to the Spanishtown flume, and perhaps two hundred to three hundred inches reached the end of the works below Riverside, but it came too late for planting that season. The Riverside neighborhood had settled up rapidly during the time of construction of the canal, so that thirty or forty families were supplied with water for domestic purposes by it. To stimulate planting the company offered to give irrigators water for a season free of charge; but only ten or fifteen acres were irrigated, and most of the water which did get through ran to waste below town.

During the fall of 1871 the ditch was extended to the Tequisquite cañon or arroyo, and during the winter of 1871–72 it was enlarged to six feet wide on the bottom all the way down to the Tequisquite arroyo, and its construction was commenced beyond that point. It was still, however, of very light grade at points, and not cut down to grade at others, so that its working capacity was not over seven hundred to eight hundred inches. The original grade of 52.8 inches per mile appears to have been set at long intervals for a straighter alignment, involving longer flumes across depressions and cuttings through the points, and then, to avoid these expensive works, the ditch was actually built on a very much less grade by following around the points and into the arroyos.

In 1873 and 1874 the ditch was much straightened by constructing flumes and fills across a number of the longest arroyos; was cut deeper where previously not down to grade, and was otherwise bettered so that in 1875 it carried one thousand to one thousand one hundred miner's inches of water. Up to this time, however, not more than three hundred to four hundred inches had been measured out to irrigators, and not more than five hundred acres had been irrigated from it.

The New England and Santa Ana Colonies:—During the summer of 1874 S. C. Evans, of Indiana, and W. T. Sayward, of San Francisco, bought eight thousand acres of land of B. Hartshorn, commencing about a mile south of the limit of the original Riverside tract—the Rubidoux-Jurupa ranch line—contemplating a colonization enterprise, and irrigation by means of a canal from the Santa Ana river. About the same time the owners of the San Jacinto Sobrante rancho, who were San Francisco capitalists (L. L. Robinson, General Carpenter, General Hutchinson, and others), segregated about four thousand acres of their ranch, lying

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in the same valley and next south of the Hartshorn tract, for irrigation and colonization. Evans and Sayward and the San Jacinto people, who were known as the San Jacinto Tin Company (there being a notable tin mine on their ranch), joined forces to construct one canal for the irrigation of both their tracts, which were called, respectively, "The New England Colony" and the "Santa Ana Colony."

There does not appear to have been any preliminary survey or careful estimate on this canal. It was expected to cost $35,000, and on this basis was commenced in the fall of 1874. After spending about $17,000 it was found that the cost would greatly exceed the expectation, that only about three thousand five hundred acres of the Hartshorn tract could be irrigated by it, and that to get high enough to effect this, even, the line of construction must pass through the lands of the Southern California Colony Association, and the Mexican settlement north of it.

The managers of the Southern California Colony Association, looking upon this Evans-Sayward-Tin company project as a rival, refused to accord right of way through their territory, and the Mexicans also resisted possession of their property for the purpose. Thus, after constructing about one thousand five hundred feet of the work near its head, the force was transferred to the plain below the Rubidoux ranch line, and the balance of the work for the season was there done. This part of the excavation was intended to be nine feet wide on the bottom, slopes one to one, depth three and one half to four feet, and calculated to carry water three feet deep, or thirty-six square feet area, on grade of 3.7 feet per mile. The upper part of the canal had grade set to 3.7 feet per mile, and at 3.2 feet of depth had a wet section of forty square feet. There is conflict of testimony as to whether these dimensions, etc., were actually attained in construction at that time.

The Matthews Mill property on Warm creek was purchased for the purpose of strengthening the water-right claims of the Southern California Colony Association, February 6, 1875. After much negotiation the Southern California Colony Association, however, granted right of way to the Evans-Sayward-Tin company combination for the lower canal route, on April 21, 1875; but all this conflict was finally solved in May by the purchase by Evans and Sayward and the Tin company of the Felton four sevenths interest in the Southern California Colony Association, for $50,000.

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The Riverside Land and Irrigating Company:—For this purpose, in April, 1875, the Riverside Land and Irrigating Company was formed, into which were merged the interests of Evans, Sayward, and the Tin company, and then followed the gradual acquirement by it of all the stock of the Southern California Colony Association; and on March 10, 1877, that company formally transferred all its real estate, rights, franchises, etc., to the Riverside Land and Irrigating Company. Thus were consolidated in this new company all the land and water interests in the valley—namely, those of the Silk Center Association, the Southern California Colony Association (Felton, North, and others), of the New England Colony (Evans and Sayward), and of the Santa Ana Colony (the Tin company). Evans, Sayward, and the Tin company advanced to the new company the money to make the purchases and prosecute its works, the Felton-Southern California Colony Association stock purchase being in large part on credit.

The Upper and Lower Canal:—Although the full management of the canals did not come into the hands of the Riverside Land and Irrigating Company until May, 1876, during 1875 as well as 1876 work was actively prosecuted by means of the new company on the upper as well as the lower work, and both were completed by October, 1876, at a cost far greater than was anticipated. In this work the upper canal was widened to seven feet on the bottom, and was much shortened by making long cuts across points, and additional fills across hollows between bends; at a total cost of $22,000. In the spring of 1875 it had a capacity of one thousand miner's inches, and that year irrigated about one thousand and fifty acres scattered through from Spanishtown to the "government strip," and supplied also four hundred to five hundred people with water for domestic use. By the new work its capacity was increased to two thousand five hundred inches.

During the irrigating season of 1875, the waters of the upper canal were at times dropped into the lower canal, and, thus, work was prosecuted alternately on the lower ends of the two. At the same time work was in progress continually on the upper end of the lower canal, so that by July, 1876, it was opened through from the head, at a total cost of $120,000. In this year of 1876 about two thousand acres were irrigated by the two canals.

During the next four or five years about $5,000 to $7,000 were expended per year for construction on the lower, and $1,500 to

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$2,000 on the upper canal system, mostly for lateral ditches. At the end of 1881 the total cost of canals, distributaries, flumes, gates, bridges, etc., was $224,885 67, exclusive of current annual expense. In the year 1882 about four thousand three hundred acres were irrigated, and it was claimed that the upper canal had a capacity to carry three thousand five hundred inches, and the lower canal seven thousand; but as a matter of fact the works were in such bad condition that they could carry only two thousand inches and three thousand two hundred inches, respectively, and the proportion of loss of this amount was very great. The average cost of water to consumers, per acre, in 1877–78 was $1 92; 1880, $2 15; 1881, $2 23.

The Riverside Canal Company:—In May, 1878, the Riverside Canal Company was formed by the controlling stockholders of the Riverside Land and Irrigating Company for the purpose of purchasing all the canals, water-rights, and water franchises of the Riverside Land and Irrigating Company, and perfecting these for the benefit of that company and the irrigation of its lands. In July, 1879, the transfer was made. The Riverside Land and Irrigating Company receiving, in payment, all of the capital stock of the Riverside Canal Company, twenty thousand shares at $20 each, with the agreement that the capital stock should subsequently be increased or decreased, so as, finally, to correspond with the number of acres that could be irrigated by the works and available waters. This clause was also inserted in the by-laws of the Riverside Canal Company.

The formation of this canal company to take the ditch and water property off the hands of the Riverside Land and Irrigating Company, and the gradual sale of water company stock to the purchasers of land from the land company, in proportion to lands so purchased, was, it is asserted, contemplated from the beginning by the managers of the enterprise, but was delayed until this time because of delay in securing all the stock of the old Southern California Colony Association. After the formation of the canal company, down to the end of 1881, about two thousand shares of the canal stock had been sold, and several hundred shares more contracted for to irrigators; of whom the most had purchased lands from the Riverside Land and Irrigating Company, but the others were settlers on adjacent Government lands, as elsewhere explained.

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THE WATER-RIGHTS AND WATER-RATES CONFLICTS:—By the early part of 1882 a general conflict between the canal and water owners and managers and the irrigators had grown up over individual water-rights and the general water-rates. This originated in differences on these points between the company and the settlers on the government land strip, elsewhere explained. In this general conflict the Canal company claimed that it was entitled to water-rates that would pay running expenses and interest on the capital invested in the canals and other water property. It represented that water-rates had at first been fixed and subsequently maintained at very low figures, to give the early colonists all the encouragement and help possible; that, in consequence, the canals had been run at a very considerable annual loss (and this was shown by exhibits of the accounts); and now that the irrigators were able to pay rates sufficiently high to meet the reasonable demands of the company, such rates should be paid.

The irrigators combatted this ground. They asserted that the Riverside Land and Irrigating Company, which was virtually the Riverside Canal Company, had, in effect, promised water to the purchasers of its lands at cost price for operation and maintenance of works; that the managers of these companies were deriving large profits from the sale of their lands, greatly enhanced in value by the existence of the canals; and that they were not entitled to a revenue as a canal company over and above sufficient for necessary current expenses for maintenance, etc. Furthermore, it was asserted that there had been no limit put upon the extent to which the Canal company might sell its water stock or undertake to deliver water; that the limit of irrigation by the water available might even then have been reached; that the company threatened to go on contracting specific or implied obligations to deliver water; and that the result would be disastrous to the whole community depending on it for a supply. On these accounts many of the land owners and irrigators had refused to buy the water stock as made available to them subsequent to the sale of the canals, etc., by the Riverside Land and Irrigating Company to the Riverside Canal Company.

Growing out of this controversy, the "Satterwhite Bill"—which was intended to compel water companies to furnish water to all customers at the same rates, and after once supplying a customer to continue service to him—became a law, and its provisions were

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immediately availed of by the Riverside irrigators. Under the new constitution, at the session of legislature of 1880, the "Streeter Bill," authorizing and directing boards of supervisors to fix water-rates which might be collected by canal companies, became a law, and soon afterwards was put in operation to regulate the charges of the Riverside Canal Company.

Under these circumstances—the current expenses exceeding the receipts, and a constant atmosphere of conflict and unrest being present—the company neglected its works, the canals got in very bad condition, the loss of water was very great, and just then came the dry seasons of 1881, 1882, 1883, when the water-supply was short. There was great complaint by irrigators of insufficiency of water; it was asserted that orchards and vineyards were suffering for irrigation, which their owners could not get at any price; that the company was neglecting its works, and sacrificing the community to the grasping desire for a revenue from its canal property.

With this condition of things in the very early part of 1882, the president of the Canal company, at several meetings of the citizens, called by him, submitted a statement of the affairs of the company, and asked to be permitted, without opposition, to secure an increase of rates from the board of supervisors. A committee of citizens was appointed to consider the matter. After examination of the company's accounts, this committee reported that the sale of lands had really furnished the capital to build the ditches—or had repaid it to the individuals, which was the same thing—and that the Canal company was not, in the committee's judgment, entitled to a net revenue on its stock. A slight advance of rates was agreed to as being sufficient to pay running expenses, however. This action appears to have widened the breach between the Canal company and the irrigators.

The Citizens Water Company:—During the season of 1882 several meetings of citizens were held to consider matters relative to this controversy; and, finally, in December, the Citizens Water Company was organized and incorporated for the purpose of dealing as a unit, in the interest of the irrigators, with the Canal company. Each land owner was privileged to take two shares of stock of the new company for each acre of land irrigated by him. There were some who refused to have anything to do with this movement, but within a year it had been very generally joined,

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and by January of 1883, stock representing four thousand two hundred acres (which was within several hundred acres of all the lands irrigated) had been subscribed for. The conflict continued through 1883; the water-supply was more than ever deficient; the canals in worse condition; some orchards greatly suffered for irrigation; some irrigators refused to pay for water, and the Canal company denied the constitutional right of the supervisors to fix rates at all. Land sales, which before had been brisk, had now gradually but greatly fallen off, so that, although matters were booming elsewhere in the southern counties, Riverside was depressed. This unhappy depression and uncertainty as to control of the situation by irrigating citizens, and the power or will of the supervisors to fix water-rates, resulted in the incorporation of the city of Riverside—a move that was made to avail of provisions of the new constitution, which would enable the citizens of the city, themselves to regulate the charges for water, through their municipal organization, independent of the board of supervisors.

Riverside Incorporated;—Compromise Propositions:—This proposal had been first made in 1881, and had been met with much opposition; but in July of 1883 the Citizens Water Company took the matter up in the affirmative, and proceedings were pushed. At an election duly authorized by the supervisors of the county, and held in the territory proposed to be incorporated, in the latter part of September of that year, the incorporation proposition carried by a majority of eighty-one in a total of three hundred and seventy-five, there being four hundred and fifteen persons on the register entitled to vote. In the meantime proposals had been made by those in control of the Canal company to sell its works and rights to the Citizens Water Company, and some further negotiations had been in progress. The Canal company offered to sell on certain conditions for $80,000. The citizens offered to purchase on about the same conditions for $40,000. This counter offer the Canal company refused, and before the vote was had on incorporation the Canal company withdrew its proposals, and for the time closed negotiations. After incorporation the proposal to buy the canals and water-rights seemed to meet with more favor. Many citizens urged that their interests were going to ruin under the existing state of affairs, but that by proper management and reconstruction, or improvement of the canals, there would be plenty of water and to spare for other lands, and the purchase could in a few years be made a profitable one.

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Riverside Canal Company vs. Citizens Water Company:—During this season, October, 1883, the contest was so bitter that the Riverside Canal Company brought suit against the Citizens Water Company, the board of supervisors of San Bernardino county, and the board of trustees of the City of Riverside, the city of Riverside, and a number of individuals composing the separate boards mentioned, etc., alleging conspiracy on their part to wrongfully deprive the plaintiff of a fair return on its investment, by fixing or procuring to be fixed water-rates that were too low. In January, 1884, the president of the Canal company again offered to sell the canal property to the Citizens Water Company. At this time about three thousand shares of the Canal company's stock had been sold by the Riverside Land and Irrigating Company to irrigators, of which eight hundred and eighteen shares were held individually by Evans and Felton, who controlled the Canal company, and also the Riverside Land and Irrigating Company. Under these circumstances the proposal was to limit the shares to six thousand in number, and for the Citizens Water Company to buy the unsold shares for $60,000—there being, also, some other important points in the proposal not necessary to mention here. In April, 1884, a provisional basis of agreement, differing materially from the Evans proposal of January, was drawn up between the representatives of the two companies. This was virtually a counter proposition from the citizens' side of the controversy, but it was not finally accepted by the representatives of the Canal company.

Riverside People vs. Riverside Land and Irrigating Company and Riverside Canal Company:—In May, 1884, nine principal irrigating land-holders in the Riverside community, for themselves and all others who had purchased land of the Riverside Land and Irrigating Company and its predecessors, and for those who held stock in the Riverside Canal Company, brought suit against those two companies, praying that the capital stock of the Riverside Canal Company be fixed at five thousand three hundred shares; that the company be enjoined from furnishing or attempting to furnish, or contracting to supply water to irrigate more than five thousand three hundred acres of land, which it was alleged was then cultivated under its canals. It was urged that this suit was based on and intended to enforce the observance of the contract between the Riverside Land and Irrigating Company and the

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Riverside Canal Company, whereby it was agreed that the stock of the latter company was in time to be adjusted to the area irrigable by the water-supply, at the rate of one share per acre. The ground now taken was, of course, that the extent of irrigation had been reached. In September, 1884, the case of the Riverside Canal Company against the Riverside Trustees, etc., and others, was decided in favor of the defendants on the ground of misjoinder of parties.

The Holt Compromise:—During the fall of 1884 matters were more than ever at a low ebb in Riverside, from a continuance of causes already recited, when a compromise proposition was brought forward by L. M. Holt, as a basis for the sale of the Canal company's property to the citizens as a water company. This proposition was accepted by those controlling the Canal company and the Riverside Land and Irrigating Company, and by the directors of the Citizens Water Company, and a provisional agreement was based upon it, which was enthusiastically ratified at a meeting of the citizens of Riverside early in October, 1884. By the fifteenth of October it was shown that of the twelve thousand shares in the new company to be organized under this proposition, the land-owning irrigators, to the number of about three hundred, had subscribed for seven thousand seven hundred and four shares, representing three thousand eight hundred and fifty-two acres of the six thousand first to be irrigated by the terms of the agreement.

The Riverside Water Company:—There were still some points of difference on which a number of land holders refused to come into the agreement, and so its consummation was delayed. The Canal company making some further minor concessions, about the middle of December the decisive step was taken, and the Riverside Water Company was formed and organized by the election of a board of directors consisting of Messrs. James Bettner, W. P. Leet, S. C. Evans, B. F. White, J. B. Crawford, J. G. North, Dr. J. Jarvis, T. H. B. Chamlin, O. T. Dyer, H. M. Streeter, and A. S. White. The ballot showed that ten thousand two hundred and fifty-two votes, representing five thousand one hundred and twenty-six acres, were present. This was an organization of irrigating land holders of the entire Riverside neighborhood, under the canals, to purchase and manage the canal and water property

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of the Riverside Canal Company, and a certain interest in the lands of the Riverside Land and Irrigating Company, according to an agreement which formed the basis of the final transfer of the property as hereinafter described.

The proposition now was to place the bonds of the new company for $200,000, of which $70,000 was to go to the purchase, and the balance to be devoted to improving the canals and water facilities, etc. The subsequent negotiations were carried on between the directors of the new Water company on the part of the people, and the controlling spirits of the old Canal company, until it was arranged that the agreement was to take effect as of January 1, 1885, but that the old company should continue to operate the works, keeping account of expenses, etc., until the new company had issued and sold its bonds, and the individual stock subscribers had all given their notes in payment for their stock.

Matters continued to drag, however, so that in February it was feared the arrangement would not be consummated. To quote from an important communication of that time, there was "a very general indifference" on the part of the land owners to the closing act. Only three thousand six hundred and forty and a half acres of the six thousand had finally come into the arrangement by the middle of that month, leaving under the terms of the agreement one thousand seven hundred and fifty-nine and a half acres yet to come in (making nine tenths of the whole) before it could be consummated. About this time an act was being urged before the legislature, and gave promise of becoming a law, requiring boards of supervisors in fixing water-rates to establish them at such figures as would yield a revenue of 7 per cent on the capital cost of works, over and above current expenses. Furthermore, it appeared that unless the Riverside people bought the Canal company stock, it would go into the hands of persons supposed to be not at all in sympathy with local interests or the people of the community—non-resident capitalists who having large means might, it was alleged, make a long fight and freeze the Riversiders out.

In this situation another strong move was made, and, finally, about the last of February the terms of the contract were fulfilled, and more than nine tenths of the acreage-stock was subscribed and paid for. At this time, of three hundred and ninety-four persons who owned the six thousand acres to be signed for, three

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hundred and fifty-four, owning five thousand four hundred and seventy-nine acres, had subscribed in proportion to their lands, and paid cash for their stock, or given their notes for payment, as by the agreement provided. When this result was reached, a local paper editorially said: "The agony is at last over. * * * Now Riverside can go ahead again. The heavy load is lifted. A new future awaits us."

The New Organization, and Agreement:—The Riverside Water Company was incorporated November 21, 1884, with a capital stock of $240,000, represented by twenty-four thousand shares; to acquire, hold, or transfer water-rights, canals, etc., works, and the stock of water or canal companies, and to do other things specified as necessary to accomplish its purpose of managing the water interests and works of the Riverside community. The number of directors named was eleven; the term of corporation lasted fifty years; and the place of business, Riverside. Its stock is issued only to owners of certain originally specified lands, and at the rate of two shares to each acre held; and thereby becoming attached as an appurtenance to the tract for which issued, in each case, it is afterwards transferred only with the title to the land.

Under the terms of the purchase of the water property from Evans and Felton, who controlled the old Riverside Canal Company, this Water company stock was to be at once issuable for six thousand acres of land, which specifically described region included all theretofore irrigated or sold by the Riverside Land and Irrigating Company for irrigation by the system, and also several hundred acres owned principally by Evans and Felton, and theretofore not irrigated. According, also, to the terms of this transfer, after the irrigation of the first six thousand acres should be fully accomplished or provided for, water stock might be sold from time to time, as the extent of surplus water-supply seemed to justify, for portions of an additional six thousand acres of land also specifically described. This tract was a part of the unirrigated lands of the old Riverside Land and Irrigating Company, which under terms of sale of the water property was transferred to a new company then organized, called the Riverside Land Company, in which the new Water company held half the stock under the terms of the purchase, and Evans and Felton the other half.

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In consideration for all the water properties and interests of the Riverside Canal Company, and the Riverside Land and Irrigating Company, thus transferred to the new Water company, and the half interest in the six thousand acres transferred to the new Land company by the Riverside Land and Irrigating Company, the Riverside Water Company paid $70,120 in its twenty-year 6 per cent bonds for the Evans and Felton interest, and agreed to take stock in the old Canal company from the outside irrigating holders thereof, at the rate of two shares for one—all of which was equivalent to paying $120,000 for the entire property. And it further covenanted and agreed to expend within two years, in acquiring additional water-supply, improving its works so as to reduce loss of water and facilitate delivery, and extending its system to command in distribution all of the first six thousand-acre district, at least $120,000, to be raised by the sale of additional bonds.

The stock of the new Water company was issued, first, to the holders of the Riverside Canal Company stock, one share for two of the old—there being two thousand four hundred and ninety-four of these latter shares outstanding under sales made as before explained; and, second, to all other owners of land within the first six thousand-acre district, at the rate of two shares to each acre, for $10 per share. The bonds of the Riverside Water Company were issued and sold, the transfer of property fully consummated, and the other conditions of the purchase have been fulfilled as elsewhere described, and thus did the irrigating land holders of this community come into the ownership of its water property.

Irrigator's Water-rights:—In no irrigating community of the State has there been such long protracted and serious trouble over individual water-rights as in Riverside, and in no community where such difficulty has occurred, has the outcome, so far as can yet be told, been, in the end, more happily adjusted for the irrigators, and, indeed, for all immediately concerned. The plan of the Southern California Colony Association apparently was to sell its lands, but retain its canal and water-rights as a separate property and permanent investment—supplying individual irrigators with water in measured streams as ordered from time to time, at rates fixed by the company. This, apparently, was the plan of the Riverside Land and Irrigating Company, although its managers have stoutly contended in later years that its intention always was to sell stock in the water enterprise to all purchasers of land

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sold by them, who desired to buy such stock—thus gradually dividing the water-property ownership amongst the land-owning irrigators.

Whether or not it was the original plan to gradually dispose of the water stock to irrigators, it is certain that the controlling owners regarded the canal property as one from which, for the time being, they were entitled to a net revenue equivalent to interest on a capital equal to its cost. This is proven by their public claims in writing, and before the board of supervisors, and in sworn complaints filed in suits brought by them, through the years 1881 to 1884, inclusive. There is equally no doubt that as early as 1878 the managers determined on offering the water stock for sale to the land purchasers. To this end, the Riverside Canal Company was formed by them to take the canal and water property off the hands of the Riverside Land and Irrigating Company, and this transfer being made, the Riverside Land and Irrigating Company, taking the Canal company stock in exchange for the works, offered it for sale with its lands, and to those who had bought lands. In the original land sales by the company there were no guarantees of water privileges, and no interest or stock in the water ownership given or transferred to the land purchaser—but simply an implied right to buy water from the company at the rates fixed by it.

In the third edition of its advertising pamphlet, issued in 1879, the Riverside Land and Irrigating Company said: "It is understood that the sale of land by the company carries the right to the purchaser to the use of water for domestic purposes and for irrigation, upon a compliance with the rules and regulations of the company, and the payment of water-rates as they may from time to time be fixed by the company. A canal company has been recently organized to which the Riverside Land and Irrigating Company will transfer all its right, title, and interest in and to all the water-rights, canals, and ditches now opened by it and to be constructed and completed to the Temescal valley. In compensation, the Riverside Land and Irrigating Company will take the stock of the Canal company to the extent of one share of stock to each acre of irrigable land, exclusive of the land within the boundaries of the villages. This stock the Riverside Land and Irrigating Company will sell only to the purchasers of its land, free from all assessments for the construction of the remaining

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portion of the canal, as follows, viz.: One share of stock for $10, payable in five annual payments, with 10 per cent interest, to the purchaser of each acre of irrigable land. As no more stock can be issued than the corresponding number of acres of irrigable lands, it is the intent and desire of the company that the purchasers of its lands shall also purchase the stock in the canals, and then ultimately own both land, canals, and water-rights.

"Owners of lands then can manage the canals to suit themselves. If, however, any of the people who buy lands do not wish to purchase stock in the canals, then they remain the common property of the people who do purchase stock, and the company, and will be managed jointly by them. The surplus earnings for the use of water for irrigation, domestic purposes, and manufacturing will be divided pro rata to the stockholders. Water is such an essential element in Southern California agriculture and horticulture, that an arrangement like the foregoing, we think, will remove the objection many might have to come under the control of a corporation owning the water. The colonists can always have a portion of the directors to manage the canals, and at any time they see fit can become sole owners of the entire water-system at a fair price and upon easy terms of payment."

It was subsequently noticed that by the above plan, the Land and Irrigating company would, by sale of a majority of its Canal company stock to land purchasers, lose control of the canals and water-rights before it had disposed of near all its lands. So, in 1880, it was determined that the Riverside Land and Irrigating Company should "take the stock of the Canal company to the extent of *two* shares of stock to each acre of irrigable land," etc., and would sell it to its purchasers of lands as follows: "One share of stock for $5, payable in five annual payments, with 10 per cent interest, to the purchaser of each acre of irrigable land; and the company obligates itself to sell the remaining shares to the same party, his heirs and assigns, upon the same price and terms, as soon as it has sold the most of its lands." And at this time (1880) it announced that: "If, however, the people who buy the lands do not wish to purchase the balance of the stock in the canals, then they remain the common property of the people and the company, and will be managed jointly by them."

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The company here referred to is the Riverside Land and Irrigating Company, and the stock in question is that of the Riverside Canal Company. By the first of these propositions, the land purchaser had the option of buying one share of stock for each acre of land. By the second proposition, it would appear that the land purchaser was obliged to take one share to each acre at the lower price, and had an option of another share at the same rate, when the company was ready to sell it. These were the terms offered from time to time by the companies, but they were not, as we shall see, generally accepted or free from harassing complications. The conflict as to irrigator's rights to be furnished with water, and as to equality of rates chargeable throughout the community, first appeared in 1877 between the Riverside Land and Irrigating Company and settlers on the government lands under the flow of the canals. These lands were some hundreds of acres in area, lying in a strip a mile or more wide, between the original Southern California Colony tract and the Hartshorn or New England Colony tract first taken in hand by the Riverside Land and Irrigating people. During 1876 and previous years the canal managers let these settlers have water for irrigation on the same terms as other irrigators. In 1877 they claimed the right to charge them a higher rate, or even not to let them have water at all, unless they paid a bonus for a water-right, as purchasers of the company's lands had in effect paid in their land purchases.

There previously had been an ill-defined understanding between some of these settlers and the managers of the old Southern California Colony Association, that the settlers were to give half of their lands when they got title thereto, in consideration of a water-right for the balance. But when the time came to adjust the matter—the canal property and some of the lands in question having changed hands—and the lands having rapidly advanced in value, owners of these lands, it was said, refused to fulfill the old promise. Then the Water company offered to sell them water-rights at $20 per acre—a rate much less than half the land valuations at the time. This proposal was accepted by some; but others refused, asserting that there never was any understanding that they had agreed to, as to the payment of a bonus, in any form, for a water-right; that they settled on or acquired their lands under encouragement from the company that they should

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have water as long as they paid the regular rates therefor, and that they thus had the right to the continuance of a supply.

Price vs. Riverside Land and Irrigating Company:—The question was brought into court in May, 1877, in the case of Price (one of the settlers) against the Riverside Land and Irrigating Company, which occupied much time, attracted great attention, and raised bitter animosities. The claim of the plaintiff was substantially as above set forth. The defendant answered that the water had been appropriated for lands owned by it, and was sufficient for them only, and that if it was forced to supply water to every outside irrigator who applied for it, the purchasers of their lands might and probably would be deprived of a due measure of irrigation virtually contracted for them.

The case was decided in the lower court in October, 1877. The court found that although there had been some talk originally amongst the settlers on the government land strip, about paying a bonus of some kind for water-rights under the canal, some of them had never assented to the proposal and there never was any agreement arrived at. Amongst those who had thus refused was the person from whom Price bought his land, who had "at all times claimed the right to purchase water of the said Colony Association and of respondent at its regular rates; and with their full knowledge of such refusal and claim he was furnished with water," at the regular rates, for a considerable period of time. And that the plaintiff bought the land thus being supplied, and at the time of his purchase had no notice, whatever, of the pretended agreement as to the expected payment of a water-right bonus. That, although there was not flowing in the company's ditches enough water to supply all of the lands owned by it, there was sufficient to supply all sold by it, and all irrigated and contracted to be irrigated up to that time, including the lands of the plaintiff. And the Southern California Colony Association having, in 1871, claimed and exercised the right of eminent domain, was a canal company in the eyes of the law and subject to general regulation as, and the obligations of such. Wherefore, the court decided that the plaintiff should have judgment, and decreed that the company should furnish him with water at regular rates on application, just as it furnished other irrigators. The case was appealed to the Supreme Court in February, 1878, where it was decided in December, 1880; the prevailing opinion supporting the opinion of the lower court

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on the vital question at issue, but the case was sent back for a new trial on some other grounds.

Settlement of the Conflicts:—During 1880 the marketable value of lands generally in the Riverside colony advanced very rapidly—from $40 to $200 per acre—many settlers on the "government strip" wanting to sell parts of their holdings, finding that they could not do so with the uncertainty as to water-rights hanging over them, compromised with the Riverside Land and Irrigating Company to the extent of $20 per acre on their lands. And in this way this particular controversy was in succeeding years gradually worked out—there being in the meantime several other suits at law commenced on substantially the same issue. The "Satterwhite Bill" (Section 552, California Civil Code) became law and went into effect in April, 1876. This was intended to compel irrigating canal companies to furnish water to all customers at equal rates for equal service, and to continue supplying every customer on demand, to the extent of ability, after once having accorded irrigation to him. But although this law was especially made to fit the case of the Riverside controversy, it does not appear to have settled it, or to have prevented the settlement above recorded, which for this case seems to have been equitable.

Coincident with the controversy between the "government land strip" owners and the Riverside Land and Irrigating Company, there was the question between the company and the purchasers of its lands as to the extent of territory it could sell water-rights for. There being no limit as yet placed on this, the irrigators generally refused to buy the stock of the Riverside Canal Company, offered them by the Riverside Land and Irrigating Company, and this led to several suits at law, as elsewhere recorded.

Finally, when the works and water-rights came to be purchased by the people for their lands in 1885, there were (1) lands sold by the Riverside Land and Irrigating Company and the old Southern California Colony Association, and entitled to receive water under the implied terms of the sales; (2) lands sold by these companies and for which Riverside Canal stock had afterwards been bought, and, so, doubly entitled to receive water; (3) lands on the "government strip" and claimed to be entitled to water under the decision of the Court in Price vs. Riverside Land and Irrigating Company, and under the "Satterwhite Bill;" and, finally, (4)

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lands on the "government strip" for which canal company stock had been bought, and which thus had this right in addition to the claim maintained for those in class three.

All these individual rights were, by the purchase of 1885, merged into and covered by the ownership of the canals and water-rights by the irrigating land owners themselves, on terms, as elsewhere fully explained, which make the water-rights and the works appurtenant to the lands irrigated, and to which the stock of the new company is attached. The Riverside Water Company is Riverside organized under another name for the special purpose of handling the local water question for itself; and each landowner in irrigating Riverside is now part of the Water company, receiving his irrigation as of right, at cost price, and having an individual interest in the community water property.

PROGRESS UNDER THE NEW REGIME:—Since coming into the ownership of the works the Riverside Water Company has greatly improved and extended them, as may have been gathered incidentally from the description already written of the various parts. The policy has been to bring them to a higher degree of efficiency, to save water, and extend irrigation over lands which, as already explained, the new Water company has a half interest in. The issues of bonds have been as follows: The first $200,000, bearing 6 per cent interest, and having five and ten years to run, was placed in 1885 at 90 to 95 cents. As security for these bonds, each owner of stock in the Water company mortgaged his irrigable property at a uniform rate of $40 per acre. The second issue was of $150,000, bearing 6 per cent interest, and having ten years to run. Of these $108,000 have thus far been placed, in August, 1888, at par. As security for these bonds, all property of the Water company is mortgaged, including that of the original purchase and that since acquired.

Recent Operations;—Since the organization of the Riverside Water company—that is to say, under the new regime—there have been expended on new irrigation works, etc., outside of costs of operation and maintenance:

For the Warm Creek canal (items elsewhere)	$72,883 71
For the enlargement, etc., of the Old Upper canal, below the Warm Creek canal junction to Twelfth Street in Riverside, etc. . . .	22,937 37
For artesian lands, general engineering expenses, telephone lines, etc.	24,371 59
Total	$120,192 67

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These expenditures, together with the amount paid the Riverside Canal Company for its works, and a small balance, account for the disposal of the receipts from the sale of the first $200,000 in bonds. Since then the second issue of $150,000 in bonds has been placed and expenditures made for improvements, of which the following are among the most notable:

Lining parts of the Upper canal (958 feet)	$2,931 15
Works at 40-foot drop for water power	3,467 00
Canal in Twelfth Street, with drop	12,375 00
Waste-water Canal, Tequisquite Arroyo	13,911 00
Tyler-street lateral—cement pipe	998 14
Harrison-street lateral—vitrified pipe	800 00
Eighth-street lateral—small iron pressure pipe	5,412 00

Pipe-line and Artesian Supply:—Until quite recently the citizens of Riverside have been generally dependent upon waters derived from the canals, for domestic supply. There had been a number of wells sunk, to be sure, but the general reliance was upon the "ditch" water. This supply was at times quite objectionable, and was at all times open to suspicion as to its purity. To remedy this evil, the Riverside Improvement Company was incorporated in May, 1879, with a capital stock of $1,000,000, divided into one hundred thousand shares. It was a private venture on the part of leading citizens of Riverside, to construct a domestic supply system of works. The company did not purpose competing with the Riverside Water company for the supply of the town, but rather to get over certain financial difficulties which were in the way of the Riverside Water Company's constructing the proposed works itself. The arrangement made was substantially as follows:

In consideration of the transfer of a tract of three hundred and fifty-nine acres of land adjoining the town on the north, and including within its limits the rocky, granite hill, called Rubidoux mountain, belonging to the Riverside Land Company, whose stock, as heretofore explained, is held by the Riverside Water Company and the old Riverside Land and Irrigating Company, the Improvement company agreed to pay to the Water company $25,000 in cash, and to develop from certain artesian wells in the San Bernardino basin, three hundred miner's inches of water, and deliver the same in pipes of sufficient capacity to points centrally located within the town. The Improvement company is also to have the privilege of taking water by the new pipe to serve their

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tract, which is above the reach of the general irrigation system; agreeing, at the same time, to pay $40 per acre for this water-right, for each acre of the tract that they may require to be thus served.

Under this agreement the Improvement company purchased seven and a half acres in the artesian belt for $4,732, and have constructed the pipe-line works heretofore described. In so far as the pipe is concerned, the contract of the company is filled, but more wells are to be bored to secure the full flow of three hundred miner's inches, contracted to be developed. This, together with some other things to be done to complete the contract, is estimated to cost $15,000. The works have been turned over to the Water company who are extending the main pipe-lines and distribution system. These works, with some others spoken of elsewhere, estimated for the next few months to cost about $45,000, will consume the balance of cash derived from the sale of the second issue of bonds.

Compromises with the North Side Canals:—The Riverside Water company is now reconstructing the Meeks and Daley ditch at an estimated expense of about $30,000, under an agreement with the North Side companies, brought about as follows: There has for years past been a controversy over the question of the measure of right which the Meeks and Daley, the San Salvador, the Jaramillo, and the Agua Mansa ditches had established, prior to the appropriations by the old Riverside canals. These ditches, diverting above these old canals, had, it was alleged, from time to time, in the annual clearances made of them, been enlarged and a greater measure of appropriation effected to the detriment of the Riverside canals and rights. Matters under this condition of affairs were fast tending towards a long and troublesome lawsuit, when a compromise was effected, whereby in consideration of a reconstruction of the line of the Meeks and Daley ditch as a canal of supply, and the delivery of waters through it to the irrigators under the four ditches mentioned, in certain measure to each, these irrigators joined in a transfer of their rights to the Riverside Water company, and agreed not to maintain their old dams in the river above, to make no diversion therefrom, allowing the waters to go down to the old Riverside canals. The amounts agreed to be delivered by the Riverside Water company were:

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To the irrigators under the Meeks and Daley right	400 inches.
To those under the Agua Mansa right	250 inches.
To those under the Jaramillo right	50 inches.
To those under the San Salvador right	150 inches.
A total of	850 inches.

The Meeks and Daley ditch being reconstructed to carry all this water, the parts due to the irrigators under each of the other ditches are turned in bulk into branch ditches at certain described points along the main canal; all of the water being taken from Warm creek at the head of the old Meeks and Daley ditch. The Riverside Water Company estimates that it will, under this arrangement, and by the expenditure of about $30,000, have warded off a most troublesome litigation, and have saved for itself about four hundred to five hundred inches of water at the period of least flow, which was lost, by the usual processes of such wasting, in the old canals mentioned. On the other hand, the irrigators under these old rights consider that they will have as much water as they ever had for actual use, and that they have saved the expense of annual reconstruction of their dams and clearances of their old ditches, and have placed their water property in such position that it is much more tangible and valuable. Furthermore, by the reconstruction of the Meeks and Daley ditch, other lands are commanded for irrigation now, which before were above the reach of the old grade lines.

SECTION II.

The Upper Riverside Enterprise.

The District and the Project—The Canal and Its Structures:—The Dam and Headworks; The Canal Construction; Earthwork, Tunnels, Flumes; Summary, Canal Parts; Capacity of the Canal; Cost of First Division. *Operation and Maintenance:* Lateral Irrigation Systems; Local Domestic Supply Systems. *Water-supply and Use:* Sources of Supply, and Claims; Artesian Well Data; Extent of Irrigation.

History of Enterprise and Water-rights:—The S. F. Department Project of 1880; The Gage Enterprise; The Financial Management; Water-right Claims; Conflicting Interests; Irrigators' Water-rights; Alleged Cost of the Work.

The Gage Canal.

District and Work:—This work, the longest and one of the largest artificial water-courses in San Bernardino county, has for its object the watering of nearly all the Riverside mesa plain

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lying above the reach of the Riverside canals. Although not depending in the main upon the Santa Ana river for its waters, its commencement is in the nature of a diversion from that stream, at a point four miles above the mouth of Warm creek, and nine to nine and one half miles below the cañon opening. Taking its departure from the left bank of the river, it swings rapidly to the south, away from the stream, over a gently sloping plain for about two miles in length; then skirts along a steep, sloping bench-land, westerly for about one mile; then clings to the face, and tunnels through the points of a precipitous bluff for nearly two miles farther westward, where, turning sharply to the south, it passes by a long tunnel through the upper edge of the mesa, out upon that sloping plain itself, and then follows it, generally as a ditch in excavation, encountering no serious obstruction save one rocky point of mountain which is passed by means of a tunnel.

CANAL AND STRUCTURES:—The length of the work over all, from head-gate to Tequisquite arroyo, is 11.91 miles; thence to the terminus, 8.22 miles—making the total length 20.13 miles, which is but 2.3 miles longer than a straight line drawn between its terminal points, in a general direction nearly northeast and southwest. It commands for irrigation almost the whole of the mesa above the Riverside Upper canal, comprising some twelve thousand acres, and extending in a belt from one half to two and a half miles in width, and about thirteen and a half miles in length. Of the area below the canal on the plain, about four hundred and twenty acres is hill land not commanded by the grade line.

For the first two thousand feet the work of the canal excavation was in sand or sandy loam; thence for about thirteen thousand feet, through an "alluvial adobe," merging into a gray clay or heavy soil, which gradually changed, as the bluff was approached, to a friable, marly earth, underlaid in some places by soft sandstone, and in others by a disintegrating soft granite, and overlaid by a thin layer of heavy red soil, except in the cross-washes, where sand beds were encountered. Coming out upon the mesa, the construction was in ordinary heavy red mesa soil, growing lighter and more sandy towards the lower end of the work, with the exception of a seven hundred-foot tunnel through hard granite at the point of mountain heretofore referred to.

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The cross-sectional dimensions of the open canal are as follows: The depth throughout, four feet; side slopes, one to one; bottom width, for fourteen thousand feet, eight feet; for forty-one thousand three hundred and twelve feet, six feet; and for the lower forty thousand six hundred and forty-seven feet, five feet. It is, for the most part, excavated to a depth of three feet below the natural surface on the lower side, the top foot of water-way being supported by the embankment. There are numerous exceptions to this rule, especially on the lower division, where considerable extra work has been done to keep the canal as straight as possible, and where there are a number of thorough cuts from ten to twenty feet in depth, frequently in very solid material, "cement" rock, and soft granite. There are four heavy fills in the work, which average about six thousand cubic yards each. The grade slope of the canal is about two feet per mile throughout.

Dam and Headworks:—The diverting dam is of wood, about three hundred feet long, extending across not only the low-water channel proper of the river, but also across a portion of its extreme flood-water way. It was planned in three sections of about one hundred feet each; the middle section being two feet seven and a half inches lower than the end sections. The floors of the end sections are about eighteen inches in elevation above the river channel, and that of the middle section is below that of the grade line of the channel. As constructed, this dam had within it a flume box intended to conduct water from artesian sources north of the river, across and under its channel into the bay of the head-gate of the canal. The north section of the dam was entirely carried away by a freshet in February, 1888; the submerged portion was injured, but the headwork was not injured. It is the intention to reconstruct the dam and contained flume, on the same general plan, lowering and lengthening the submerged section, and protecting the whole by means of square and sheet piling.

The head-gates are framed into the end of a receiving chamber thirty feet in length, ten feet wide, and eight feet deep. The floor of the chamber, being eighteen inches below the grade of the canal, serves the purpose of a sand-box; there being a sluice-way provided at its lower end, and just above the canal head-gates, by which to clear it when necessary. The flume, as constructed within the dam, joins this chamber on the side at the upper end. The head-gates at the lower end of the chamber are arranged in

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two bays closed by sliding wooden gates, which are moved by a rack and pinion combination of the frame-work above. The sluicing-gates are of the same character and similarly operated.

Tunnels:—There are fifteen tunnels, whose aggregate length is six thousand one hundred and seventy-eight feet—the longest being two thousand three hundred and twenty, and the shortest one hundred and ten feet. Of these, fourteen, whose aggregate length is five thousand four hundred and seventy-eight feet, occur within less than 2.5 miles, and were driven in marly earth, soft sandstone, or cemented sand, and soft disintegrating granite. These tunnels, in rock, are 6.5 feet wide and 6.5 feet high in the clear at center, the top being in arched form. In earth they are lined with concrete on bottom and sides, and timbered overhead, the waterway being 6 feet wide and 4.5 feet deep on the sides in the clear. The concrete lining on bottom and sides averages six inches in thickness. Where tunnels run through "cemented clay" (probably marl), the roof timbers were inserted into the sides and the concrete afterwards carried up to and around them. In construction through soft clay or earth which would not stand without timbering, temporary shores and lagging were used. About five thousand five hundred linear feet of tunnel were thus lined with concrete and cemented. An attempt was made to carry water through the work before these tunnels were thus protected, but it so far injured the channel by washing out at points as very nearly to prove seriously disastrous.

Flumes:—There are thirteen flumes whose aggregate length is four thousand one hundred and seventy feet; the shortest being forty-eight and the longest one thousand feet. Of these, three are, in section, seven by four feet, five are six by four, and five are five by four—the width decreasing with that of the canal in three successive divisions of the work from the head. The flume over the Tequisquite arroyo is eighty feet high in the deepest part and one thousand feet long; supported on trestle bents sixteen feet apart. These trestles are of Oregon pine, of rather light dimensions, but well braced and apparently stiff in all directions. Its cost was about $6,000.

SUMMARY OF CANAL PARTS:—The following table shows the total length of each division of the work, and of the various sizes and classes of the work:

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	First Division.		Second Division.		Total Canal.	
	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.
Tunnel—Clay and soft rock	5,478	....	....	....	5,478	....
Tunnel—Hard rock . . .	700	....	....	....	700	....
Tunnels, total	6,178	1.170	....	....	6,178	1.170
Flumes, 7x4 feet	688	....	....	....	688	....
Flumes, 6x4 feet	722	....	....	....	722	....
Flumes, 5x4 feet	....	....	2,760	....	2,760	....
Flumes, total	1,410	0.267	2,760	0.523	4,170	0.789
Structures, total	7,588	1.437	2,760	0.523	10,348	1.959
Earth, 8 feet wide	14,000	....	....	....	14,000	....
Earth, 6 feet wide	41,312	....	....	....	41,312	....
Earth, 5 feet wide	....	....	40,647	....	40,647	....
Earth, total	55,312	10.472	40,647	7.698	95,959	18.170
The canal, in all	62,900	11.909	43,407	8.221	106,307	20.129

COST OF THE FIRST DIVISION:—Following is the reported cost of construction of the Gage canal, between Santa Ana river and Tequisquite arroyo—11.91 miles:

Ordinary open excavations and fills	$36,000 00
Clay and cemented sand tunnels, 5,500 feet	27,500 00
Rock tunnel (not cemented), 700 feet	11,200 00
Cementing and timbering tunnels, 5,500 feet	31,500 00
Flumes and stone foundations, 1,410 feet	14,100 00
Total	$120,300 00
Dam and head-gates	$3,500 00
Engineering	5,900 00
Right of way	95,300 00
Lands of which water sources form a part (2,700 acres)	175,000 00
Artesian wells (29)	25,000 00
Total	$425,000 00

For purpose of taxation in 1888, the work itself is assessed at $100,000, or $8,333 per mile for twelve miles.

Operation and Maintenance:—The distribution system is composed generally of pipes of iron and cement and wooden flumes of small size, the grade of the plain laterally from the canal being seventy-five to one hundred feet per mile. All distribution is

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effected at the expense of the purchasers of water-rights, who have planned and carried out their works in their own way, as best suited their means and convenience, in some cases individually, and in some cases by combining together in little districts. As far as known, these laterals are at present about as follows: Two miles iron pipe; 4.12 miles cement pipe; 12.12 miles wooden flume; three miles open ditch, all varying much in size. The aggregate cost of these is given at $17,469. The canal supplies domestic and irrigation water to several additions to the town of Riverside, each of which has its separate system of pipes, heading in a small distributing reservoir, placed immediately below the canal.

Water-supply and Use:—SOURCES AND CLAIMS:—Near the upper limit of the artesian basin, the Gage canal has about six hundred acres of river-bottom lands lying in a belt a little less than two miles in length, and with a maximum width of little over half a mile, at and above the head of its canal and at points wherein the first four groups of wells have been sunk. It is claimed by the engineer and the manager of the enterprise, that the results of these borings has shown a capacity on the part of these lands to yield an artesian flow of at least twenty miner's inches for each acre of ground, and that one well to each acre will develop such supply. Upon this assumption, it is estimated by those in charge of the work, that a flow of twelve thousand miner's inches could, if required, be obtained by boring the necessary number of wells, namely, one to each acre; and thus, it is asserted that water may be obtained from this source alone, up to the capacity of the canal, and sufficient to supply, at the rate of an inch to five acres, all of the lands of the mesa which the canal controls.

Thus far the wells already bored have generally been kept capped; there having been sufficient water in the river to supply the demand for delivery to the customers of the canal. The work of boring additional artesian wells on this tract is being actively pushed, the larger size, ten-inch, having been adopted.

It is the intention to keep this work going uninterruptedly until, as is hoped, two thousand miner's inches are made available from this source.

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The amount of water claimed to be available for the Gage canal July 30, 1888, is as follows:

From Santa Ana river	400 miner's inches.
From Spring Ditch	103 miner's inches.
From sixteen artesian wells	764 miner's inches.
Total	1,267 miner's inches.

The amount claimed to be available for this canal during period of lowest flow in streams is as follows:

From Santa Ana river	400 miner's inches.
From Spring Ditch	50 miner's inches.
From sixteen artesian wells	764 miner's inches.
Total	1,214 miner's inches.

The Riverside Water company dispute the right of the Gage canal to divert any more water from the river during the period of low flow, than the measure of right established by the Old Camp Carlton ditch, which they claim was not to exceed one hundred and fifty miner's inches. The question is now before the courts. If decided adversely to the Gage interest, the available supply at such times as the Riverside company require the water will be reduced by two hundred and fifty miner's inches, leaving nine hundred and sixty-four inches under the foregoing claim. It remains to be seen how long a time the wells already bored would continue to flow, up to the volume of discharge above accorded to them, if kept continuously running during the months of greatest demand; and it is for the future to determine whether or not as great a volume as two thousand inches can be had as a constancy during each irrigation season, from this source for this canal.

Artesian Wells:—The following table is an exhibit of grouping, location, diameters, measures of flow, and average depth of the wells thus far bored by the Gage canal management, as reported by the engineer in charge of the work:

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Group.	Number.	Location.	Diameter. Inches.	Head. Feet.	Flow. Miner's Inches.
A	2	In the south bank of the canal just below the head	7 7	0.71 0.73	63 72
B	6	At the foot of the high bank immediately north of the headworks of the canal	7 7 4 7 7 7	0.95 0.42 0.325 0.505 0.175 . . .	236 20
C	4	At the foot of the north high bank, one mile above group "B"	7 7 7 7	0.11 0.095 0.155 0.15	44.64
D	4	At the foot of the south high bank, above the headworks of the canal	10 10 10 10 10	0.4 0.4 0.4 0.4 0.45	Weir. 329
E	9	Below the canal line bored to supply the H. & C. ditch not on river bottom land	7	. . .	130
F	4	Scattered at various points not in the river bottom land belt, specially reserved for local water-supply	. .	. . .	60

Summary.

Group.	Number.	Diameter. Inches.	Average Depth. Feet.	Flow. Miner's Inches.
A	2	7	140	135
B	6	7	150	256
C	4	7	150	44
D	4	10	226	329
	16			764
Scattered	4	7		60
Hunt	9	7	115	130
	29			954

The average of the first sixteen wells is 47.7 miner's inches per well, that of the total twenty-nine wells is thirty-three miner's inches per well.

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IRRIGATION:—Barely sufficient water is allowed to flow down the canal to supply present needs. It is believed by its managers that the entire area commanded by it will rapidly come under cultivation, and the works thereafter be taxed to their utmost capacity. In the present year (1888) there will be one thousand one hundred and six acres irrigated; of which six hundred and thirteen are in oranges, two hundred and sixteen in vines, sixty-two in alfalfa, fifteen in summer crops, and two hundred acres are town and residence lots cultivated as gardens.

History of Enterprise and Water-right:—The success achieved in irrigation of the mesa plain south of the Santa Ana river by the Riverside canals, and the high values attained by the lands there irrigated and planted to the orange and the vine, for which the soil and climate proved specially suitable, stimulated desire to furnish water to that portion of the mesa lying above the reach of the highest of these canals, where the soil was equally fertile, but barren for lack of irrigation. But water-supply for a canal from the Santa Ana river to cover this higher belt of land seemed to be out of the question, as the stream was all appropriated in the irrigating season above the point where such a canal would necessarily have to be derived, and claims below seemed to cover all the water in the river, during the season of greatest demand.

THE PROJECT, ORIGINAL:—Surveys were made by the State Engineer in 1880 to determine the feasibility of irrigating this plain, and a canal line was run in substantially the position now occupied by the Gage canal where out on the mesa. The plan then in view was the forming of a reservoir in Bear valley (since carried out by private enterprise), and the construction of a canal from the mouth of Santa Ana cañon, skirting the valley on the south and east to Mill creek, crossing the Mill Creek ditch, continuing around the valley to the south of the present Lugonia, Redlands, and Mound City tracts, and thence extending to the Riverside plain. In connection with this system a reservoir was planned for the main Yucuipa valley, and one or two others in the vicinity to serve as feeders and regulators of the canal. A large reservoir was also to be made in the Tequisquite arroyo above Riverside, into which the canal was to discharge. Parts of this comprehensive system have since been carried out by private parties, but independently of their connection with the whole; the Gage canal,

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in its course around the bluffs and out on the mesa, being substantially one of the links.

ORGANIZATION:—The first section of the Gage canal, from its head to the Tequisquite arroyo, 11.91 miles, was begun October, 1885, and completed so far as to carry water through it November, 1886, although regular use in the way of irrigation was not begun until the spring of 1887. Work was begun on the extension of the canal February, 1888, and completed June, 1888, a distance of 8.22 miles, to a point a short space further down the valley than the terminus of the Riverside canals. This completed the canal as far as it has been projected, and its terminus will doubtless remain where it is for years to come. The enterprise has been carried forward purely as a business operation by one person—Mr. Matthew Gage, of Riverside. His capital was small. He obtained a bond on the water-bearing and riparian lands; outlined the project; secured several small, old ditch water-rights, and an advantageous agreement with owners of another old ditch right; and then negotiated a bonus for irrigating water-rights with owners of the dry lands out on the mesa. He contracted a number of irrigating water-rights at rates ranging to $100 or more per acre of land to be irrigated, and obtained agreements that held the lands as security for their acceptance and payment. Virtually, on this foundation which represented so much cash, or very valuable lands should the works prove successful, he borrowed the money to carry it through to a point where it made a good showing as a work. Just then came a boom in water and land matters. Water-rights, generally, were in demand. Those in the Gage canal sold at high figures. Land secured by bond or contract by the promoter jumped from tens to hundreds of dollars in market value. And so the financial strength of the enterprise was sufficiently assured to carry the works to completion.

WATER-RIGHTS AND CLAIMS:—The Gage canal depends for water-supply upon several sources and claims of right. There is (1) the Old Hunt and Cooley right of diversion from the river; (2) the Wells and Long claim also from the river; (3) the Parish or Caric claim to water rising on bottom lands north of the river and above the head of the ditch; and in addition to these (4) the water obtained and to be obtained by boring artesian wells.

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The Hunt and Cooley ditch was one of the oldest diversions on the middle part of the Santa Ana through its course in this basin. It diverted water at about the point now occupied by the Gage canal, and carried it on to the lands south of the river and considerably below the present grade line of the Gage ditch.

Owning artesian lands at a lower elevation that would supply their ditch, the managers of the Gage enterprise made an arrangement with the owners of the Hunt and Cooley ditch whereby they would supply these latter with artesian water equivalent to the agreed capacity of the Hunt and Cooley ditch, and in return they secured the right of diverting into their canal the amount of water claimed from the river for the Hunt and Cooley ditch. Then, to make good their contract to the Hunt and Cooley irrigators, the Gage management bored a number of artesian wells, and, securing enough water in this way for these lower irrigators, were themselves enabled to carry water under the Hunt and Cooley claim out of the river and through their new canal to the higher mesa. The agreed amount to be delivered to the Hunt and Cooley people was one hundred and thirty miner's inches. It had been the custom of the Hunt and Cooley ditch for a number of years prior to the spring of 1884, to divert during each season all the water flowing in the river at the point of its heading. That is to say, the flow of the river during the irrigating months was not more than sufficient to fill the ditch. Thus, the ditch laid claim to all the flow of the river at its head. The heavy freshets of 1884 cut down the channel of the river through underlying gravels, so that in the succeeding seasons of 1885, 1886, and 1887 there was a very much greater flow in the low water channel of the river than had been known before in years of similar rainfall; and thus, for an agreement to deliver one hundred and thirty inches of water to the Hunt and Cooley irrigators, the Gage canal has been enabled to divert about three hundred to five hundred inches from the river under the claim of the Hunt and Cooley ditch to "all the water of the river flowing at its head."

The Wells and Long claim from the river is based upon the construction of a ditch out upon the north side, and use of water previous to 1884. The floods of that year swept the head of this ditch away, and it has not since been used. The Spring ditch, known also as the Parish or Caric ditch, rises upon lands owned

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by the Gage canal management, and rights which had been established to the use of its waters by other parties on the northern bank of the river, having been bought out, the Gage management is entitled to its full flow.

Riverside Water Company vs. The Gage Canal:—The Gage diversion from the Santa Ana river brought about a conflict with the Riverside Water Company, which culminated in a protracted struggle before the superior court in the last and present year. The Riverside company acknowledged the Hunt and Cooley right to not more than two hundred inches as being prior to theirs, and complained that the Gage canal had, by diverting much more than that amount, deprived their canals of at least four hundred and fifty inches of their rightful supply. They asked to be adjudged damages in the sum of $5,000 and costs, and that the court issue an injunction perpetually restraining the Gage canal management from diverting any water from the river in excess of three hundred inches, measured under a four-inch pressure; and that they be restrained from doing anything whereby the Riverside company would be deprived of waters of the Santa Ana in excess of three hundred inches; and, finally, that the court adjudge that the Gage canal is not entitled to the flow of the waters of the river to any extent in excess of two hundred inches, but that the Riverside company is the owner, and entitled to the free use and enjoyment as against the Gage management, of all the flow in the river in excess of two hundred inches.

Gage denied that the Riverside company had any right whatever in the river waters diverted by the Gage canal. On the contrary, that (1) the Gage management has right to water by reason of owning a large body of land riparian to the stream, of which over one thousand six hundred acres can be irrigated by the canal in question; (2) that the defendant's grantors have been for more than twenty years in actual possession and use of all of the water of the river at the point named.

The answer goes on to show that the waters of the river, at low-water or irrigation period, had for years back been all diverted from the channel by several canals over six miles above his work. That nearly all the water which came to his canal at such times rose in the river channel on his land. That the Hunt and Cooley ditch had for twenty years regularly diverted the full measure of low-water flow, in all except seasons of extraordinarily full sup-

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ply. That a large part of the waters now flowing in the river at low season had been placed there by Gage in opening up and clearing out springs in his bottom-land along the streams; and that his artesian wells furnished water as heretofore stated.

Aside from the question as to measure of diversion formerly made by the Hunt and Cooley ditch, and other important questions of fact, the case presents the following points at law: May a proprietor, on the basis of riparian ownership, utilize waters of a stream on lands not riparian to the stream, but remote from it, to the detriment of an appropriator below? Does the diversion of "all the waters of a stream," when it has habitually flowed, for instance, two hundred inches at low period, constitute an appropriation which will cover all the flow of the stream, when by some natural cause it increases in volume at such times to two or three times that amount? The case is as yet, August, 1888, undecided.

Irrigators' Water-rights:—While the upper section of the canal was under construction, irrigators' water-rights, entitling the purchaser to one miner's inch, continuous flow, to each five acres of land, were sold at the rate of $100 per acre, or $500 per inch. This is the cheapest rate at which the water-rights have been sold. Subsequently the price was doubled, and at one time reached as high as $250 per acre, $1,250 per inch. They are now held at about $200 per acre. The total sales of these water-rights cover about three thousand acres.

SECTION III.

HIGHEST RIVERSIDE MESA SCHEME:

The Vivienda Water Company's Projects.

The Vivienda Water Company, the North Riverside Land and Water Company, and the Jurupa Land and Water Company are corporations acting in unison and under one management for the development of water and the irrigation of dry lands on both sides of the Santa Ana river. The Vivienda company has a contract with the owner of the Raynor springs property, which is elsewhere described in connection with the Rancheria and Colton ditches, to develop a greater flow of water there, and is now engaged on the work. It has also an artesian well source at a point on the west

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bank of Lytle creek near two miles below, and a mile and a half west of San Bernardino.

Water-supply Development:—The latter system at present consists of eight artesian wells, seven inches in diameter, and three hundred to three hundred and fifteen feet deep. The flow from these wells at present aggregates about one hundred and fifty miner's inches. The elevation of the surface at that point is one thousand one hundred and five feet. From the wells, an eighteen-inch pipe of No. 16 iron has been laid for one and three fourths miles to Colton Terrace, and the lands of the Orange Land and Water Company adjacent to Colton, and a portion of the water, is in use there. The pipe-line is to be prolonged to the Jurupa rancho, by a route north of Slover mountain, joining on the way with another conduit to be laid from the Raynor springs source of supply. The wells pass through three artesian strata; encountered, the first, from ninety to one hundred and sixty feet; the second, from two hundred and fifty to two hundred and sixty feet; and the third, from three hundred and five feet to the bottom. They have not been able to go through the last strata of water-bearing gravel as yet. The intermediate strata are clay. The total cost of this system is said to have been $40,000, and more wells are being bored.

The Raynor springs development work consists of deep drain-cuts into the *cienega*, and artesian borings therein. The waters developed are concentrated into a flume, to be one and a half miles in length, five feet wide, and three feet deep. From the lower end of the flume, which is at an elevation of one thousand one hundred and ninety-six feet, a twenty-four-inch pipe is to be carried south across the river, and up on to the Riverside mesa at an elevation of one hundred and forty feet above the Gage canal, a distance of seven miles. The point of delivery is at an elevation of one thousand one hundred and forty feet, giving a mean hydraulic grade of eight feet per mile in the pipe. The lowest point of depression will be about two hundred and thirty feet below the hydraulic grade line, giving a pressure of about one hundred pounds per square inch.

District and Works:—The company contracted with land owners on the mesa to deliver four hundred miner's inches through the

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pipe at the terminus, for $750 per inch, taking mortgages on the lands to secure payment. The purchasers will make the distribution at their own expense. A pipe or ditch will be required to carry the water from the end of the pipes to some lands, a distance, to the end, of about five miles, terminating at Tequisquite arroyo. It is expected to irrigate about two thousand acres of the mesa, of which the stockholders of the Water company own one thousand three hundred acres, above the reach of other works now existing. Another part of the plan is to build a conduit (flume or pipe) to Colton Terrace, where it will form a junction with the eighteen-inch line, and to be extended to the Jurupa rancho, as before mentioned.

COST ESTIMATE:—An estimate of the probable cost of these works, exclusive of the Jurupa line, is given as follows:

Seven miles pipe	$84,000
Flumes, etc.	16,000
Development of water	10,000
Total	$110,000

ORGANIZATION:—The Vivienda Water Company was incorporated August, 1887, with a capital stock of $250,000, in five thousand shares of $50 each.

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CHAPTER IX.—SAN BERNARDINO[4]; WORKS AND PROJECTS[7].

SANTA ANA RIVER WORKS.

BASIN DIVERSION GROUP[3].

SECTION I.—*South Side Santa Ana Sub-group (b):*
Camp Carlton Ditch;
Hunt and Ward Ditch;
Old Jansen and Warren Ditch;
Belarde and Salazar Ditch;
Several Spring and Well Irrigations.

SECTION II.—*Warm Creek and City Creek Sub-group (c):*
Hawes Ditch;
Rabel's Dam Ditch;
Stout's Dam Ditch;
McKenzie Dam Ditch;
Spark's Ditch;
Stewart's Ditch;
Waterman's Ditch;
Davis' Mill Ditch;
Grucer or Ball Ditch;
Heap Spring Ditch;
Johnson Swamp Ditch;
Coburn Swamp Ditch;
Other Spring and Swamp Irrigations.

SECTION III.—*Lytle Creek Springs and Town Springs Sub-group (d):*
Raynor Springs Ditch; Rancheria Ditch;
Colton Land and Water Company's Ditch;
Town Ditches;
Beamis Ditch;
Garner Swamp Ditch.

SECTION IV.—*North Side Santa Ana Sub-group (e):*
Santa Ana Waste-water Ditch;
Meeks and Daley Ditch;
Jaramillo Ditch;
San Salvador Ditch;
Agua Mansa Ditch.

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SECTION I.

South Side Santa Ana Works—Sub-group (*b*).

Among the irrigation works counted in the Basin Diversion group of the Santa Ana ditches, those which take water out on the south side and distribute it within the San Bernardino basin have been ranged in this sub-group (*b*). They are the Camp Carlton, Old Hunt, Old Jansen, and Belarde and Salazar ditches, all old works, primitive in character, of small capacities, and owned by those who use their waters.

Camp Carlton Ditch.

For a number of years this ditch diverted at a point now held as a heading by the Gage canal. Under an agreement which has been noticed in describing that larger work, the Camp Carlton ditch is now supplied with water from the Gage canal, and from artesian wells, situated about midway down its course. As originally made, after about half a mile of construction, along the bluff river bank, it extended across the plain south of the river, in a southwesterly direction, crossing Mill Creek waste-water wash, a distance of about two miles, to where it now receives its supply, and thence southerly to the first mesa bluff on the south side of the San Bernardino valley, it turned to the west around the sloping plain at the foot of this bluff, distributing its waters westerly and northerly to quite a compact body of land lying south of the river, and, for the most part, bordering the Southern Pacific railroad reservation between Colton and Mound City station. With a total length of 4.2 miles, which, with its main branch makes 5.4 miles of channel, it had a capacity of one hundred and fifty to two hundred and fifty miner's inches. Its present working length, on account of delivery of water from artesian wells and the upper canal, is about two miles less than that above given; and it now serves in irrigation about four hundred and fifteen acres of land.

Operation and Maintenance:—There never has been any stated organization for the management of this ditch. There has ordinarily been a watermaster chosen for each year from among the owners, who has not been paid otherwise than by allowing him some pay for time spent on the dam and upper part of the ditch.

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An estimate has been made each year of the cost of clearances and work on the dam; this was apportioned to each owner in proportion to his ownership, and he has either paid in money or worked out his share of the assessment. The whole cost of maintenance has ranged from $100 to $200 per year.

Water-supply and Use:—The seasons have been very few when this ditch—being the uppermost one to tap the rising waters of the Santa Ana—has not had a supply fairly up to its capacity throughout the driest months.

IRRIGATION:—The following is an exhibit of the extent of irrigation for various periods, from the time of commencement under this ditch to the last year:

PERIOD.	Number of Years.	Number of Irrigators.	Number of Acres Irrigated.
1864–1866	3	4	211–217
1867–1868	2	3	240–253
1869–1871	3	4	363–380
1872–1873	2	5	390–390
1874–1880	7	6	435–435
1881–1884	4	6	455–455
1885–1887	3	5	442–445

Irrigation commenced under this ditch claim in 1860, and its progress from time to time is shown by the data of the above table made up from the testimony of its owners during the recent trial of a case at law. According to statistics from time to time collected by the state engineering department, however, the extent of irrigation shown by this exhibit is excessive. In 1879 its owners reported a summer irrigation of about three hundred and twenty acres. In 1882 there were six owners in the ditch, holding the total number of one hundred and sixty-eight hour-shares; the highest holding being forty-eight, and all the others twenty-four each. The period of rotation was seven days (one hundred and sixty-eight hours). The delivery of the ditch during irrigation months varied between one hundred and twenty and one hundred and sixty miner's inches. The total irrigated area was three hundred and forty-eight and one quarter acres, which was cultivated, in grain one hundred and eighty-two acres, in summer crops fifty-five, in alfalfa eighty-six, in orchard twenty and

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one quarter, and in vines five; and as already stated it irrigates this year four hundred and fifteen acres.

History of Water-right:—The ditch of which this is the lineal successor was first taken out from the river in 1859 at a point two and a half miles below where the last heading was located, and it irrigated only a small portion of the lands now cultivated under the right. It was known, from its owners, as the Hunt and Cooley ditch. The flood of 1861 and 1862 so much damaged the upper part of this work that it was abandoned and another heading established about a mile and a half above the old one, and just above the point where now the California-Southern Redlands branch crosses the river. This was in 1862, and nearly opposite the ditch head was an encampment of troops known as Camp Carlton, to which name the ditch immediately succeeded. The head of the original Camp Carlton ditch was destroyed by the flood of 1868–69, and so a new heading was sought for it and established in 1869, about where the Gage canal now diverts its waters, where it remained until the arrangement was made with Gage as heretofore written. There is a water claim of record for this ditch, and in August, 1865, the Water Commissioners viewed and sanctioned the work. For purposes of taxation this year the Camp Carlton ditch and water right were assessed in seven shares, at $675, making a total valuation of $4,725.

The Old Jansen ditch below was taken out in 1857, and it was the practice for the Hunt and Cooley, or Camp Carlton, and the Jansen ditches to divide the waters at period of low flow—taking all the river brought to them.

The Old Hunt Ditch.

At a point just below the output of the Mill Creek waste-water wash, and something over half a mile above the mouth of Warm creek on the southeast bank of the Santa Ana river, this old ditch derives its supply; and coursing in a southerly direction under the trestle of the Southern Pacific railroad, and along the foot of the first mesa bluff, it runs a distance of about a mile to the foot of the high bluff forming the northern limit of the Riverside plain and the extreme southern edge of the San Bernardino basin, along the base of which it turns a half mile westward. Thus, with a total length of one and one half miles of main

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ditch, it serves for the irrigation of a compact body of land lying next to the high bluff, about one hundred and three acres in area.

The diversion is effected by a rude brush and sand dam, which, being washed out at every high-water period, is replaced in the spring when the water falls. The ditch itself is for the upper portion through a sandy bottom-land, and then gets out on to the second bottom, or lower plain, where the soil is of a heavier quality. Its capacity is about one hundred and twenty-five to one hundred and fifty miner's inches, depending very much, as is the case with so many of these little works on light soils, upon its condition. After the flood of the spring of 1884, the upper three fourths mile of this ditch was made to serve as a feeder for the Old Jansen ditch which had previously diverted half a mile below it; and now each spring this portion of its route is cleared out so as to carry double the amount which it would deliver below.

Operation and Maintenance:—There is no organization of the owners of this ditch. It is simply a little partnership property. Each man does work on it in proportion to his interest in the supply, and they severally take charge of distribution, each during his hours for using the water.

Water-supply and Use:—This ditch seems to have succeeded to the relation with the Jansen ditch, with respect to division of the low-water flow, which the original Hunt and Cooley, afterwards Camp Carlton, ditch established prior to the flood of 1861–62—the two ditches have divided the available flow up to the limit of their capacities. The two have claimed all the water up to that limit, which probably has varied between one hundred and one hundred and seventy-five inches each. They are of low grade and of character such as rapidly close up by the growth of weeds after cleaning.

IRRIGATION:—Irrigation commenced in 1863 under this claim. In 1879 it served about one hundred and ten acres. In 1881 there were two owners of the water-right, one owning one hundred and twenty hour-shares and the other forty-eight of the one hundred and sixty-eight-hour or seven-day period. The total area irrigated was one hundred and twenty-five acres, of which eighty-four were cultivated in alfalfa, forty in summer crops, and one in orchard. The extent of irrigation remains about the same to this time, but the character of cultivation has materially changed.

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History and Water-right:—This ditch was taken out in 1863, the year after abandonment of the head of the original Hunt and Cooley ditch, and when it made its first move up stream, as already described. There is a filing in the county records, in the name of A. Hunt, dated March, 1865, and claiming all the water in the river at the proposed point of diversion, which, as described, is that where this work takes water. This diversion is now called the Ward and Warren ditch; Ward owning the Hunt ditch, and Warren the Jansen, and the two diverting water together. For purposes of taxation for the current year, the Hunt ditch was assessed to the holders of its one hundred and sixty-eight hour-shares at $10 per hour, or a total valuation of $1,680.

The Old Jansen Ditch.

At a point about a quarter to half a mile below the head-work described for the Old Hunt ditch, is the location of the former point of diversion of the Old Jansen ditch—the oldest appropriation of water along this portion of the Santa Ana river—and it ran just below and parallel with the general course already described for the Old Hunt ditch, for three fourths of a mile, and then turned westward, irrigating lands at the base of the high bluff bounding the Riverside mesa plain and lying next west of those irrigated by the Old Hunt ditch. The upper half mile of the Old Jansen ditch now receives its supply from the Old Hunt ditch, which, being enlarged, has been made a canal for both of these appropriations. The total length of the Old Jansen ditch is about 1.3 miles. It has capacity to deliver one hundred and ten to one hundred and thirty miner's inches of water.

Organization and Maintenance:—Like other ditches of its class now described, there is no organization of its ownership, and its affairs are carried on about as those of the Hunt ditch.

Water-supply and Use:—Originally dividing water with the Hunt and Cooley, and subsequently with the Old Hunt ditch, this work, although the oldest one above Warm creek mouth deriving supply from the rising waters of Santa Ana, has had at disposal only half of the low-water flow which would come to its head. Indeed, it would seem that after originally compromising for half with the Hunt and Cooley, it afterwards divided the remaining half with the Old Hunt. There have been seasons when the sup-

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ply has been short for these irrigations, but, as a usual thing, there has been an abundance and some little to spare to go on down and augment the supply to the old Mexican and other ditches which have depended mainly on Warm creek waters entering the Santa Ana below.

IRRIGATION:—In 1879 this work irrigated about one hundred acres. In 1881, there were three owners of the ditch and water-right; holding respectively, eighty-two, fifty-six, and thirty hour-shares each. The total area reported as irrigated was one hundred and thirty-two acres; of which twenty-seven were in summer crops, one hundred and three in alfalfa, and two in orchard. There was some grain flooded also, but the area is not known. At present the cultivation and extent of irrigation remains about the same. (See summary at close of report.)

History of Water-right:—This ditch was taken out in 1857, it being the first diversion made above the old Mexican ditches at Agua Mansa, except that of Bishop Tinney, which, as already explained, was afterwards abandoned. It stands to-day, therefore, as the oldest established water-right initiated by others than Mexicans on the upper Santa Ana river, except the Jurupa or the Rubidoux ditch. Its relation to the Hunt and Cooley or Camp Carlton and to the Old Hunt ditch have already been explained. The county water commissioners viewed the ditch in 1865, and acknowledged its legal existence, but made no record of its capacity, extent of use, or priority of claim. The work is now known as the Warren ditch. For purposes of taxation in the present year, it was assessed to the owners of its two hundred and sixteen hour-shares at $10 per hour, making a total valuation of $2,160 for the work.

Belarde and Salazar Ditch.

District and Work:—At the southeast corner of Colton the Belarde and Salazar ditch takes its waters from the Santa Ana river, and carries them on a course nearly south, and a little less than a mile, to the base of the Riverside mesa bluff; and thence westerly along the foot of that bluff, a total distance of about 1.7 miles. Its diversion is effected by means of the ordinary brush and sand dam, which has to be replaced each year. For the first half mile the ditch extends through sandy bottom-land; and

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thence, as in the case of the Old Ward ditch, out upon a better quality of soil. Its capacity is that to deliver seventy-five to one hundred miner's inches; and it irrigates about fifty-five acres of land, some of which is situated on a lower bench next west of the irrigations of the old Jansen ditch, and some of which is situated across a swampy piece of land therefrom, and lying in a long strip westerly close along the foot of the Riverside mesa bluff, down to and beyond the line of the California Southern railroad. In its course it passes by flume across the swamp mentioned, is carried under the long trestle of the Riverside Warm Creek canal, and near its lower end passes under the California Southern railroad trestle, at the base of the bluff.

Organization and Maintenance:—There have never been over five owners in this ditch right, and it has been managed without organization upon the simplest principles of coöperation and successive turns in distribution by hours. The period of rotation has been at times one hundred and forty-four, and one hundred and sixty-eight, and at others one hundred and ninety-two hours, and for three or four years past, two hundred and sixteen hours.

Water-supply and Use:—This is the first diversion in position from the Santa Ana river below the mouth of Warm creek, and there has always been much more than a sufficiency of water to fill the ditch; but diverting subject to prior claims below, it has, of course, never taken all the flow.

IRRIGATION:—The area of lands commanded by the ditch has always been very small—situated as its district is, at the very lower end of the south side plain, where the river approaches the bluff and its outlet from the basin. There has been much irregularity in the amount of flow to this ditch, caused by the acts of turning on or off the water to the mill race in Warm creek, half a mile away. And these sudden waves have been a great source of damage to the dams that have made the diversion.

In 1881 this ditch was reported as owned by three irrigators, each holding forty-eight hour-shares, making a total period of one hundred and forty-four hours, or six days. The total irrigation was twenty-six acres; of which seventeen were in summer crops, one in orchard, and eight in grain. It now irrigates about fifty-five acres, of which forty are in alfalfa, and the balance in summer crops principally.

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History of Water-right:—This ditch was located by the Board of Water Commissioners in February, 1875, on petition of the two owners whose name it bears, and it remains now as then placed. There was no specification as to amount of claim made at that time, but the irrigators have since asserted claim to half the flow of the stream at the head of the ditch. But they could not have taken that amount until after the recent diversion of Warm creek by the new Riverside canal. Now that the old north side ditches of the Agua Mansa all receive water through the new Meeks and Daley ditch, the Belarde and Salazar is the only diversion which the Riverside Warm Creek canal is obliged to consider in supply below its point of diversion. This ditch is assessed for the current year for two hundred and sixteen hours, at $10 per hour, making a total valuation of $2,160.

Several Spring and Well Irrigations.

In this South Side Santa Ana district are two little irrigations, which are specially notable because of the character of their water sources. These are the irrigations from Hunt's spring, and from the Filanc artesian wells.

Hunt's Spring Irrigation:—Just within the limit of the San Bernardino artesian basin, at the foot of, and within a recess in a drop (of about ten feet) in the plain, this spring bursts forth, and from it little ditches lead, which, with a flow of twenty miner's inches of water, effect the irrigation of about thirty acres of land lying immediately below the source.

The Filanc Wells Irrigations:—A quarter of a mile northwest of the Hunt spring, above the drop in the plain, and just within the limit of the artesian basin, there are four artesian wells, whose combined flow is about forty-five miner's inches. This water is collected into an earth-embanked reservoir of about one thousand five hundred cubic feet capacity, whence it is used in the irrigation of about forty-two acres of land lying on the point just south of Mill creek waste-water wash, and extending westerly to the river bank.

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SECTION II.

Warm Creek and City Creek Works—Sub-group (*c*).

Of the irrigations classed in the Basin Diversion group, those comprised in sub-group (*c*) derive their supplies from the rising waters of Warm creek, of the lower part of City creek, of the extreme lower part of Lytle creek, and from various small drainage ways, and large springs and *cienegas* or swamps, in the same immediate neighborhood of the river. Their irrigations are all within the belt or zone of the water-supply, which is wholly in the artesian basin of the valley. Twenty little works have been identified in this region, some of which are very small and insignificant, and there are possibly half a dozen more of the very smallest class that have not been visited, and receive no mention here. The principal ones of these ditches are: Four diverting from Warm creek, above the mouth of City creek wash, namely, Hawes' ditch, Rabel's or Upper Dam ditch, Stout's Dam ditch, and McKenzie's or Lower Dam ditch; four diverting from City creek, namely, the Sparks, Stewart, Waterman, and the Davis Mill ditches; the Heap Spring ditch, the Johnson ditch from Byrne's swamp, and the Coburn Swamp ditch.

UPPER WARM CREEK DITCHES.

Hawes' Ditch.

This is the uppermost diversion from Warm creek. Taking water from a swampy place on the south side, amidst a lot of springs, by a small cutting at a point about a quarter of a mile below the extreme head of the creek, this little ditch with a capacity of about fifty miner's inches, and a total length of 0.75 mile, carries water out upon the ridge half a mile south of Warm creek, to properties next south of Base Line road, where it irrigates about twenty-five acres of land. Its water-supply has always been quite constant in volume, as is the case with all of the Warm creek ditches. But the use of water has been of a very primitive and wasteful order and limited to less than forty acres. The management of the work has been substantially that of a farm distributary amongst neighbors—there being no organization. As at first taken out, it represented one of the eight parts in which

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the Rabel Dam ditch was originally owned, and which was separated off from it, carrying one eighth of the water-right, in 1862.

Rabel's Dam Ditch.

District and Work:—At a point in the channel of Warm creek, about half a mile below its extreme head, where a large group of warm springs burst forth in its bed and in adjacent *cienegas*, is a wooden dam, with waste-way and sluice gate, which raises the water four to five feet, forming quite a pond. This is Rabel's dam, from which, on the south side, the ditch extends southwesterly an extreme length of two miles, and with branches making up an aggregate length of 4.2 miles. Its capacity is that for two hundred miner's inches, and it irrigates a compact body of land lying south of Warm creek, and extending nearly over to the City Creek wash.

Operation and Maintenance:—The organization of this work has always been in the form of a simple association of neighboring cultivators, there being no articles of agreement other than memoranda of proceedings to which the owners have assented at meetings. A watermaster is appointed annually, and he is the sole officer of the association, acting as secretary as well. The work is owned in seven shares on a seven-day period, and the subdivision of interests are not spoken of as hours, but as fractions of a share. Water is distributed by turns with the full flow of the stream, according to the number of shares or parts of shares owned by each irrigator. A schedule is made out for each season's distribution, by which the *zanjero* works, and the irrigators can examine or copy it if they choose. The watermaster being one of the owners, receives no compensation. The cost of maintenance is rated in so many "days' work," and has been generally paid in kind.

Water-supply and Use:—This is the best water-supply on the upper part of Warm creek; the diversion is made just below the strongest springs of this remarkable source, so that the Rabel Dam ditch has never been without a fair supply of water, even in years when, as old residents say, "everything dried up from the Santa Ana to the Los Angeles river." The work is entitled to a "tight dam," and takes all the water that comes to it up to the limit of its capacity.

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IRRIGATION:—In 1881 there were eight owners in this ditch who irrigated in all two hundred and sixty-seven acres, of which thirty-one were cultivated in summer crops, one hundred and seventy-nine in alfalfa, thirty-seven in vines, and twenty in orchard. In 1885 there were thirteen owners, who irrigated three hundred and twenty-five acres, of which fifty-five were in summer crops, one hundred and ten in alfalfa, one hundred in deciduous fruit tree orchard, and sixty in vines. In 1888 there are about three hundred and fifty to three hundred and seventy-five acres irrigated, the increase being in deciduous fruit tree plantation, and the number of holders of shares has increased to fifteen or sixteen.

History of Water-right:—This is the first ditch taken out of Warm creek for purposes of irrigation, by the Mormon occupants of the country. The exact dating is not known, but it is believed to have been dug in 1854. There was no recording of the claim; but the ownership and prior right have been long well established. The fact that it commands only low basin-lands restricts its value to a figure low in comparison to that of diversions from the cañon streams, while the permanence of its water-supply tends, on the contrary, to increase that value. In the present year it is assessed in one hundred and sixty-eight hours at $55 each, making a total tax valuation of $9,240.

Stout's Dam Ditch.

District and Work:—About a mile and a quarter below the extreme head of Warm creek, and at a point just below where it receives large accessions of water from a *cienega* tract covering fifty to sixty acres, lying immediately north of its channel, the Stout's Dam ditch heads. The dam is of earth with a wooden waste-way, and raises the water-plane about four feet. The ditch starts out through the right bank, and extends westerly in quite a direct line, about 1.3 miles along the foot of the plain sloping from the north. With a capacity to carry about one hundred miner's inches, it irrigates a little district lying in a long narrow strip below its grade line, and north of the bank of the creek.

Operation and Maintenance:—This ditch is owned and managed in the same manner as in the Rabel Dam ditch, there being a seven-day period, and eighteen to twenty owners of "shares" or "hours."

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Water-supply and Use:—The supply is not as abundant and unfailing for the ditch as in the Rabel Dam supply, and it is remembered by old residents that in some of the dry years succeeding the flood of 1861–2, the Stout's Dam ditch "got hardly water enough to fill a plow furrow." There have been no years since 1879, however, when the supply available for the ditch has been less than the requirements of the irrigators. It claims "right to a tight dam" as against all irrigating ditches below, notwithstanding the fact that the McKenzie Dam ditch preceded it in time of appropriation.

IRRIGATION:—In 1881 there were eleven holders of the one hundred and forty-four hour-shares in the flow of this ditch, of whom the largest held thirty and the smallest two hours. The total irrigation was one hundred and forty acres, of which twenty-five were cultivated in summer crops, seventy-nine in alfalfa, thirty and one half in deciduous fruit tree orchard, and six in vines. There may have been some grain flooded in the spring, but this was not reported. In 1885 there were two hundred and ten acres irrigated, of which forty were in summer crops, ninety in alfalfa, sixty in deciduous fruit tree orchard, and twenty in vines. In 1888 there are two hundred and forty acres irrigated, the increase being in orchard and vines.

History of Water-right:—This ditch was taken out in about 1857 or 1858—the year following the digging of the McKenzie ditch, so that it ranks third in the list of irrigation appropriations on Warm creek. There was no record made of its claim, but its rights have long been established and recognized. The rights and works are taxed for the current year on a valuation of $20 per hour for the one hundred and sixty-eight hours, making a total valuation of $3,360.

McKenzie or Lower Dam Ditch.

District and Work:—As one of its names implies, this ditch starts out from the lowest of the three dams in Upper Warm creek, which dam is of wood, and located three quarters of a mile below Stout's dam. Coming out through the south bank of the creek, this ditch and its branches extends 2.2 miles in length, in a southwesterly direction. With a capacity of about two hundred miner's inches, it irrigates two hundred and forty-one acres of

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land in the pocket between Warm and City creeks, and its waters were used also on about eighty-five acres lying south of City creek, across which they are led in a flume. Its total length, with the main branch, is 4.1 miles.

Operation and Maintenance:—This little work was originally owned in eight shares, having been taken out and built by eight individual farmers, and they agreed to divide its waters amongst themselves, each one taking the full run of the stream for one day; so that the period of rotation became fixed at eight days, or one hundred and ninety-two hours. Although the interests are now subdivided, they still adhere to the day as the unit in the organization, so that the water being divided according to the schedule fixed at a meeting each spring, before the irrigation season commences, the owners are grouped into days, according to their sources of title—each one taking so many hours run of the ditch during the day of which he has purchased or has owned from the beginning a part. The owner gets a ticket showing the day and hour in which his turn is to commence, and each takes the full flow of water for the number of hours he owns. The water-day commences at sunrise. Those who own a share or day jointly fix its subdivision and hours amongst themselves. At meetings each owner is accorded a vote without regard to extent of interest. If any important matter were to be considered, it is probable that voting by extent of interest or number of hours in the period would be insisted upon by the larger owners. In 1885 there were twelve owners, the largest holding a forty-eight-hour interest, the smallest a one-hour interest, and most of them holding twelve to eighteen hours each. There are no paid employés, the watermaster serving gratuitously, he being always one of the irrigators. Maintenance, paid generally in work, costs $60 to $75 per year.

Water-supply and Use:—This being the lower one of the three ditches "entitled to a tight dam" each, and although Warm creek receives in ordinary years quite a fine accession of volume below Stout's dam, still the McKenzie ditch sometimes is short of supply. This, however, is in what may decidedly be called dry years, and the period of shortage lasts only a few weeks, except in those seasons of which we are told by the old residents who saw "cattle

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die at every step, from San Bernardino to San Fernando, for want of water."

IRRIGATION:—There are now about three hundred and twenty-five acres irrigated under this ditch, of which one hundred and ninety are in alfalfa, fifty-five in orchard, fifty in summer crops, and thirty in vines. The soil over which it takes its water is for the most part adobe, and very retentive. There is very little or no waste in the ditch north of the Sixth-street line. In some portions of its district, water stands within three or four feet of the surface of the ground.

History of Water-right:—This ditch was taken out by Mormon settlers about 1856, and was the third construction of the kind in the immediate neighborhood made by them—the first being the St. Bernard, now Davis Mill ditch; the second, Rabel's Dam ditch.

About 1884 an eleven-hour interest in the ditch and water-right was sold for $1,200; this would make the total water-right at that time worth about $18,000. A short time previous to that some shares changed hands at $75 an hour; but in 1887 offers were made and refused at the rate of $200 per hour. For purposes of taxation for the current year, it was assessed by the hour-share at $10 for the one hundred and sixty-eight hours, or $1,680 for the whole work and right.

LOWER CITY CREEK DITCHES.

Sparks' Ditch.

This little ditch takes water from the south side of City creek, two miles above its junction with Warm creek, and with an apparent capacity of twenty-five miner's inches and a total length of 0.5 mile, it serves in irrigation about twenty acres of land lying on the ridge between City creek wash and the head of Waterman's swamp. It is owned by one individual, and the date of its first diversion is not known.

Stewart's Ditch.

Taking water from the north side of City creek at a point a mile and a half above its junction with Warm creek, the Stewart ditch with a carrying capacity of thirty-five miner's inches, and a total length of 0.8 mile, irrigates forty-seven acres of land

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lying immediately north of City creek, east of and adjacent to the lands irrigated by the McKenzie ditch, and southwest of those irrigated by Rabel's Dam ditch. It is owned by two or three individuals, is sometimes called the Feudge ditch, and the date of its first diversion is not known.

The Waterman Ditch.

Taking its supply from the south side of City creek a little more than half a mile above its junction with Warm creek, this ditch which has a carrying capacity for about fifty to sixty-five miner's inches of water, with a main channel length of 0.55 mile, and a total length, with its branch, of 0.85 mile, irrigates about fifty-five acres lying on the sandy ridge of the plain between City creek and Waterman swamp, and immediately north and west of lands served by waters from Stout's Dam ditch brought across City creek, as heretofore described. This is the old Waters ditch, which was the first diversion from lower City creek. There has recently been combined with it the waters claimed under the Logsdon, Ferrel, and the Brooks ditch rights, which were diverted at points a short distance below, and used on portions of the same lands.

St. Bernard or Davis Mill Ditch.

District and Work:—Taking waters at the junction of City and Warm creeks, the Davis Mill ditch conducts them a little to the south of west, parallel to, along, and above the bluff bank of Warm creek about half a mile, where is a waste-way into Warm creek: thence, turning abruptly to the left, it courses somewhat more than half a mile across the neck to the high bank of the creek which gathers its waters from Waterman swamp above. Here it serves water for power purposes, which then drops into the Swamp creek and flows down to Warm creek, and so on. A branch, known as the Grucer or Ball ditch, a few hundred feet above the mill, runs westerly not quite half a mile to Warm creek, serving as a waste way and irrigating channel. Davis Mill ditch has a total capacity of about one thousand five hundred miner's inches, and a main length of 1.2 miles.

History, Water-right:—The diversion of water from the junction of City and Warm creeks for purposes of this water-power constituted the first appropriation of waters made in this valley,

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except those on Lytle creek and Garner swamp by the early Mormon settlers. The ditch was taken out about 1853, and its waters have ever since been utilized for purposes of milling power. It claims all the water of Warm and City creeks for its purposes; the water having been dedicated to this use before it was ever taken out above for irrigation. The milling property was originally held as a community property by the Mormons, and was sold by them with the rancho at the time of their departure in 1857.

Warm creek ditches rank in order of construction about as follows: Davis Mill ditch, 1853; Rabel Dam ditch, 1854; McKenzie Dam ditch, 1856–57; North Side or Stout's Dam ditch, 1857–58; and the ditch heretofore referred to as Hawes ditch is a part of the original Rabel Dam ditch. The Davis mill was for a long time known as the St. Bernard mill, and is the only one of the several milling powers established in the early times, which is still utilized, except Meeks' mill near the mouth of Warm creek. The mill owners claim that in 1857 there was a very limited area in irrigation from Warm creek. At that time there were certainly not more than two ditches besides the mill ditch, and they probably irrigated less than one fourth of the area they now cover. So that the mill-right water must take precedence to that of the irrigators, seeing that at that time it used as much water as it does now. Although the waters of Warm creek were very much diminished during the seasons of 1857 to 1861, inclusive, there was still enough flowing to turn the mill when required, and it is asserted upon good authority that the flow was full three fourths of the ordinary flow of the stream.

Heap Springs or Beam Ditch.

Heap springs are an outburst of water at the head of an arroyo in the plain, several hundred yards north of the channel of Warm creek, which it joins at the mouth of the arroyo, nearly three fourths of a mile above the junction with City creek. A little ditch heads in the arroyo a few hundred feet above the Warm creek channel and carries its waters out upon the plain, north and west of the creek. With an extreme length of 0.7 mile of main channel, it reaches nearly to the eastern limit of the town of San Bernardino. And with an apparent capacity of forty-five miner's inches, it irrigates on its course about seventy acres of land lying

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between the northeastern, town swamp and the channel of the Warm creek. Its period is twenty-eight "days," that is to say, its flow is held in twenty-eighths, which are called "days." Of these, in 1887, there were three owners holding respectively two, eleven, and fifteen shares.

Johnson Swamp Ditch.

This ditch has for its supply a portion of the drainages from the locality of the strongest natural outburst of artesian waters in the San Bernardino basin. Its sources are in the *cienegas* or artesian springs, within half or three quarters of a mile north of the Santa Ana river, and about the same distance within and east of the artesian basin line. These *cienegas* so closely cover several large tracts here as to make them almost inaccessible swamps. and the particular piece from which this ditch takes its waters is, from the owner's name, known as Byrne's swamp. Taking waters out of various drainage ditches on this tract of about one hundred and sixty acres, the Johnson ditch conducts them southwesterly down to the point of land between Warm creek and the river. With a length of 0.95 mile of main ditch, and a capacity for about one hundred and twenty miner's inches, it irrigates about one hundred and fifteen acres of land. This ditch was originally dug and owned by three persons, who each had fifty-six hours or one third of the seven-day period of one hundred and sixty-eight hours. In 1888, it is owned by nine irrigators holding from one to fifty-six hours each.

Coburn Swamp Ditch.

Immediately north of the Johnson swamp ditch, and receiving its waters from a part of the same great group of *cienegas*, but rising in the next tract in ownership, the Coburn swamp ditch conducts its supply south and west with a total length of 1.65 miles of main channel. Having a capacity for about sixty-five miner's inches of water, it irrigates about fifty-six acres of land lying in several detached pieces just east of Warm creek and a little farther up stream than the irrigations of the Johnson ditch.

The several little ditches from lower Lytle creek will be enumerated in the summary at the close of the report.

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SECTION III.

RAYNOR SPRINGS WORKS.

Rancheria Ditch.

District; Water-supply; History:—The Raynor springs, or *cienegas*, situated about two and three quarters miles west and north of San Bernardino, on the west side of Lytle creek, and made by a natural outpour on the western margin of the San Bernardino artesian basin, have for many years supplied water for irrigation. During the years of the very first occupancy of the valley by the Mexicans, a settlement of them conducted the waters to lands lying two to three miles below, and where yet may be seen the remains of little reservoirs made at the time, and utilized them in irrigation on lands now between San Bernardino and Colton. Subsequently in early days of Mormon occupancy of the country, the springs were known as Garner springs, and a swamp formed by their overflowings towards San Bernardino was the source of the very first water-supply taken into the old Mormon stockade town in 1852. When, soon after, the town got water by a large ditch from Lytle creek, taken out some distance above, the Garner springs waters were again turned down the ridge along the west bank of Lytle creek and there again utilized in irrigation. From the fact of their being an old Indian rancheria in that neighborhood the ditch became known as the Rancheria ditch. It was, of course, a roughly-made and poorly cared-for ditch, and moreover, serving a section whose lands in some parts were naturally moist, and in others very poor and sandy, it had little importance. The whole supply of water from the springs was claimed by the Rancheria ditch owners, however, but some fifteen or more years ago the owner of the lands embracing the springs disputed this right.

The Colton Land and Water Company, in which Mr. Raynor was a principal stockholder, was formed, and the waters were developed and increased in flow, and diverted by its works south towards Colton. The conflict was afterwards adjusted by the Rancheria ditch claim being recognized as a prior right to the extent of seventy-two inches; which was one third of the stream when measured for the purposes of the settlement.

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There were, about 1870 to 1874, as many as twenty to twenty-five irrigators under this right. Gradually, however, the number fell off, owing chiefly to the fact that the country where the water was being used, was gradually growing more damp and did not need irrigation. Artesian wells had been sunk in it at various points, so that by 1879, the number of irrigators from the ditch had fallen to fifteen, and in 1882 to ten. About this time, the entire ditch rights were secured by cultivators out on the upper part of Colton Terrace, and the waters were transferred to a line of conduit leading from the springs property directly there. In June, 1879, the water was being used east of the wash on one hundred and fifty acres of land, and the ditch was carrying about eighty-five inches of water. In 1881, there were ninety-nine acres irrigated, of which eighty-six were in alfalfa, ten in orchard, and three in vines. In 1888, the water is being used about two miles south of its source, on the upper portion of Colton Terrace, where it irrigates about one hundred and eighty acres of land, planted about one hundred and five acres in vines, fifty in citrus orchard, and twenty-five in deciduous fruit tree orchard.

Colton Land and Water Company's Ditch.

The Colton Land and Water Company was formed in June, 1877, with a capital of $50,000, divided into five hundred shares. It acquired the right to waters from Raynor Springs, increased the output from the springs tract by sinking artesian wells, and compromised with the Rancheria ditch claimants, allowing them seventy-two inches, about one third of the stream. The remaining waters were conducted to the neighborhood of the town of Colton in a simple little earthen ditch, where about half have been used in irrigation and the other half piped to the town and there used. The works are in no way notable. The water-source is spoken of elsewhere. The Raynor springs water output is now being further developed and piped by the Vivienda Water Company as already spoken of.

In 1881, there were six irrigators cultivating in all one hundred and twelve acres by irrigation, of which one hundred and six are in citrus fruits, four in vines, and two in alfalfa. In 1888, there are ten irrigators under this ditch having right to thirty-one and a half inches of water in a ten-day period; the largest holding being forty-eight hours, and the smallest twelve hours. There are

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two hundred and four and a half acres irrigated, of which one hundred and twenty-seven are in citrus orchard and seventy-seven and a half in deciduous fruit trees.

Town Creek and Swamp Ditches.

Between the channels of Lytle creek, a mile west of San Bernardino town limits, and the edge of the Warm creek basin proper, near the eastern margin of town, there are three or four little rising streams of water whose names are much confused, and whose ditches, from an irrigation point of view, are of slight importance.

Town creek rises at various points in an arroyo in the plain located diagonally from northwest to southeast through the center of the town, and empties into Warm creek. The waters of this stream were utilized among the very first by the original grantees of the Rancho San Bernardino, and following them the Mormons continued their utilization, and the lands now composing the main business part of the town, and its chief resident section as well, have all been irrigated from this source. These works are still utilized in irrigating gardens and vegetable plats and little orchards in town. They used to be known as Town Ditch Nos. 1, 2, 3, etc., but of later years the water commissioners' records refer to them as the "East Upper Dam," "West Upper Dam," "Lower Dam," etc., ditches.

The Beamis ditch formerly took water from the rising swamp, just west of and above the present location of the California Central railway shops, and utilized it on the lands beyond, and once had a local importance.

The Garner swamp ditch took water from the swamp northwest towards Raynor springs, but east of Lytle creek, and utilized it on the ridge lying along, and near the east bank of the creek at the edge of town. This ditch is still in existence and use, but no examination has lately been made of it, for it is a small affair, and its territory is being occupied by the spread of the city. There were several other little irrigations through this section, but it is unnecessary to mention more of them.

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SECTION IV.

North Side Santa Ana Works—Sub-group (*e*).

The ditches, which deriving waters from the Santa Ana river on its north side, and from Warm creek near its mouth on that side, distribute them in irrigation on lands within the San Bernardino valley, but not all of them within the basin proper, have been spoken of as sub-group (*e*) of the Basin Diversion group of works. These are the Santa Ana Waste-water, Meeks and Daley, Jaramillo, San Salvador, and Agua Mansa ditches. They are old diversions, belonging to the irrigators under them, and, until within a few months past, have all remained for many years as primitive structures.

Santa Ana Waste-water Ditch.

District and Work:—At a point high up in the wide wash of the Santa Ana river, about where the original North Fork or Timber ditch, as heretofore described, diverted water in the very earliest times of American irrigation in San Bernardino valley, the ditch now known as Santa Ana Waste-water ditch commences. Thence it courses down the wash several miles, gradually getting out on the plain north of the river, and occupying for the most part the channel-way of the old Timber ditch. It then runs westerly about one and a half miles out on the timbered ridge between the river bank and the southern limit of the *cienega* ground heretofore referred to as Waterman's swamp. With a total length of three and a half to four miles of main ditch, and a capacity to carry four hundred miner's inches of water, it irrigates a compact body of land within the district known as the Timber district, and which is a sandy ridge in the plain, and entirely within the limits of the artesian basin.

Operation and Maintenance:—This ditch property and water-right is now incorporated and there is, of course, a board of directors and the usual officers of a corporation. The distribution works are all little primitive earthen ditches. There is a watermaster, and the water-supply is distributed by the principle of "turns" among the irrigators—each taking the full flow of the stream for his proportionate part of the rotation period, which is nine and two thirds days.

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Water-supply and Use:—Up to the season of 1884, and particularly during those of 1881, 1882, and 1883, which were exceptionally dry, the water-supply for summer irrigation by this ditch was considered to be *nil*. The full-river year of 1884 cut the bed down into the gravels at the point of diversion, and there has since been a better flow—claimed to be, from 1884 to 1887, inclusive, about two hundred inches up to the end of July and even into August.

IRRIGATION:—In 1885 there were irrigated about two hundred and thirty acres of land, which was chiefly cultivated in early summer crops, alfalfa, and deciduous fruit tree orchards. In 1888 there are about three hundred acres irrigated and planted to the same crops—the increase having been chiefly in fruit culture.

History and Water-right:—This is a rehabilitation of the old Timber ditch whose history has been traced in articles on the North and South Fork ditches. The original holders of Timber ditch water-rights gradually sold out their individual interests to the south side people and then filed a claim to the waste-waters, or surplus waters of the Santa Ana river, to the extent of the capacity of the old ditch, which was said to be about five hundred inches; and the claim being known as the waste-water claim, the ditch became known as the Santa Ana Waste-water ditch, although in reality it was the same as the old Timber ditch. The claim is for five hundred inches of the waste-waters of the river, that is, when there are five hundred inches over and above the amounts diverted by the ditches which take water out farther up the stream. It was divided into two hundred and ninety and one half acre-rights, but now each acre represents two shares in the company. The acre-right really has no significance in this association, seeing that the irrigators apply their water to as many or as few acres as they choose. This term is one which has come down from the early times of the original ditch. In 1886 there were sixteen owners in this ditch, the largest holding being eighty shares, and equal to forty acre-rights, and the smallest ten shares. The holdings remain about the same to this day—all the owners being resident irrigators. Previous to 1884, the shares were worth about $5 each, but the full flow of that year produced such a surplus, or volume of "waste-water," available for the supply of this ditch, that the shares rose to $20 and $25 each.

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The Berry Roberts waste-water claim on the south side of the river was located and filed before that of the Santa Ana Waste-water ditch, and so this north side waste-water ditch was subject to the claim of the south side ditch, to the extent of several hundred inches, but in practice the two ditches used to divide the waste-water between them as long as the Berry Roberts was used as a waste-water ditch at all.

The Timber Water Ditch Company was incorporated in June, 1885, with a capital stock of $5,810, divided into five hundred and eighty-one shares, each share representing "the right to use in turn all the water owned, held, or controlled by the corporation, for twenty-four consecutive minutes."

Meeks and Daley Ditch.

District and Work:—At a point on Warm creek about a mile above its mouth, where it swings against the bluff edge of the higher plain which, about midway between Colton and San Bernardino, overlooks the low lands of San Bernardino artesian basin, the Meeks and Daley ditch takes its supply. Skirting along the base of this bluff, in a southwesterly direction, as the general surface of the country rapidly falls this ditch gradually comes out upon the lower bench of the western plain, and turning westerly through the southeast corner of the town of Colton, it courses around the face of the sloping plain about as far as Slover mountain. It distributes its waters to a district wholly below its left bank and lying between it and the river bottom lands served by the old Spanish ditches, next to be described. As spoken of in the paragraphs relating to the Riverside Water Company works, the Meeks and Daley ditch has, within the past few months, been remodeled in alignment and grade, and constructed as a paved canal. Previous to that time it was a primitive earthen channel, very crooked, and with a capacity, when in a fair condition, to carry about six hundred miner's inches.

Diverting water, only by means of a small brush and sand dam, the Meeks and Daley ditch never commanded the flow as its position enabled it to; and being located generally with very little grade, it had a comparatively sluggish current and suffered a large proportion of loss. Before remodeled the total length of the main work was five and a half miles, which, with the main

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distributaries, gave it an aggregate length of six and three quarters miles of channel way.

Now it is, as reconstructed, about five miles long, on a uniform gradient of three feet per mile, with a section three feet wide on the bottom, five feet on top, and two feet in depth, and a capacity to carry eight hundred and fifty miner's inches of water. Its alignment is made quite direct, and its curves are long and easy, where before it was a very crooked ditch. It is lined throughout with limestone rubble laid up in lime mortar, and plastered with cement to make a smooth inside facing—the whole to a thickness of six to nine inches. The new headwork is of stone in cement, holding a six-foot iron plate weir to measure the eight hundred and fifty inches allotment to the ditch, and with wooden regulating gates and escape-way above.

Operation and Maintenance:—The Meeks and Daley ditch and water-right belong to an incorporated company, composed for the most part of the irrigators under the work. There is a watermaster, who distributes the supply in irrigating heads of about fifty inches each—the larger irrigators taking several heads in a stream; but there are no measuring appliances, and all is left to the judgment of the watermaster. In this manner water is divided among the owners in proportion to the extent of their interest in the whole. No water is sold by the company; no charge is made to the irrigators other than an apportionment among them of the annual expense, which has ranged from $300 to $1,000.

Water-supply and Use:—Water-supply for the Meeks and Daley ditch has always been abundant. Warm creek, at the point of diversion of the ditch, has at all times flowed much more than the ditch would carry, and the claim is the oldest irrigation right commanding this supply. The adverse limiting right has been that of the Meeks mill, which went into the ownership of the Riverside Canal company at an early period of its history. This mill on the creek, half a mile or more below, had an adverse claim to water of the stream for power purposes, and the Riverside people have kept it in operation for the purpose of holding that right, and thus bringing the water down to their points of diversion. Nevertheless, there has never been a scarcity of supply to the ditch for the irrigations it has commanded; but

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the work has been wasteful of that supply, and poorly managed in distribution. Under the arrangement with the Riverside Water Company, it is now assured four hundred inches for its own irrigations, and four hundred and fifty more to be distributed to the old Mexican ditches, as elsewhere explained.

IRRIGATION:—In 1881 there were thirty-one holders of the three hundred and ninety hour-rights in this ditch, the largest holding being forty-eight hours, and the smallest one hour. The total irrigated area was three hundred and fifty-nine and one half acres, of which one hundred and forty-six were cultivated in summer crops, fifty and one half in alfalfa, forty and one half in orchard, twenty-one in vines, and thirty-five in grain. The period of rotation was eight days. In the present year there are about three hundred and eighty-five acres irrigated, of which about one hundred and ninety are in deciduous fruits, thirty in oranges, and the balance in summer crops and alfalfa.

History of the Ditch:—In 1858 or 1859, Edward Daley and two others took out a small ditch from a point on Warm creek near its mouth, and below the present location of the Matthews or Meeks mill, and carried the waters by it around to irrigate lands on the lower portion of the bench opposite the present town of Colton. In 1859 or 1860, four other settlers in that neighborhood joined with these three and built a new ditch out from Warm creek, commencing at a point where the Meeks and Daley ditch now heads, and following substantially the same course which the Meeks and Daley ditch has had until recently reconstructed. During the flood of 1862, Lytle creek broke over from its course into Warm creek, and ran down through what is now known as Lytle Creek wash, through the eastern part of Colton, and in doing so, destroyed a portion of the then new Meeks and Daley ditch. This creek continued to run in that course during the season; and in the following one, a ditch was constructed out from it, which supplied the Meeks and Daley ditch. But the latter ditch was reopened and used from Warm creek in 1864, and has since been maintained substantially as within the past few years, except that the overflow from Lytle creek during the flood of 1868 again swept it away, and interrupted its use for a portion of one season.

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The Meeks and Daley Water Company was incorporated in 1885 with a capital stock of $78,000, divided into seven hundred and eighty shares; all of the owners of hour-rights in the old ditch taking the stock in exchange for their rights—two shares of stock to each hour. There were originally thirty subscribers to the stock, all being land owners and irrigators.

Agreement with Riverside Water Company:—On the last of August, 1887, an agreement was entered into between the Riverside Water Company as the first party, and the Meeks and Daley Water Company, San Salvador Water Ditch, and the Agua Mansa Water Company, and the several individuals owning stock or shares in these associations, which with an agreement with some owners of the Jaramillo ditch, seems to set at rest the matter of apportionment of available water-supply of Warm creek and the Santa Ana river, in so far as these parties are concerned. In consideration of the three north-side ditches giving over to the Riverside Water Company all of their claims other than those conceded and to be maintained in the agreement, the Riverside Water Company engaged to construct the new ditch which has been described as the Meeks and Daley ditch, with the certain branches to convey waters to the other ditches, and to construct and maintain a proper sand-gate at the head of it, and a proper measuring-gate to measure eight hundred inches of water, and to deliver in perpetuity into the work, at this head-gate, as long as the supply is in Warm creek, a continuous flow of eight hundred inches of water.

The work to be built in sections, under the supervision of the Riverside Company's engineer, and each section to be accepted by the engineer or other representative of the second parties at time of completion; and all the works were to belong to the second parties. The waters were to be owned and apportioned out as follows: The Meeks and Daley Company, four hundred inches; the San Salvador, one hundred and twenty-five inches; and the Agua Mansa, two hundred and fifty inches; and twenty-five inches were added to cover loss by evaporation in transit. The rights, claims, and works abandoned by the second parties under this agreement constituted the old diversions theretofore made by them, and their old ditches and headworks and their claims as riparian proprietors on the stream.

At a later date an agreement was entered into between the Riverside Water Company and the several owners of the Jara-

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millo water-right, whereby, in consideration of fifty inches of water to be delivered by the Riverside Water Company into the head of the Meeks and Daley ditch as reconstructed, and in consideration of the construction of a branch ditch from it down to the locality of the old irrigations under the Jaramillo water-right, the owners of the Jaramillo claim agreed to abandon their old ditch and works of diversion from the river. Thus, hereafter, there will be a clean run for the waters of the river below the mouth of the Warm creek all the way to the head of the Old Upper canal, except for the dam of the Belarde and Salazar ditch on the south side. And to secure this the Riverside Water Company has built a new ditch for the old northside irrigators, and acknowledged their prior rights to waters to the extent of eight hundred and fifty inches in the aggregate, which they have agreed to deliver to the new ditch in perpetuity, while the stream supplies it.

Jaramillo Ditch.

At a point about half a mile above the California Southern railroad crossing of the Santa Ana river this little old Mexican ditch diverted its waters by means of a small brush and sand wingdam, and carried them out across the sandy bottom lands westerly, a total distance of about 0.6 mile; and with a capacity for about fifty miner's inches of water has irrigated on these lower lands and on the edge of the second bottom about thirty acres of land, lying on each side of the track of the railroad, half a mile north of the river crossing. The exact date of this ditch right is not known, but it is believed to have been some time between 1863 and 1866. It now receives a supply of fifty inches through the Meeks and Daley ditch, under the agreement with the Riverside Water Company, as heretofore explained.

San Salvador Ditch.

About a quarter of a mile above the California Southern railroad crossing this little ditch made its diversion by means of the usual sand and brush wingdam, and carried its waters through a total length of about 0.6 mile of channel way, passing under the railroad, delivered them for the irrigation of about fifty-five acres of land lying in the lower bottom-land belt immediately north of the river, and on each side of the railroad. It had a capacity to carry about one hundred and fifty miner's inches, and

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was of very low grade and sluggish current. It now receives its supply, as in the case of the Jaramillo, through the Meeks and Daley ditch, and by means of a paved branch for its special accommodation. In 1882 there were three owners of the one hundred and fifty-six hour-rights in this ditch, holding respectively thirty-six, sixty, and sixty hours each. The total irrigation was one hundred and thirty-three acres in extent, of which forty-seven were cultivated in summer crops, thirty in alfalfa, one in vines, and forty-five in grain. The water claim was for enough to fill a ditch three feet wide and eighteen inches deep, which on this grade would have given about two hundred to two hundred and fifty miner's inches; but it never diverted that quantity at any time inspected by the state engineering department. In the present year it is owned by two individuals, and irrigates fifty acres of low bottom-lands. It was taken out in 1862, 1863, or 1864, and ranks next to the Agua Mansa in priority of right in this group.

Agua Mansa Ditch.

District; Work; Operation; Water-supply and Use:—This very old Mexican work of diversion had its head on the north bank of the Santa Ana river about one hundred feet east of the California Southern railroad crossing, and conducted its waters on a western course, a distance of about two and three quarters miles. With a capacity to carry about three hundred miner's inches of water, it used to serve in irrigation along its route about three hundred acres of the river bottom-lands comprised within the old Mexican settlement of Agua Mansa. It has always been owned and operated chiefly by Mexicans or native Californians. The old works are all of the most primitive character and the management of the crudest kind. The interests have been incorporated through the efforts of several influential personages, but the management was thereby not materially altered.

After very much altercation and several years of differences, it was, about 1880, determined that there were three hundred and ten shares or hours in the right, held by seventeen personages. Of these, eleven were actual irrigators, holding two hundred and sixty-four shares, the largest holding being twenty-three hours, and the smallest twelve hours. The total area irrigated by these, in that year, was one hundred and sixteen acres, of which sixty were in summer crops, thirty in alfalfa, three in orchard, three in

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vines, and twenty in grain. Under the agreement with the Riverside Water Company, as already explained, the Agua Mansa irrigators are now assured a supply of two hundred and fifty miner's inches delivered through the newly constructed Meeks and Daley ditch and by a special branch, down to the old Agua Mansa work, the heading of which is abandoned.

History of Work:—Before the flood of 1861-62, the lands on which this ditch is used were moist and rich bottom-lands, producing fine crops without irrigation, and containing the residences of a flourishing settlement of native Californians. In that year the Santa Ana river swept these improvements all away, and deposited a comparatively barren sand in the place of the old fine soil. Thereafter, irrigation had to be resorted to, and the Agua Mansa ditch was taken out for the purpose in 1862. There had been a ditch in this district, however, taken out as early as 1845 by the first Mexican settlers, to the water-right of which this ditch may be said to have succeeded.

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CHAPTER X.—SAN BERNARDINO[5]; WORKS AND PROJECTS[8].

SANTA ANA RIVER WORKS.

JURUPA PLAINS WORKS.—SUB-GROUP[f].
JURUPA VALLEY AND RINCON GROUPS[3], [4].

SECTION I.—*Jurupa Plains Sub-group (f):*
North Riverside Land and Water Company's Project;
Vivienda Water Company's Project;
Jurupa Land and Water Company's Project.

SECTION II.—*Jurupa Valley Group (3):*
Jurupa or Rubidoux Ditch;
Trujillo Ditch;
Linville Ditch;
Island or Bickmore Ditch;
Soucal Ditch;
Hall Ditch.

SECTION III.—*Rincon Group (4):*
Yorba Ditch;
Fernandez Ditch;
Cota Ditch;
Taylor Ditch;
Spring Valley and Fugua Ditches.

SECTION I.

JURUPA PLAINS WORKS AND PROJECTS.

Among the works to be counted in the San Bernardino basin diversion group, although they are not diversions from the Santa Ana river, are those of the Vivienda Water Company and of the North Riverside Land and Water Company, which deriving their supplies from rising waters within, or just on the edge of the San Bernardino basin, conduct them out to the plain west of the

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Santa Ana river, below San Bernardino basin proper, and opposite Riverside, and which we have called Jurupa plain. Thus, this is a sub-group of the basin diversion works, and to which the name of Jurupa Plains Sub-group is applied for convenience of description and reference.

CONTEMPLATED NORTH RIVERSIDE IRRIGATIONS.

North Riverside Land and Water Company.

District and Works:—The works of the North Riverside Land and Water Company, designed for the acquirement of an irrigating supply, are confined to the development of water in the bottom lands south of the Santa Ana river, and between it and the northern end of the Riverside mesa.

Water Development:—The immediate scene of operations is now in the Peter Peters slough, and the Warren slough. The canal has been excavated through the bottom lands, three to twelve feet deep, in which is placed a covered flume, open at the bottom, three feet deep and five feet wide. The flume has three branches, the total length of which is one and one half miles. The most northerly branch is being carried across and under a high-water channel of the river, and is designed to tap as much of the underflow as can be reached. This work has been in progress nearly a year, and is now flowing in all about six hundred miner's inches in the main flume.

CANAL AND STRUCTURES:—The extension of these works is a canal, excavated in rock two thousand feet, around the hill, immediately above the Riverside Old Upper canal, from the end of which a flume is carried on trestles across the river, in a northwesterly direction, the distance from bluff to bluff being two thousand four hundred and sixty feet. Thence the grade skirts around the steep sides of the bluff bank of the north-side mesa for two miles, where the water is to be carried in a flume resting on the bench so excavated. From the end of this flume is a tunnel four thousand feet in length, and an open ditch three miles in length will extend thence to and into the Jurupa mesa lands. The works are still incomplete. The grading for the lower section of ten thousand feet of flume is finished, but the flume is not yet begun. The river crossing flume is also in an incomplete state.

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owing to an injunction gotten out by a land owner who objects to its crossing his land.

Tunnel:—The tunnel is all done but one hundred feet. Its dimensions are: four feet wide on the bottom, five feet six inches wide at water surface, three feet above bottom; height in clear, six feet six inches. The material was chiefly sand. It was excavated by contract for $4 per foot, including lining, but at considerable loss. The tunnel lies under a flat ridge or mesa, about forty feet below the surface. It was worked from six headings. The timbering bents are four by six-inch, placed two feet apart in sand, four feet apart in solider material. From the lower end of the tunnel the grade of the canal is reduced from five feet to four feet per mile.

COST OF THE WORKS:—The total cost of the works to July 30, 1888, is given as follows:

Development, under ground, flumes	$15,000
Rock cut	3,000
River flume	12,000
Tunnel	16,000
Grading, ditch excavation, etc.	4,000
Total	$50,000

History; Organization:—The company was incorporated in August, 1887, with a capital stock of $50,000, in five thousand shares of $100 each. The company have purchased a third interest in the Agua Mansa ditch, which, under the contract with the Riverside Water Company, will receive two hundred and fifty inches of water in perpetuity. They thus have eighty-three and one third inches unembarrassed by any litigation that may arise. The company owns that portion of the Rubidoux rancho north of the Jurupa ditch, about nine hundred acres, and have sold four hundred acres at $300 per acre, with water-rights at the rate of one inch to five acres.

The Jurupa Land and Water Company.

District; Works; Water-rights:—The Jurupa Land and Water Company was incorporated in May, 1888, with a capital of $3,500,000, by the persons who control the Vivienda and the North Riverside companies. This company has a contract with the Stearns ranchos syndicate for the purchase of the large tract of the Jurupa

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rancho (some twenty-six thousand acres) which has so long lain dormant and unimproved. The two other water companies mentioned agree with the Jurupa company to furnish all the waters they can develop, not required to fulfill prior contracts. It would appear that the company propose making a fight for a share of the waters of the Santa Ana, against all prior appropriators, on the ground of their rights as riparian proprietors. They control, under the Jurupa rancho contract, a large frontage on the stream. Moreover, they intend to divert water from the Narrows below Riverside, where there appears a rising supply apparently unaffected by the higher appropriations. From this source they can command about eight thousand acres of the lower end of the rancho. If this is diverted it may affect the supply to the Orange and Anaheim canals, and there, probably, will be more litigation resulting from these conflicts.

SECTION III.

JURUPA VALLEY OLD IRRIGATIONS.—GROUP[3].

In the low-land valley through which the Santa Ana courses below the San Bernardino valley proper, and thence down to the Narrows about three miles west of Riverside, are to be found a number of old irrigation ditches, most of them little individual farm works, and some of them almost indefinable by name or location. These, so far as known, are the Trujillo, the Jurupa or Rubidoux ditch, the Stockman Waste-water ditch, the Soucal, the Island or Bickmore, and the Hall ditch, and there are possibly some others not known to the writer hereof.

Jurupa or Rubidoux Ditch.

District and Work:—The Jurupa ditch diverts water from the west side of the Santa Ana river, at a point two miles below the head of the lower Riverside canal, and carries it around the edge of the bluff below the Jurupa plain, for the irrigation of the larger part of the bottom-lands in the old Rubidoux ranch, lying across the Santa Ana river from Riverside. For the first mile and a quarter of its length it is located on a swampy bottom-land, and in part occupying old natural channels running parallel with the

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Riverside canals, sometimes close in against the bluff without commanding any lands for irrigation. At this point the bottom land widens out, the river takes a course over to the southeast side of it, the ditch takes a course more westerly, and so it continues for a total length of about six miles, commanding an area of the bottom-lands a mile and a quarter in greatest width, and about three and one half miles maximum length, containing one thousand eight hundred to two thousand acres of land, a large part of which, however, being very low river bottom-land, subject at times to overflow.

The Jurupa ditch, when well cleaned out, is five feet wide on the bottom, eight feet wide on top, and two feet deep, with a very variable grade, and a capacity ranging between two hundred and fifty and seven hundred and fifty inches. It would be right, perhaps, to accord it a capacity of four hundred inches. In 1883 it laid claim to seven hundred inches, and there was a suit brought by its owners against the Riverside Canal Company to compel that company to allow as much as seven hundred inches to come past its works for the supply of the Jurupa ditch. This suit, however, was compromised, and the Jurupa is acknowledged by the Riverside company to have a prior right to three hundred miner's inches of water measured at its head-gate. The original claim, it is said, was for two irrigating heads, and it was believed that a head of water as used in this settlement was about one hundred inches.

Operation and Maintenance:—The work has always been a rudely constructed and loosely managed property, losing much water in the main ditch and its distributaries. It is owned by an association of irrigators, who, until recently, have had no stated organization, even as a simple association. It is conducted solely for the benefit of the irrigators, no water being sold and no water charge being made. The cost of maintenance is borne by the irrigators in proportion to their shares of ownership; and it is generally worked out by them by the contribution of labor instead of payment of money. A *zanjero* is appointed for the irrigation season only, and at other times the ditch takes care of itself.

Water-supply and Use:—In May, 1879, this ditch was carrying about three hundred inches of water, and irrigated that season three hundred and seventy-five acres of land owned by fourteen different irrigators.

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IRRIGATION:—In 1880, there were twelve owners, who held amongst them nine hundred and fifty-three acres of irrigable land, of which four hundred and forty-six acres were irrigated. Of this amount, one hundred and eighty-seven acres were cultivated in grain, seventeen acres in orchard, fifty-six acres in vineyard, and eighty-six acres in alfalfa. In 1885, there were nineteen owners and about five hundred acres of land irrigated. In 1888, there are twenty irrigators owning the three hundred and eighty-four hour-shares in the sixteen-day period; the largest holding being forty-eight, and the smallest six hours. There are five hundred and fifty-seven and a half acres irrigated, of which thirty-one and a half are in citrus fruit orchard, one hundred and fifty-four in deciduous fruit tree orchard, one hundred and five and a half in vineyard, two hundred and twelve and a half in alfalfa, and fifty-four in summer crops.

History of the Old Ditch:—About 1843 to 1845, B. D. Wilson constructed a ditch out from the river, located about where the Jurupa ditch now is, and which was conducted down to his settlements on the Rubidoux ranch, at the edge of the bottom lands opposite where Riverside now stands, and there used for mill-power purposes, and, also, afterwards used to some extent for irrigation by him. This ditch, it was alleged, was abandoned for a number of years, and relocated by new settlers in that country in 1869; but it is asserted by others that it was in use continuously from the time of Wilson down to the time when the later settlers took charge of it, since which time it has been owned and controlled as heretofore described.

Trujillo Ditch.

District; Work; History:—The Jurupa rancho was the first grant made in California under the Mexican policy of granting large quantities of lands in new countries controlled by that Government, to influential subjects. This grant was made by Governor Alvarado in 1840 to Don Juan Bandini. Bandini sold a piece in the center of the ranch, opposite the present site of the town of Riverside, to B. D. Wilson, who resold it to Luis Rubidoux. Bandini, in order to protect his ranch from incursions by Indians who came down upon it from the San Bernardino country, and who after the secularization of the missions in 1833 and aban-

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donment by the padres of the Old San Bernardino mission station, became troublesome in that country, induced a colony of New Mexicans to settle there, giving them lands and other substantial benefits.

This was about 1843, and the settlement made by them was in the lower part of what is now known as Agua Mansa. At that time the bottom lands in this locality presented a beautiful landscape, with deep, rich soil, and a narrow river, well confined between stable banks, coursing through them, where irrigation was not needed, as there was sufficient moisture from below, and the soil was yet sufficiently heavy to retain it. For several years these lands were under a high state of cultivation without irrigation, but the flood of 1861–62 utterly destroyed their improvements. The character of the bottom-lands was changed; the fine, rich bed of soil was washed away, and heavy sand deposits took its place. The Mexican settlers moved back to the edge of the mesa, where now their houses are, on the northern side, and a part of them moved across the river below the point of the hill around which the Riverside ditches are constructed as heretofore described, where they took out the ditch since known as the Trujillo ditch.

When the constructors of the Riverside Lower Canal came to build their work, they found the Trujillo ditch in existence and use, and occupying the location they desired to take for the upper portion of their work. An arrangement was made with the Californian owners of the Trujillo water claim, to allow the new ditch to take the place of theirs, and for them to take their water out from it at a lower point, and this is the arrangement to-day. Under an agreement entered into in compromising a suit at law, the Trujillo irrigators receive thus a flow of one hundred miner's inches.

IRRIGATION:—There are about ten irrigators under this ditch, and its waters serve about two hundred and fifty acres in irrigation, which are cultivated principally in summer crops and alfalfa. In May, 1879, the Trujillo ditch was carrying about two hundred inches of water, and irrigated two hundred acres of land that season.

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The Linville Ditch.

About a mile and a half or two miles below the head of the Jurupa ditch, and on the same side of the river, the Linville ditch diverts its waters, and carries them three fourths to one mile on some lowlands, which are also commanded by the Jurupa ditch. In 1880 this ditch was owned by three irrigators, who were also shareholders in the Jurupa ditch. The extreme capacity of the Linville ditch was one hundred and fifty inches, but it should not be accorded a greater average capacity than one hundred inches. In that year it irrigated seventy-five acres of land, cultivated principally in alfalfa and summer crops, and there has been little change since.

The Soucal Ditch.

This ditch takes water from the Santa Ana river on the west bank, about two miles below the Linville ditch, and is about three fourths of a mile long, three feet wide on top, two feet at the bottom, and one foot deep; and in May, 1879, it was carrying about one hundred and twenty-five miner's inches, and irrigated that season from seventy-five to one hundred acres of land. The extent of irrigation is reported to have remained about the same.

The Bickmore or Island Ditch.

This little channel is taken from an old bed of the river opposite Riverside, and with a length of about a mile and a half, is led on to the tract called the Island, which is between two channels of the river; where, in 1882, it irrigated about one hundred and twenty acres of land, belonging to three individuals, who were also owners in the Jurupa ditch-right. These lands are low bottom lands, cultivated in summer crops and alfalfa. In 1886 there were three owners in the ditch, who irrigated one hundred and twenty acres, of which ninety-five were cultivated in grain, and twenty-five in alfalfa; and there has been little change to this time.

The Hall Ditch.

This little work is an individual farm ditch, taking water from the Santa Ana river on the east side, just below the mouth of Spring brook, immediately west of the town of Riverside. It has a capacity for about fifty miner's inches, and carrying its waters

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down to some low bottom-lands between the edge of the Riverside mesa and the river, in 1880, irrigated about one hundred acres, cultivated chiefly in summer crops; and this is about the condition to the present time.

SECTION III.

RINCON DITCHES.

Yorba Ditch.

The Yorba ditch irrigates the bottoms and lower bench-lands between the northwest end of the South Riverside mesa and the Santa Ana river. Taking water at a point about four miles above the commencement of the Santa Ana lower cañon, it skirts the base of the mesa south of the river, and extends a total length of about three and a half miles, commanding a strip of land from a half to three fourths of a mile in width. It crosses the line of the Temescal wash at its mouth, and commands the new townsite of Rincon, which is laid out around the old Yorba residence. The diversion is effected by an ordinary brush dam, and the ditch itself is of the primitive class of earth excavated works. The head-gate and waste-way are substantial wooden works of the kind, but there are no other structures worthy of mention. The owners claim seven hundred and fifty inches of flow for the ditch, but the capacity of the work, as reported for the state engineer, is about four hundred to five hundred miner's inches only. In August, 1888, it was carrying two hundred and fifty inches of water. There is no organization regularly controlling the work, and as there is ordinarily an abundance of supply for the demand, each irrigator seems to take the water whenever he desires to use it.

The South Riverside Vineyard Company and the Rincon Town and Land Company each own an interest in this water-right, acquired within the past few months. Besides, there are nine owners who in the present year irrigate four hundred and eighty-five acres, of which one hundred and thirty-one are in vineyard, two hundred and sixty-six are in alfalfa, and eighty-eight in summer crops. The lands irrigated are fine, rich, alluvial bot-

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tom lands not requiring water in any great volume; indeed, crops are raised without irrigation on them.

The Yorba ditch was taken out by Mexicans in 1876, mainly to irrigate natural grass lands, and has been gradually developed into a regular irrigating ditch for cultivated crops.

Fernandez Ditch.

The Fernandez ditch takes water out on the north side of the Santa Ana river, commencing at a point about three quarters of a mile below the head of the Yorba ditch, and commands the low bottom-lands lying in the Rincon, opposite to the district supplied by the Yorba. The extreme width of its district is about a mile, and the ditch is about two and a half miles in length. It is a very ordinary earthen ditch about the same size as the Yorba and the same capacity, and with a claim for one thousand miner's inches of water. During August, 1888, it was carrying about three hundred inches of water. It is owned in equal parts by four persons, who divide its flow by the week—each one taking the full flow for a week in his turn. There is no organization or management other than those of a simple farm ditch. It irrigates a rich alluvial bottom-land, which does not require much irrigation, nevertheless in the old primitive fashion there is much water used per acre. In the present year there are two hundred and seventy-nine acres irrigated, of which twenty-four are cultivated in deciduous fruit tree orchard, five in vineyard, twenty in summer crops, and two hundred and thirty in alfalfa. The ditch was dug in 1870, and from the fact that it was started by Captain Leonardo de Cota, is sometimes called the Cota ditch.

Taylor Ditch.

This little ditch, owned in four parts, of which three belong to the Pasadena and Rincon Land and Water Company, diverts its supply from Chino creek, on the west side, about three miles above its mouth. It ordinarily carries about fifty miner's inches, is about half a mile long, and during the season of 1888 served six acres of land, cultivated half and half in alfalfa and summer crops. Vines and deciduous fruit trees do perfectly well in its district without irrigation, and grain crops rarely fail.

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Cota Ditch.

This is a little farm ditch with a capacity for carrying about three hundred miner's inches, which, diverting water on the east side of Rincon Mill creek, irrigates about fifty acres of land below the Jurupa plains bluff just east of the Rincon bottoms. It was dug in 1870, and has since been in use for the supply of about three acres of orchard, four of vines, ten of alfalfa, and thirty of summer crops. It was reported as carrying about two hundred miner's inches in August, 1888.

Spring Valley and Fugua Ditches.

The Spring Valley, formerly known as the Mayhew ditch, takes its supply from the Rincon Mill creek near its head, and irrigates about forty-seven acres of land within a mile of length on the west side. Its waters are then returned to the creek and taken out on the east side in the Fugua ditch, where about sixty-six acres are irrigated. These works are both little primitive ditches with capacity for about one hundred miner's inches, and managed without special organization or system. There are three irrigators who cultivate, with the waters, seventeen acres in deciduous fruit tree orchard, two of vineyard, sixty-four of alfalfa, and thirty of summer crops. The water-supply is unfailing for fifty to seventy-five inches, and of nearly even volume throughout the year. The little valley in which it is used is narrow and the scope for irrigation much restricted by this fact, as well as by the fact that the country commanded is moist, and irrigation not an absolute necessity.

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CHAPTER XI.—SAN BERNARDINO[6]; WORKS AND PROJECTS[9].

SAN BERNARDINO VALLEY WORKS.

South Cañon's Group[5].

Section I.—*Mill Creek Ditch and Irrigations:*
Old Mill Creek Ditch;
The Old Zanja;
Operation and Maintenance;
Water-supply and Use;
History of the Water-right;
Crafton Water Company;
Redlands Heights Pipe-line.

Section II.—*Yucuipa and San Gorgonio Creek Works:*
Upper and Lower Yucuipa Ditches;
Upper and Lower San Timoteo Ditches.

Section III.—*Temescal Wash Works and Projects:*
South Riverside Land and Water Company's Works;
Water Development and Collection;
Works in Construction;
Other Sources and Projects;
History and Organization.

SECTION I.

Mill Creek Ditch.

The Old Zanja.

District and Work:—This is the oldest water-right and work in San Bernardino county, and under good management could by this time have been made the most valuable and the most useful, but it is still a crude and helpless organization and a rude and excessively wasteful work. Constructed between sixty-five and seventy years ago, this ditch has long lost the semblance of

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an artificial work. The channel receives waters from Mill creek, where it courses close to the south hillside of its wide open lower cañon, and conducts them down the slope of the plain on grades dropping from two hundred and fifty to one hundred and fifty feet per mile, over a cobble and bowlder bed and by a winding and even tortuous course, with large alders and other trees growing in the immediate banks. There are many picturesque spots found in its windings, and the beauty of the stream is held by the land owners to constitute a material element of its value.

It delivers water in irrigation along a route on the southern plain of the valley from Crafton to old San Bernardino, and sandwiched in between the Lugonia and Redlands settlements. Its total length is about twelve miles. No definite cross-sectional dimensions can be assigned it, because of its very irregular form, and even in the matter of capacity it is exceedingly indefinable. Doubtless, as much as two thousand inches have often coursed through it, but at the expense of local overflowings, equally without doubt. The claim of right to the waters is held by its owners to relate to a point where the creek comes out of a narrow cañon, about a mile above where the old ditch apparently commenced. A piece of paved ditch, about one thousand feet in length, was constructed in 1885, to bring waters over a portion of this route, but it has never been used.

Operation and Maintenance:—The water-claim is owned in hour-rights, and the division is made by the measure of time, without respect to volume. The rotation is so well known, by long custom and decree of court, that each irrigator takes the flow during his allotted hours, and closes it off for himself without the services of a watermaster. There is a watermaster, however, who has, as may be necessary, to look after the head of the ditch, and to see that no irrigator takes more than his share of supply.

Water-supply and Use:—This right has always controlled the full supply in Mill creek, which has been much more than sufficient for the irrigations effected. But waste in every form has been the rule; lavish use came down as a tradition from early irrigators, and the vines and trees themselves, long grown under profuse waterings, have come to need a greater supply than if they had been more thoroughly cultivated and judiciously irrigated

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when young. The data of the flow of Mill creek will be given with other water-supply data in a succeeding chapter. The water-right is held in individual interests; forty-two hours every ten days by upper irrigators, and the balance among the lower irrigators in hours of a seven-day period.

IRRIGATION:—In 1879, it was reported as irrigating six hundred acres, cultivated in vines, citrus fruits, summer crops, and alfalfa, besides several hundred acres of spring flooding of grain. In 1882, there were nineteen owners, the largest holding thirty-six hours; the smallest, one and a half, of a mixed seven and ten-day period. The total area of summer irrigation was five hundred and thirty-six acres; cultivated, seventy-four in summer crops, eighty and a quarter in alfalfa, two hundred and sixteen and a half in orchard, principally oranges, and one hundred and sixty-six in vines; besides which there were seven hundred and seventy-two acres of grain flooded. In 1885, there were twenty-two owners (counting the Craft property as one), the largest holding being a thirty-six hour-right every seven days; and the smallest, one and a quarter hours. Of these owners, nineteen used the waters that year, irrigating one thousand and sixty-five acres; cultivated, ninety-eight acres in citrus orchard; four hundred and fifty-eight acres in deciduous fruit trees; two hundred and eighty-nine acres in vines, ninety-seven in alfalfa, and one hundred and twenty-three acres in summer crops. There were also four hundred and fifty-sixty acres of winter flooding. During the present year, there are about one thousand three hundred acres irrigated during the summer months, the increase being almost wholly in vines and citrus orchard.

History:—*The Spanish Mission Station, and Mexican Grant*:—Soon after the founding of San Gabriel Catholic mission in 1820, the policy of establishing subsidiary stations, where local tribes of Indians might be brought under control and employed in agricultural pursuits, was inaugurated. The valley whose irrigation development we are now tracing must have presented an attractive field for this kind of effort, and the present Mill creek neighborhood seems to have been the place most suited to the purpose. Here, about 1821, on a spot now within the Barton ranch, an extensive work of the kind was placed—houses and granaries were built, and a water-supplying channel was constructed. This was

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the Mill creek ditch, located, so far as known, without change as we find it to-day.

Under the rule of the church, and through much tribulation and even bloodshed, some hundreds, possibly several thousand, acres were cultivated where the Barton vineyard and the lower part of Lugonia settlement and the upper part of Old San Bernardino now are. Within a decade this station had grown to be a very important one, with a large number of neophytes, and great herds of cattle running over the valley, which was all claimed and held by the mission fathers. In 1833 the government of Mexico secularized the missions in California—took from them their great estates and vested the local control of affairs in civil authorities. By this time a considerable settlement of Mexicans had collected at and near the San Bernardino station, and by these the old *zanja* was kept up, and irrigation continued—though, it is believed, over a much less area—after the clerical establishment had been broken up and the Indians had, for the most part, returned to their primitive mode of life.

The Rancho San Bernardino was granted to José Maria Lugo and others by Governor Alvarado, in 1842, and it was expressly limited and described, so as to take in the important part of Mill Creek *zanja* and the immediate adjacent cultivated lands, in order to cover this water-right. And so the ditch, it was thought, became an appurtenance to this magnificent landed property in private ownership, and the use of its waters was continued as before.

Mormon Regime and Other Settlers:—In June, 1851, a colony of about three hundred Mormons, after great suffering in crossing the desert, entered San Bernardino by way of Cajon pass. A unmber of these purchased the Rancho San Bernardino in 1852, and soon the whole valley was under Mormon dominion and settlement. Among other localities and properties immediately and actively worked by them was the Mill creek ditch and lands at its lower end, where was established the settlement since known as Cottonwood Row, or Old San Bernardino, and where tillage was aided by the waters from the old *zanja*. In 1857, under orders from the church at Salt Lake, most of the San Bernardino Mormons sacrificed their property, and went back to Utah. A number, however, refused to go, and among these, quite a little coterie at Old San Bernardino, who held on to their Mill creek property

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and irrigations. Other settlers succeeded by purchase to some of the Mormon lands and rights there, and so the foundation for the present Mill creek water-right became established under our law.

Recent Years—Individual Water-rights:—There have been a number of internal controversies over rights on this ditch, but never any conflict with claimants under any other ditch right. Indeed, the collective claim has always been for all the flow of Mill creek, up to the capacity of the ditch, and as this claim covered the entire low-water supply (which was ordinarily all diverted by it) there has been no other ditch started from that source. At one time it was contended that the ditch was not an artificial construction, but a natural water-course—its history not being known to the claimants—and this constituted a point in the case of Cave vs. Crafts, tried before the local courts in 1875. The trouble originated between settlers who located along the upper part of the ditch, in the neighborhood now known as Crafton, and those of Cottonwood Row at the extreme lower end of the ditch, six miles away. These were two distinct settlements, with an intervening space of seven miles not cultivated; the lower one at that time composed almost entirely of Mormons, the upper neighborhood of settlers not Mormons. The Cottonwood Row people had a clear title to their land and water-rights by legal succession from the original grantees of the rancho; and they claimed that all the waters were due to them—following the originally established usage. Some of the upper settlement people had titles to lands acquired from the United States Government, bordering the grant, and through which the *zanja* ran; and these or their grantors had, from very early times, used in irrigation a portion of the ditch waters.

There had been an action brought by the lower settlement people against some of these, several years before, on the point of their right to use water from the ditch, which had resulted in a compromise, to the effect that the particular upper settlement people then sued were accorded the right or privilege to use the waters from 3 to 9 P. M. each day; it having been ascertained by practice that the effect of closing off the flow above was not felt until six hours afterwards at the lower end of the ditch; and that by this arrangement those below would be deprived of the water only at night, when they would not want it. The right thus previously acknowledged was advanced in defense by some

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of the parties in the suit of Cave vs. Crafts, and the plea was also set up, on the part of other settlers, that the ditch was a natural water-course flowing through their lands, and that they were entitled to a share of its waters, as an appurtenance to their riparian properties. The case was disposed of in the lower court in April, 1876, in accordance with the foregoing recited facts as to the history of the ditch; and it was found that, although Crafts had been using water at times when he was not entitled to it, still he had certain rights, and that certain other defendants had rights by adverse use. By this decision it was determined that the waters were not inseparably appurtenant to any land, but that certain persons had established rights to use them.

Nature of Individual Water-rights:—A case of somewhat similar nature came up in 1883–84, in which Mr. Byrne brought suit against Crafts, setting up the plea that the ditch was a ("natural or artificial") water-course, whose waters had been used on lands afterwards within the Rancho San Bernardino since some time prior to 1826; and that the right to use said waters was exclusively an appurtenance to the lands of said grant. It was found by the court in deciding this case, however, that none of the waters at the time of the grant were ever or at all incident or appurtenant to the ranch lands, or any portion of them, except to that portion known as Cottonwood Row. The decision in the former case of Cave vs. Crafts was sustained; and it was furthermore found that an owner of a water-right in the ditch could do what he chose with the water during the hours the flow was allotted to him, provided he did not thereby deprive holders of other hour-rights, of the full flow of the stream during the period of their turn; and, moreover, that the waste-waters of the ditch were not and could not be any specified quantity, but only such waters as irrigators from time to time did not use.

Condition and Management of Property:—Running, for a distance, in a rude channel through the natural gravel wash of the creek, and thence tumbling down a bowlder bottomed bed, worthy of being called a ditch only in such times as those when the Indians, the Mexicans, or the Mormons cared for it, the waters of Mill creek have always been in great part uselessly lost by percolation along its course. In 1880, after examination, this

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loss was stated in the current report of the state engineer to be a very large part of the total flow. In 1885, subsequent to careful measurements, the ditch being still in its primitive condition, it was found, as elsewhere stated in this report, that the loss, for the time, was enormous. This fact was then brought to the attention of a number of principal owners in the property; and an effort was made by them to bring about such an organization of all the owners as would make it possible to improve the waterway. Something towards this was accomplished, and the piece of paved and cement ditch near the head, and already spoken of, was soon afterwards constructed. But here the work dropped, and the property is still managed on the old primitive plan—the association being one of the loosest in organization, and the work being about the least cared for, of any of real importance in Southern California. The water-supply is ample for the use of the present claimants, and as yet no one from the outside has interfered with them.

Crafton Water Company:—The Crafton Water Company is an organization holding about one seventh of the Mill creek water-right, for the irrigation of lands adjacent to the *zanja* along the upper part of its course and in the extreme southeast corner of the valley. The waters are taken around the easterly and southerly edge of the valley in a ditch, about a mile, to a small earth-embanked distributing reservoir, and thence are led still onwards around the head of the Redlands mesa about a mile and a half farther. Distribution is made by wrought-iron pipes down the slope from the reservoir and main conduit, and all waters are delivered within a mile of these sources of supply. The irrigation for this system is included within the area reported for the Mill Creek *zanja*. Some portions of these irrigations are amongst the oldest in the country; but the works here described are quite recent constructions out from the old *zanja*, and are designed to facilitate the subdivision and irrigation of the old tracts.

Redlands Heights Line:—From the end of the Crafton main, a sixteen-inch cement pipe leads around about two miles on to the rolling hills which overlook Redlands mesa from the south; and this, with about two miles more of fourteen-inch pipe, and with several miles of small distributaries, constitutes the Redlands Heights system, intended for the supply of about one thousand

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acres lying above the plane of the Bear Valley and Redlands canal. The work has been carried out within the past eighteen months, and is now in control of the company next spoken of.

Crafton, Lugonia, and Redlands Domestic Water Company:— This is an organization primarily for domestic supply to the settlements and towns indicated by its name. Its water-rights are made up of shares or hours put into the organization by those who formed it, as follows:

Old South Fork shares	31¾	for	$31,430
Bear Valley water certificates	281	for	18,626
Redlands Water Company stock	108	for	14,429
West Redlands Company stock	162	for	16,175
Crafton Water Company stock	200	for	20,000
Mill Creek Zanja hours	12	for	18,000

Its works consist of a large paved and cemented reservoir at the upper limit of the Lugonia settlement, deriving waters from the Bear Valley canal, and a wrought-iron distributing pipe system thence through the Lugonia and Redlands settlements, together with the Redlands Heights line already described. Water is supplied for irrigation of garden plats, and from the higher line it is expected to furnish irrigation to quite an area of orange growing lands divided into small orchards. The whole system is less than two years old.

SECTION II.

YUCUIPA AND SAN TIMOTEO DITCHES.

The Yucuipa is on a smaller scale, one of those peculiar, boxed-in depressions in a rolling, mesa-like formation, described as occurring in a number of instances throughout San Diego county just within and next the coast mesa limit. It covers about three thousand acres in area; is about two miles southeast of the southern edge of San Bernardino basin, and has an outlet westward, by a gorge or cañon through the mesa, to the San Timoteo cañon, or creek, which is thus joined about five miles above its outlet into the San Bernardino valley. The Yucuipa valley receives waters during heavy rain months from a watershed on the southern face of the high hills, east of the Mill Creek cañon.

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Its bottom is a moist meadow with some *cienega* land, all of which is drained by Yucuipa creek through a gorge to San Timoteo creek.

Lower Yucuipa Ditch.

The Lower Yucuipa ditch takes its waters from the south side of Yucuipa creek, about a mile above its junction with San Timoteo creek, carries them to and across this last named wash, and down its west side, a distance of about four miles, commanding a narrow strip of land, whose soil is a mixture of red mesa clay with light ashen-colored alluvion. This is a very small work, having a recorded claim to seventy-five miner's inches and a capacity for about fifty miner's inches. The upper portion is a simple earthen ditch, and the lower two miles an eight-inch cement pipe. The lands served lie immediately along the main line of work, so that there are no distributary or branch ditches or pipes.

Distribution is made on the basis of the full volume of flow, and of a nine-day recurring period; and there is no organization and management other than that of a simple association of neighbors, on the general plan of a number of others explained elsewhere in this report. There are two hundred and sixteen hour-shares in the property, held by sixteen irrigators—the largest holding being thirty and the smallest six hours. In the present season (1888) one hundred and sixty-six acres in all are irrigated, of which nine and a half are in citrus orchard, eighty-one and a half in deciduous fruit trees, thirty-nine in vineyard, twenty-four and a half in alfalfa, and eleven and a half in summer crops. The ditch was built about thirty years ago by the Mexicans and Indians, but has since 1873 been chiefly used by American cultivators.

Other Small Ditches.

There is a small ditch in Yucuipa valley, used for irrigation of summer crops and natural grasses, called the Upper Yucuipa ditch. And there are several ditches on the San Timoteo and a branch known as Elder creek, above the Yucuipa junction, but this department has not had means to carry the investigation farther east than here reported.

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SECTION III.

South Riverside Works and Projects.

District and Work:—The South Riverside plain is a red mesa slope between Temescal wash or creek and the northeastern face of the Coast Range of mountains, in the extreme southwestern corner of the great San Bernardino valley. It lies across the farther end of the Riverside plain, as it were, beyond the creek, and at its northern end reaching down to and overlooking the Santa Ana river and the Rincon basin. The South Riverside Land and Water Company have for several years been prosecuting works for the development of water with which to irrigate these lands, and building delivery and distribution works as well. The water-supply is derived and expected to be derived from Temescal cañon and side gorges.

Water Development and Collection:—Mayhew cañon is one of the main tributaries of the Temescal. It has a large watershed of precipitous character, and the quantity of debris brought down into the valley indicates a very torrential character. Immediately below the point where it joins the Temescal, the latter passes through a gorge called Gregory cañon, where a masonry dam is contemplated. The distance between bedrock walls is about nine hundred feet, and the depth down to bedrock bottom has been found to be sixty feet. The construction at this point of a masonry dam founded on bedrock, and extending forty feet above the surface, would form a lake in the valley of the Temescal. There is already a lake of considerable dimensions and depth a short distance above, called Lee lake, which is the receptacle of all the drainage of the upper valley of the Temescal, and is unfailing in supply. The wash from Mayhew cañon has thrown a bar across the Temescal valley, where it is proposed to build the dam, and this bar has caused the forming of Lee lake. About $5,000 has been spent on a tunnel to under-drain this basin, but no use has been made as yet of the water (about twenty-four inches) developed by it.

Coldwater cañon is another important tributary of the Temescal, heading in the Coast Range. The company has a claim to this flowing water, but are in litigation over the amount of their

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right. This cañon and several others empty into a valley whose bottom is an artesian basin, before joining the Temescal proper. In this basin is a *cienega*, covering about one hundred and fifty acres, in which the company have bored three ten-inch artesian wells, and have obtained a flow of one and three fourths inches over each, affording about seventy-five miner's inches. They have two steam boring machines at work, and intend to further develop the *cienega* and artesian flow. Water is oozing from the *cienega* on the surface in numerous little streams, and these are being collected in pipes and flumes and carried to the main.

Below the large *cienega*, and all the way for a couple of miles from it to the Temescal, is water-bearing land, springs, and smaller *cienegas*. The development of these by flumes and pipes now affords one hundred and fifty to two hundred miner's inches. A tunnel has been run some one thousand three hundred feet towards the lowest of the *cienegas*, beginning near the lower end of the valley of the Coldwater cañon, which is intended to penetrate the dike of blue clay that forms the upper basin. At the end of the tunnel they are just reaching the clay, and propose to continue to a point to where the drift will be one hundred and fifty-five feet below the surface, and then wells will be bored and cut off at that depth, from which good results are anticipated.

South of the town of South Riverside, and within three miles of it, are two other sources of supply which have been tapped, viz.: Hagedor cañon and Lord's cañon. In the former, a small masonry dam, twelve feet high and thirty feet long, has been built, and eight thousand nine hundred feet of six-inch iron pipe has been laid from it to a small reservoir, from which a four-inch screw pipe, two miles long, was laid to the town. This was the first water-supply put in for temporary purposes, while the other works were in progress. In Lord's cañon, a four-inch screw pipe, seven thousand feet long, is laid out of the cañon to supply an orange grove at the southern line of the tract.

WORKS IN CONSTRUCTION:—The works consist principally of twenty miles of pipe-line, of which forty-seven thousand feet is thirty-inch cement, nine thousand feet is sixteen and eighteen-inch cement, and forty-nine thousand feet is iron of all sizes, from four to thirteen-inch. The main pipe is laid on a grade of seven feet per mile, and has a capacity of nine hundred miner's

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inches. It heads in the valley of Temescal creek, and skirting the south side of it, passes over several deep arroyos by trestled flumes, and penetrates a number of spurs by tunnels, respectively one hundred and fifty, two hundred and fifty, two hundred and fifty, nine hundred and sixty, one thousand five hundred, and five hundred feet in length, a total of three thousand six hundred and ten feet. In the tunnels the pipe was laid in sand, and earth filled in solid on top thereof. Into this main pipe, lateral flumes and pipes bring water from the several side sources. The total supply thus far claimed to be developed and collected amounts to one thousand two hundred to one thousand three hundred inches. This is not allowed to run in the pipe at present, however, seeing, it is alleged, that there are not enough irrigators to care for it.

A statement, furnished by the secretary of the company, gives the following detailed schedule of the works:

Thirty-inch cement pipe, with three thousand six hundred and ten feet of underground flume	47,000 feet.
Flume above ground, main line	3,300 feet.
Sixteen-inch cement pipe, lateral supply line	9,000 feet.
Twenty-four-inch iron pipe, lateral supply line	1,060 feet.
Thirteen-inch iron pipe, lateral supply line	2,900 feet.
Flumes	15,448 feet.
Eight and one half-inch iron pipe	7,302 feet.
Six-inch iron pipe	14,065 feet.
Five-inch iron pipe	2,500 feet.
Four-inch iron pipe	37,366 feet.
Two-inch iron pipe	25,575 feet.
Total	165,516 feet.
Tunnels (development and conducting)	5,829 feet.
Ditches	167,558 feet.

OTHER SOURCES AND PROJECTS:—Another pipe-line is contemplated from Lee lake and the artesian wells, which will be about one hundred and fifty feet higher than the present main, and cover a portion of the lands; and a third main of iron (pressure pipe) from Mayhew and Coldwater cañons, will be required to reach the higher lands lying next to the foothills. Another source of supply which has not been developed, is a *cienega* some four miles above the town in the valley of the Temescal. From the natural flow of this *cienega*, thirty acres are now being irrigated in its immediate vicinity. Water developed in it will cover the Auburndale tract, lying next the Santa Ana river. On the Tin Mine grant, directly below the last *cienega* mentioned, is a gorge

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some three hundred feet in width with porphyry walls, where the owners of the Tin mine propose to build a masonry storage dam for mining and irrigation purposes.

History and Organization:—The South Riverside Land and Water Company was incorporated in May, 1886, with a capital stock of $500,000, divided into five hundred shares. The object being that usually set forth for land and water companies operating in the southern part of this state.

The Temescal Water Company was incorporated in 1888, with a capital of $1,600,000, divided into sixteen thousand shares, for the purpose of conducting water and developing a supply by extending operations commenced by the South Riverside Water Company. To this new company the water-bearing lands, pipe-lines, flumes, artesian wells, and other works of the South Riverside company are to be, or have been, turned over, etc. In selling its lands, the South Riverside company transfers shares of the stock of the Temescal Water company, which is supposed to represent a water-supply equivalent to one tenth-inch per acre sold. It is claimed that about $300,000 have already been spent on the water-works, and much remains to be done before all the lands belonging to the company are supplied. The main pipe-line commands about six thousand acres, and there are four thousand to five thousand acres of arable land lying above its reach.

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CHAPTER XII.—SAN BERNARDINO[7]; WORKS AND PROJECTS[10].

SAN BERNARDINO VALLEY WORKS.

NORTH CAÑON'S GROUP[6].

SECTION I.—*Plunge and City Creek Works:*
Old and New Plunge Creek Ditches;
Old Base Line Ditch;
City Creek New Canal.

SECTION II.—*Twin Creeks and Cajon Pass Works and Projects:*
Old Town Ditch;
East Twin Creek Ditches;
West Twin Creek Ditches.

SECTION III.—*Lytle Creek Works and Projects:*
Old Lytle Creek Ditches;
Rialto Canal;
Riparian Rights-Appropriation Conflict,
Semi-Tropic Land and Water Company.

SECTION I.

PLUNGE AND CITY CREEK WORKS.

Plunge Creek Ditches.

There are two small ditches out of Plunge creek on the west side: an old one which diverted waters under an authorization of the board of water commissioners as long ago as 1870, and a new one constructed about 1883 or 1884. The old one is a little primitive work taking water from near the mouth of the cañon, and delivering it in the irrigation of some lands which are also served by waters from the North Fork ditch. Its capacity may be put at about fifty inches, and the extent of its irrigation at not over fifty acres. The newer ditch comes out from a point a

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couple of miles up the cañon, is built around on the high mountain's face, and reaches to the very highest bench-lands at the foot of the mountain slope. It was made as a paved and cemented ditch, six to eight inches wide on the bottom, eighteen inches on top, and sixteen inches deep, but for some reason has not been in use for several years.

City Creek Ditch.

District and Work:—This little work heads about a mile up in the narrow, rocky cañon of City creek, and brings its waters by a tortuous rock-cut channel around the face of the cliffs and bluffs out to the southern slope of the mountain's footing, west of the stream, and thence extends westward on hillside and winding into ravines for a total length of two and a half miles. Its waterings are chiefly above the line of the Highland Vineyard Company's extension of the North Fork ditch, which is located below City creek ditch, and about a quarter of a mile therefrom. The work is well constructed. Where not in solid rock cutting it is paved or lined with bowlders or rubble laid in lime mortar, and its face is cemented throughout. It is one and a half feet wide on the bottom, three feet on top, and two feet deep, with a uniform grade of one inch to the rod.

COST OF THE WORK:—The upper four thousand and forty-two feet of the work, of which nine hundred and ninety was solid rock cutting along a nearly perpendicular cliff, and two hundred and twenty-five feet were in tunnel, cost the contractors about $3,000—counting their own labor at common labor rates. To construct this work under ordinary conditions of employed labor would have cost fully a dollar per foot. The next six thousand and twenty feet cost at the rate of about 40 cents per foot, including paving and cementing. This too was done under exceptionally favorable circumstances as to the matter of labor, and ordinarily would cost fully 55 cents per foot.

Operation and Maintenance:—There are no works of distribution in this system worthy of special note, and no system of management differing from those described for other works. The water belongs to the irrigators, to whom it is distributed by the measurement of time of flow of the entire stream, during a nine-day period of rotation.

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Water-supply and Use:—After July the supply of water to this ditch has always been very uncertain; indeed, from its lower point of diversion, it seldom had any flow of consequence after that month. In 1879 it was reported as having capacity for about two hundred and fifty inches, and in May of that year it carried one hundred and seventy-five inches of flow, irrigating about sixty-five acres of land. In 1881 there were four owners of the interests in the upper prong of the ditch and four in the lower, holding two hundred and fifteen shares. The highest holding was sixty and the lowest twelve. The total irrigation was sixty-five acres, of which two were in summer crops, thirty in alfalfa, twenty-five and one half in orchard, and seven and one half in vines. In 1885 there were two hundred and three acres irrigated by it; of which forty-five were in citrus orchard, fifty-six in deciduous orchard, forty-nine in vineyard, fifty-one in alfalfa, and the balance in summer crops. In the present year the area of irrigation is about the same, but it has become confused with service from the North Fork canal.

History and Water-right:—About the year 1865 some settlers along the base line on lands just west of City creek crossing, and lying above the district served by the Old Cram and Van Lueven ditch, brought waters out from City creek, commencing in the turn just above the first point of rocks on the west side of the cañon. Their old ditch followed the base of the cañon wall out to the bench-lands, around whose edge it skirted to the plains, and thence westerly to the lands irrigated—a length of several miles. It was a very rude structure, carried about one hundred and fifty miner's inches of water, and was known as the "Base Line ditch." The records of the water commissioners first mention this ditch in 1871, when, in April, it appears that the owners had a dispute arbitrated by the board, but no mention is made of the amount of water claimed for it. In February, of 1874, the commissioners viewed and laid out a ditch, commencing at the same point, but holding a lighter grade, and coming out on the bench-lands near the base of the foothills, immediately west of the cañon mouth. On the twenty-fourth of the month, an agreement was recorded wherein an owner of property on the bench-lands, which could be served with water from the proposed new ditch, contracted to build the necessary flume and ditch around to a certain point, to carry

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"three hundred and thirty-six cubic inches under a four-inch pressure;" in consideration of which he was to receive a one ninth interest in the ditch, and in the Base Line ditch water-right, from the six persons owning it, and with whom the agreement was made. This ditch and flume was built during that year of 1874, and was used for the first time in 1875.

The waters thus brought out on higher lands and soils supposed to be fitted for a better class of culture than those of the lower plain, commanded prices such that a larger part of the ownership was soon transferred to the "bench." The original owners having found by that time that they could get along with less water, parted with a portion of their interests on discovering that they could, by constructing higher grade distributaries, get water from the Cram-Van Lueven ditch, and at less cost. Thus, by 1882 the location of the water interests had so much changed that a strong party in the ownership wanted a ditch brought out on a much higher line still. By this time the old flume had begun to show signs of decay, and the ditch was shown to be wasteful of the water-supply as compared to a work that might be constructed, so all the owners desired a better one.

In the spring of 1883 surveys were made for the present canal, and a contract was let for its construction. Again, the contracting party was the owner of higher lying lands, specially interested in the proposed change, because more of his property would thereby be commanded for irrigation. All the owners joined in the move, and paid, proportionately to share-holding, for the main work as far as the "divide," a length of 4,042.5 feet, but the contract price was much less than the cost of the work, and it is doubtful whether it would at that time have been constructed, but for the very low offer made. To this point the canal was finished by the spring of 1884, and used during that year. During the summer of 1884 the owners of fifty-five of the two hundred and sixteen shares extended the canal 6,022.5 feet, at their own expense, to carry water on to their lands.

In the meantime, the old ditch of 1874 was still in use as a distributary around the face of the bench-land, but the Highland Vineyard company's branch of the North Fork canal, as elsewhere explained, has now occupied its route. In 1886–87, the City Creek ditch was farther extended by the owners of a small portion

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of its shares for a distance of about two thousand feet, and so it stands at the present time.

The City Creek Water Company, composed of those owners who desired to relocate the canal on a higher grade line, was incorporated in May, 1878; and this organization has since controlled the work and water-right, although not all of the interests have been merged into it.

SECTION II.

Twin Creeks and Cajon Pass Works.

The waters of the Twin creeks were first appropriated by authority of a special act of the Legislature, passed in 1854, for municipal and domestic purposes in the town of San Bernardino. Under this authorization, a ditch was dug by direction of the municipal authorities, and the waters of both creeks were brought into the town in 1855. It was soon found that in winter the little work was partially washed away by each freshet, and in summer the waters were lost in the sands long before reaching the town limits, and so it was abandoned in several years afterwards.

West Twin Creek Ditch.

Soon after the abandonment of the Twin Creek Town-ditch, a settler on the slope immediately west of Twin Creek's wash, made claim to the waters of the West creek and took possession of and used the ditch; and from that time on they have been utilized about as next described. West Twin Creek ditch is now a small work which takes its water from the West creek on the west side at the mouth of the cañon, and conducts them around the upper edge of the bench-land about a quarter of a mile, dumps them into Wallace gulch, picks them up again a short distance below, and conducts them still further around the edge of the foothills and out on to the steep sloping bench-land, a total distance of about a mile. Here they are distributed in irrigating lands of a very porous and absorptive character, lying on very steep slopes at the upper edge of the San Bernardino valley plain. The soils are coarse granitic washings, but very rich and productive under sufficient irrigation.

The ditch has for a number of years been owned in equal parts of thirty-six hours per week each, by three irrigators who have

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used its waters on sixty to eighty acres of land, cultivated about fifteen to eighteen acres in deciduous fruits, twenty-five to twenty-eight in vines, and fifteen to seventeen in alfalfa, and ten to fifteen in summer crops. As now used, the ditch is, for the most part, roughly paved, but not cemented; and has capacity for about fifty miner's inches of water. The ordinary summer flow of the creek at the ditch head is about thirty inches, and the little work diverts all that comes to it, to the extent of its capacity, when wanted by the irrigators who use it. There is a loss of at least ten inches in transit, however, so that the summer stream of water delivered may be put at about twenty inches, which thus performs a net duty of irrigating three and a quarter to four acres to the inch.

Waterman Hot Springs Irrigations.

In 1874, some waters of West Twin creek were taken out for irrigation of several small plats of bench-land in the cañon of the stream, lying at an elevation of about one thousand eight hundred feet above the sea, and above the head of West Twin Creek ditch. For this purpose, two small flumes, having capacity for from twenty to thirty inches each, were constructed—one out on each side of the stream, which here has a fall of about one hundred and fifty feet per mile. By this means, there are now irrigated thirty-five to forty acres of most productive lands, surrounding and in part forming the beautiful place known as Waterman Hot Springs. The cultivation is about ten to fifteen acres in grapes, ten to fifteen in deciduous fruit tree orchard, a plat in citrus fruits, and the balance in summer crops and garden.

East Twin Creek Ditch.

History, Conflicts, Water-supply and Use:—After the San Bernardino authorities gave up the idea of using the Twin creek's waters for town purposes, the flow of East Twin creek remained unused for several years, when it was taken out by means of a small, individual farm ditch, following around the foothills, easterly, about a mile. Several other such little diversions were made, until in 1875 or 1876 some of the property changed hands, and the water claims were consolidated and applied to one ditch, which, commencing just in the mouth of the cañon, extended as a simple earthen excavation, about a mile easterly around the base of the steep hills. In 1885 it had capacity for about sixty

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to seventy miner's inches of water, and was owned by five persons, in shares from one eighth to a fourth each. Four of its owners were irrigators, who used its waters on an aggregate area of sixty-nine acres of land, of which seventeen were cultivated in deciduous fruits and fifty-two in alfalfa. The soil of this little district is of a loose granitic wash, and the ground was much broken, cut up, irregular, and steep. The water-supply at the head of the work at period of lowest flow has generally been about seventy-five to one hundred inches. There was great waste in this ditch, however, and probably its useful delivery has not exceeded thirty to forty inches, which makes its net duty, say, one and three quarters to three acres to the inch.

In 1885 the owner of an eighth interest in the water-right, who was not an irrigator under the old work, commenced the construction of a ditch from a higher point of the creek, and located around on the steep hillsides of the cañon. Because of difficulty in getting rights of way this work was stopped. In 1887 an association, known as the Kansas City Syndicate, acquired the rights of the older irrigation, and desiring to transfer the utilization of the water to lands farther east, commenced the construction of another ditch out of the cañon, on the steep, rocky cliff and hillside, above that commenced in 1885. Conflicts arose as to rights to water between the owners of these two upper ditches, and, so, work on the second one was stopped, and they now remain unfinished and unused—the question of right having been carried before the courts. Thus the waters of East Twin creek are not being utilized this year (1888).

Cajon Pass Works and Projects.

Glen Helen Ditch.

District and Work:—A project for the utilization of the waters of Cajon Pass stream and tributaries from the western mountains is that of the Glen Helen ditch, now in part constructed and in use. Commencing in the cañon wash opposite a point known as "Vincent's," it delivers waters on the Glen Helen farm, which lies on the southern slopes, just where the cañon opens into San Bernardino valley. As yet this is a simple excavated ditch one and a half to two feet wide on the bottom, four feet on top, and two feet deep; but it is the intention to enlarge it to several times

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these dimensions, and pave and cement it where necessary to prevent loss of water. Its route is quite tortuous—winding up into many side cañons and around intervening spurs, and located for the most part high up on hillsides. The ravines are crossed by flumes, of which there are thirteen, aggregating about one thousand three hundred and twenty feet in length, of which the longest is two hundred and sixty feet, and the highest trestle support sixty-six feet. These flumes are four feet wide, sixteen inches high on sides, and built to admit of sides thirty-two inches high within the frames—thus anticipating the proposed enlargement of the ditch. Two of the ridges are pierced by tunnels three hundred and ten and one hundred and fifty feet long, respectively, and four by six feet in section, driven in moderately hard granite, and not timbered. Almost every side ravine passed has at a higher point, and within the protection of deeper cañon and denser growths, its stream, perennial in flow, to the extent of five to twenty inches. Seven of the larger of these little streams are brought into the Glen Helen ditch by means of small box-flumes, carried from it on heavy gradients, back to the points where the waters flow unconcealed over bedrock bottoms.

The total length of the main work is about three and a half miles, and its grade is about twenty-six feet to the mile. The work has thus far cost between $10,000 and $15,000, and now commands about two hundred inches of water at period of lowest flow. As a further means of conserving this water-supply, there is now in construction an extension of the main work up the pass to the mouth of Swartout cañon, with the view of taking waters at the higher point to save loss in the stream bed. This upper work consists in part of a rock-cut canal, and in part of a thirty-inch cement pipe—all on heavy gradients, for a length of about two and a half miles. Near the lower end of the work as constructed are several small reservoir sites, in which, by means of earthen dams, it is proposed to store winter waters, but their capacity is not known. This work, built altogether as a private enterprise by one individual, and primarily for the purpose of serving his own lands, has come into use only during the past year. It now irrigates about two hundred acres of land, of which about seventy are in alfalfa, twenty to thirty deciduous fruit tree orchard, and the balance in summer crops and grain. Thus far the work, it is hoped by the projector, is but the commencement

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of an operation that will develop and save a volume of water, ranging at period of lowest flow, above one thousand miner's inches; and it is proposed not only to enlarge and improve the canal as described, but to extend it for the irrigation of the plain lying northeast of Lytle creek, and north of the town of San Bernardino.

SECTION III.

LYTLE CREEK WORKS AND PROJECTS.

The Rialto Canal.

District and Work:—This work is the successor to the main part of the Lytle Creek Water Company's old ditch. Taking water from the south side of Lytle creek, at a point about a mile within the extreme limit of its cañon, the Rialto canal conducts it southeasterly about six and a half miles, parallel to, and about a quarter to half a mile from the edge of the present Lytle creek wash; thence this water is distributed southerly over the plains, reaching about two miles to the town of Rialto, on the California Central railway; and also it is distributed easterly through the old Lytle Creek ditch, about two miles to the neighborhood known as the Old Mt. Vernon irrigation district, lying on the opposite side of Lytle creek, and about a mile and a half to two miles and a half northwest of the town of San Bernardino.

Dam and Headworks:—An ordinary cobblestone and bowlder dam across the channel of the creek diverts water to an old natural channel, which skirts along the southern side of the cañon for about a third of a mile, where, at a locality close against a bed-rock point of the south-side mountain face, is situated a little masonry headwork, built of bowlders gathered from the cañon, laid in cement. The intake is four feet wide, and two and a half feet deep, and is protected by a double system of iron bar gratings, but there is no provision for overflow and escape of surplus waters, should there be a supply presented in time of flood greater than the work will receive.

The Canal and Distributaries:—From here a flume four feet in width, and two and a half feet in depth, on a grade of four inches in sixteen feet, set into the ground, lies close along the base of the

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cliff about seven hundred feet, where is provided a wooden regulator with escape way, and which has been intended to serve as a sand-box. This structure is sixteen by eight feet in plan, and with a cast iron regulating gate, movable by a rod screw, engaging a heavy stationary nut in a frame-work overhead. From this point a paved and cemented ditch, two feet wide on the bottom, three feet deep, and five feet wide on top, leads away a total distance of about five miles. This ditch follows the general slope of the country, and is, for nearly its full length, set entirely in cutting. Its grades vary between three and a half inches and nine inches in sixteen feet. From this lower point on, about a mile and a quarter, the water is at present conducted in one of the old earthern ditches of the Lytle Creek Water Company, and it is the intention either to continue the paved ditch over this section of the work, or to lay a twenty-four-inch cement pipe in its place. At this last point commences the distribution system of the Semitropic Land and Water Company, supplying the region southerly to Rialto, and from the end of the present completed cement ditch extends another one of the old ditches of the Lytle Creek Water Company, which takes the supply across the creek into the Mt. Vernon district.

Construction of the Work:—For nearly the entire length of the paved ditch the work is located through a heavy, gravelly soil, filled with cobblestones and bowlders, evidently a deposit by the creek torrent. Thus, a large portion of the material for paving the ditch was taken out of the excavation in which to set it. No blasting was required, and frequently the excavated material was quite loose. The ditch having been dug approximately to the required size, the bottom was paved with bowlders set in by hand, and a thin lime mortar, composed of one part of lime to seven of sand, was poured into the interstices. The side walls were built up in layers, about ten inches at a time, between mold-boards and the sides of the excavation, and into the interstices in each such layer, lime mortar was poured, so as to thoroughly fill them.

The canal thus completely lined with masonry to a thickness of eight inches to a foot, was then plastered with a one-to-three cement plaster on the sides, about three quarters of an inch in thickness, and on the bottom sufficiently to even off the surface level with the top of the paving stones. The cement plaster of the sides was

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brought well up over the masonry on top, and the whole work was kept wet for a number of days after completion.

Grades and Velocities:—Commencing at an elevation of something over two thousand four hundred feet above the sea, in its five miles of length this little canal falls about eight hundred and sixty feet, so that water flows through it with immense velocity. Even when only about one thousand three hundred miner's inches in volume, the stream's velocity is at all points so great that its depth cannot be measured with any degree of accuracy. The impetus acquired by the flow seems to be so great that changes of grade from nine inches in the rod to three inches in the rod, for several hundred feet in length, apparently make little difference in the depth of the water section. Through a measured distance of 2.2 miles the current passes in twelve and one half minutes, and this is not the steepest part of the route. There are several abrupt angles made in the line, one with a deflection of about 45 degrees, without the introduction of any curve whatever, or any provision to prevent the piling up of waters over the side. Should the work ever be run to its intended full capacity the effect would be to destroy it at these angles by the waters going entirely out of the channel and washing away outside of the masonry. The velocity acquired by the water in this work has been a matter of surprise to its constructors, and it has been shown by the practical result that a canal of very much less size, and costing much less, would have served to conduct all the water that they have at hand or that they expected to get.

The Work as a Structure:—The notable features about this work are the excellence of the masonry, the apparent absence of all systematic engineering plan, the very great fall upon which it is expected to conduct a considerable body of water in an open channel. The face of the canal presents a true and even finish throughout, and for three miles at a stretch is as straight and unbroken in alignment and finish as possible, without a break in the masonry at any point. But there is no provision for taking irrigation waters out of it at any point upon its course, or for turning out the waters of freshets which may enter it, nor is there any sufficient provision for the control of floods at its head, or of the cross drainage from the side cañons which must pass over it; and no provision for the measurement of its waters, which might readily have been made

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in connection with the headwork, by the introduction of a weir in the masonry.

COST OF THE WORK:—The contract price on this work was $1 20 per linear foot, covering the work of excavation and lining and materials used. Extra grading done in adjusting the work to better gradients, and setting it deeper in the ground at points to avoid heavy breaks in grade, made the total cost come to about $1 60 per linear foot.

Operation and Maintenance:—The distribution system constructed by the Semi-tropic Land and Water Company in their Rialto district is upon the general plan of that described for Redlands, except that there is no provision for measuring the distributed streams or apportioning them by measurement over weirs.

DISTRIBUTION:—The water is conducted in cement pipes, ranging in size from ten to twenty inches in diameter, by far the greater portion being the smaller sizes. These are laid, on quarter-mile parallel lines, down the general slope of the plain, upon grades of about seventy-five to ninety feet in the mile. At each one eighth mile station, there is a length of twelve-inch cement pipe, set vertically into the leading main for an irrigation outlet. The top of this pipe comes about six inches above the general level of the ground, and into it is placed a sheet iron gate, worked in an iron bearing set in a cement shoulder, by means of an iron rod standard coming up through a guide on top. The flow of the water onward through the leading pipe can by these means be cut off, in whole or in part, and caused to raise up in the stand pipe and flow over its edges for distribution in irrigation. There is such a surface outlet placed at the highest corner of each twenty-acre piece, and the system appears to be a very serviceable and manageable one, in all, save the absence of provision for properly measuring the waters at points of division. About twelve miles of this pipe distributing system have been laid, making the service complete for about two thousand two hundred and twenty acres. This work has all been done within the past year, and as yet no rules and regulations have been adopted for the control of distribution.

In the sales of land by this company, the purchaser receives stock in the water company, which entitles him to a water-supply at the rate of one miner's inch to each ten acres of land, and for

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which he has to pay, in addition to the purchase price, his proportionate part of the expense of maintenance and administration of the works.

The waters of the Lytle Creek Water Company, other than those due to the interest held by the Semi-tropic Land and Water Company, are distributed from this canal through primitive earthen ditches, in the old-time wasteful fashion. A portion taken out near the opening of the cañon is led around by the old Perdue ditch, skirting the base of the mountain westward for several miles, and there used. That which is taken from the lower end of the paved canal is led across the sandy bed of Lytle creek wash in a ditch, which is destroyed by the freshets each year, and has to be reconstructed the next spring, and in which there is an immense loss during the period when water is most needed through the summer. The total length of this old work with its main branches was about fifteen miles.

Water-supply and Use:—For a number of years, as elsewhere explained, the Lytle Creek Water Company has controlled all the flow of this stream, which has ordinarily ranged between one thousand two hundred and one thousand four hundred miner's inches at the cañon during the months of greatest demand, but until the construction within the past year of the new work, which has now been described, by far the largest portion of these waters has been lost in the sands and gravels of the long, dry slope, down which they were carried in a primitive ditch, before reaching the nearest point of use.

IRRIGATION:—In the spring of 1879 there were ninety-one owners of water-rights in various Lytle Creek ditches, and it was claimed that between one thousand five hundred and one thousand six hundred acres were irrigated. But this acreage must have included the spring flooding of grain, for subsequent examinations have shown that there could have been no such area in summer irrigations at that time. In March of that year the Perdue ditch was carrying about seventy inches of water; and the main Lytle Creek ditch, down at the point where irrigation commenced, had a supply of six hundred and twenty inches flowing in it.

In 1881 these old ditch rights were held by seventy-five owners, whose summer irrigations in all covered five hundred and fifty acres; cultivated, twenty acres in summer crops, three hundred

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and twenty in alfalfa, one hundred and seventy in orchard, and forty in vines. And there was also some spring irrigation of grain, and the flooding of natural grass lands during the summer, the extent of which was not ascertained.

In 1885 there were forty-five owners of these water-rights, who had merged their interests into the Lytle Creek Water Company, and held about six hundred and fifty-five of its seven hundred and forty-four shares of stock. Of these thirty-eight were land owners, and seven simply held the water stock and rented the use of their water. There were thirty-three actual irrigators, who watered an aggregate area of seven hundred and fifty-eight acres, of which seventeen were cultivated in citrus orchard, three hundred and thirty and one half in deciduous orchard, one hundred and thirteen in summer crops, and the balance in various crops not segregated in the returns. There were three owners of water-rights who had not merged their interests into the corporation, and these irrigated about fifty acres additional.

In 1888 there are thirty-one owners of Lytle Creek Water Company's stock, besides those who acquired water-rights from the Semi-tropic Land and Water Company. These, holding three hundred and sixty-six of the seven hundred and forty-four shares in the company, irrigate an aggregate area of six hundred and two acres. There are twenty-one irrigators under the semi-tropic system who irrigate in all four hundred and seventy-five acres, making a total of one thousand and eighty-seven acres of irrigation. The cultivation is, approximately: citrus fruits, three hundred and five acres; deciduous fruits, three hundred and ninety acres; vines, two hundred acres; alfalfa, fifty-two acres; and summer crops, one hundred and forty acres.

History of Water-right:—The first utilization of Lytle creek neighborhood waters was the Rancheria ditch, taken out from the springs now known as Raynor's Springs. This was either effected under the regime of the old padres, or by the Lugos, the first Mexican possessors of the San Bernardino rancho. It has been stated on some authorities that the Rancheria ditch was constructed originally by the Indians, under the instruction of the padres, and afterwards utilized by Mexican settlers under the ownership of the Lugos. At any rate, this ditch had been abandoned at the time of the Mormon settlement; it being said that the Mexicans

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who had utilized its waters, had quarreled with the Lugos, and had moved down to the Agua Mansa settlement. The next utilization of the waters of the Lytle Creek neighborhood was made in 1852 for purposes of supplying the Mormon settlement in San Bernardino with water for domestic purposes. This was a small ditch taking water from Garner's Swamp, which swamp was made by the accumulation of water from Garner's Springs. These springs have been subsequently known as Meek's Springs and Raynor's Springs.[1] This was a small ditch which would carry at most about forty inches of water, and which came down to the stockade inclosing about ten acres of land, within which the Mormons at that time dwelt. The principal occupation of the Mormons at that time was that of stock-raising, and it was not until several years afterwards, say 1854 or 1855, that they seemed to have concluded generally to attempt cultivation of the ground.

Settlers and Mormon Ditches and Conflicts:—In the meantime, George Lord, a newly arrived emigrant to the country in 1853, stopped in the valley to recuperate his animals, at a place on the south side of Lytle creek, beyond what he was told was the limits of the ground purchased by the Mormons from the Lugos, and there established a temporary home and took out the waters of Lytle creek for irrigation to raise a crop or two. This was the first ditch constructed by Americans for irrigation from Lytle creek. In the same year and that succeeding, two other settlers, Garner and Day, continued and enlarged the Lord ditch; and in 1859–60, its head was moved several miles up stream, which amounted to the construction of another ditch. When the Mormons concluded that they wanted to irrigate, in 1854, they went a short distance above the Lord ditch, on the north side of the creek, and there diverted quite a large stream, bringing it down to the neighborhood of their settlement for the irrigation of fifty-two one-acre pieces, which had been staked off and allotted each to a different Mormon family for cultivation, under direction of the ruling spirits of the organization. Water being scarce, and Lord asserting a right to use a continuous flow of all which he had for two years utilized, a conflict arose between him and the

[1] This is not altogether clear, for Raynor Springs is west of Lytle creek and Garner swamp and San Bernardino are east of it. But the facts are of record in testimony, and are adhered to as above by several persons who have personal recollection of the case.

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Mormons. As this conflict was approaching a crisis, a wet year came along, and not only did away with the necessity for irrigation, but pretty effectually washed away the Mormon ditch. Thus, for one or two years more, the Mormon garden plats not requiring irrigation, the conflict was put off. Finally, in 1855 or 1856, the Mormons constructed a larger ditch, out from a point higher on the river than the previous diversion, and asserted a right to all of the waters of the creek. This led to a more serious conflict between them and the Lord water-right, and which was continuously on the carpet from that time on to the time the Mormons left the country; and continued as between their grantees, until within a very few years ago.

In the meantime, about 1854 or 1855, a diversion of water was made from the south side of Lytle creek, way up just at the mouth of the cañon, for purposes of cultivating corn. This venture failing, the ditch was abandoned, when in the next year it was taken up and continued somewhat farther by Perdue. Then, in a subsequent year or two, it was continued still farther by Hale, and this was the original of the Hale and Perdue ditch. In 1869 Jos. Dotson constructed a ditch out on the south side and low down on the creek, which was changed to another locality in 1876. Then, about 1871, Suverkrup and Houston, by permission of Lord, constructed a branch ditch out of his ditch, for purposes of domestic supply to their claim, agreeing that they would turn in at the head of the lower ditch as much water in addition to that turned in by Lord, as they took out. This was the origin of the Suverkrup claim; and the Suverkrup ditch was originally a branch of the Lord ditch. Again, in 1871, one Henderson constructed a ditch out from the creek on the south side, starting at a point below the Lord ditch, but running squarely off to the south and crossing it. This ditch, dating subsequent to the Hale and Perdue claim, and the Houston and Suverkrup claim, was regarded as a waste-water ditch; and, in fact, did not get any supply except in time of pretty full flow in the stream. The Anderson ditch was afterwards constructed running off from the Henderson ditch, south of the Lord ditch; and the Anderson water-claim bore the same relation to the Henderson water-claim that the Houston and Suverkrup claim bore to the Lord claim.

When, in 1857, the Mormons began to leave and sell out their rights and lands, their water-claims were bought out by some

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Gentile settlers. These people, a Mr. Muscott among the number, succeeding to the Mormon claim east of the river, began to use water in general farming. In the meantime, the cultivation of the Lytle creek tracts of community property by the Mormon families had gradually been abandoned, and about that time were totally given up. By this time a number of branch ditches had been constructed from the large Town ditch, which was the one built by the Mormons for purposes of irrigation; and these ditches became known as the Upper Town ditch, the Middle Town ditch, and the Lower Town ditch. Then, as other branches were made for purposes of carrying water to the settlers' farms, they became known by the name of their constructors, as, for instance, the Tompkins ditch, the Thorn ditch, and others.

Riparian Rights Against Appropriation:—In later years the appropriation of these waters has given rise to one of the most interesting and important water cases which has come before the courts of the state. At the time of the settlements along Lytle creek, west of the San Bernardino grant, it was supposed that the country there was unoccupied government land. The Muscupiabe grant was understood to be a one-league grant somewhere in the opening of Cajon pass, several miles from the nearest point on Lytle creek. But in 1872 a final survey of this grant, embracing over thirty thousand acres of land and covering Lytle creek from the cañon to the San Bernardino ranch line, including all of the old settlements and ditches there located, was approved, and title to the grant was soon thereafter confirmed.

Pope vs. Kinman:—In May, 1877, A. J. Pope, one of the owners of the grant, sued N. Kinman and others of the water appropriators, alleging that the waters of the creek were due to the Muscupiabe grant lands which were riparian to the stream, and that use of them on lands not bordering on it, was without authority of law. The defense of appropriation under the laws of the state and of Mexico was set up, and it was urged that the waters, having been used for over five years, the right to continue their use had been established under the "statute of limitations." In December, of 1878, the case was decided in the superior court of San Bernardino county in favor of the principal defendants, and substantially in accordance with their answer. It was appealed to the supreme court, which rendered a decision in December, 1879, in

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effect reversing the lower court, and declaring, *first*, the supremacy of the doctrine of riparian rights as against appropriation, and *second*, that the "statute of limitations" does not run in favor of an appropriator of water against a claimant of land whose title is held in abeyance by the United States authorities.

Lytle Creek Water Company:—Into the Lytle Creek Water Company nearly all of the appropriation interests on the stream were merged, except those of the Lord ditch. The company was incorporated in October, 1881, with a capital stock of $75,000, divided into seven hundred and fifty shares. Its purpose was to unify the interests of appropriators on the stream, to fight the grant owners. These latter had the law on their side, but the settlers had the water, and were holding and using it. An injunction was issued, in favor of the grant owners, restraining the settlers from using the water, but it was never enforced. The conflict was a long and a bitter one. In the meantime the grant owners, and others operating with them, quietly bought up the stock of the Lytle Creek Water Company, until enough to control it was secured, and sold out these rights to the projectors of the Semi-tropic Land and Water Company, with the riparian lands, which movement seems to have quieted the conflict.

Semi-tropic Land and Water Company:—The Semi-tropic Land and Water Company was incorporated in February, 1887, with a capital stock of $3,000,000, divided into thirty thousand shares. It has for its object the development, conservation, and delivery of the waters of Lytle creek, and their distributaries over certain lands owned by it, and the management and sale of the properties thus improved. The company acquired something more than twenty-eight thousand five hundred acres of land, embracing the channel of Lytle creek for ten miles, thereby becoming riparian proprietors on the stream. As a water-supply, they have nearly all of the old George Lord water-right, which consists of the first right to ninety-six inches of flow from Lytle creek, and three hundred and seventy-eight of the seven hundred and fifty shares in the Lytle Creek Water Company, which will probably give them about eight hundred inches in all of living water. Works of storage and of water development are in contemplation, by which it is expected to increase the supply as soon as it may be needed. With the land purchase made, a very considerable in-

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terest in the Lord right and in the Lytle Creek company was obtained. In addition to this, about $34,000 have been expended in the purchase of further water-rights and shares, and in the development of waters; and about $98,000 in the canal and distribution works, which includes about $12,000 for iron, cast and wrought, pipe for the town of Rialto, and not as yet laid. The new canal has been constructed at the expense of this company, but all of the Lytle Creek Water Company's waters, which organization the Semi-tropic company now controls, are taken through it. It is expected that some arrangement will be made with the Lytle Creek Water Company as a whole, whereby these waters will be brought permanently through the new work, for it is claimed that fully five hundred miner's inches of the supply are saved by the change.

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CHAPTER XIII.—SAN BERNARDINO[9]; WORKS AND PROJECTS[11].

CUCAMONGA PLAINS WORKS—GROUP[7].

SECTION I.—*Day's Cañon and Other Works:*
Etiwanda Colony Irrigations;
Hermosa Water Company's System;
Other Small Irrigations.

SECTION II.—*Cucamonga Cañon and Other Works:*
Old Cucamonga Cañon Ditches;
Cucamonga Development Company's Works;
Cucamonga Vineyard Company's Irrigations;
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SECTION III.—*San Antonio Cañon and Other Works:*
Ontario Water Company's Works;
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SECTION I.

DAY'S CAÑON AND OTHER WORKS.

Etiwanda Colony Irrigations.

District and Works:—The colony neighborhood of Etiwanda is situated upon the great Cucamonga plain, about twelve to fourteen miles west of San Bernardino, and, commencing on the north about a mile from the edge of the mountains, extends down the plain to the California Central railroad, a distance of about four miles. It comprises seven thousand six hundred acres of sloping plain land, which it was the design of its projectors to irrigate by means of water brought from Day's, Young's, and Middle cañons, found in the mountains immediately north, and one to three miles distant. The main work of supply consists of a "V" shaped flume, twenty-four inches wide on top, and eighteen inches on the

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sides, leading from a point on the east side of Day's cañon, about a mile within its opening, out upon the face of the hill; thence easterly, intercepting and receiving waters brought by another flume from the middle cañon, about a mile, where it receives another small tributary stream brought by an open ditch; thence south, receiving the waters brought from Young's cañon from the east by another tributary flume, a total distance of two and three quarters miles, to the point of distribution at the head of the colony lands. Here was constructed a little concrete-walled reservoir, about eighteen feet square and seven feet deep, into which the waters were to be received as a heading for the pipe distributing system. From some defect in the work, we now find a small wooden tank substituted; and thence lead the cement distributing pipes, the entrances being regulated by a sliding gate movable by a lever. The grades of the flume are enormous—reaching as high a rate as three hundred, or even more, feet per mile—and the velocities attained by the water are consequently very great, so that the capacity is large for so small a structure.

Operation and Maintenance:—The pipes vary in size from seven-inch up to ten inches. Thus far, in the body of the colony, there are seven parallel lines of piping, at distances generally five chains apart for serving every ten-acre tract; but, in some instances, ten chains apart. The waters are divided between the several pipes where they branch, by means of small concrete chambers built in the ground, into which the supply pipe leads on one side, and from which two or more pipes lead out on the other. By means of small iron gates, sliding in grooves in the cement work over the openings of the out-going pipes, the spaces are adjusted so that by some rule derived by practice, and familiar to the *zanjero*, he is enabled to divide the stream between the pipes below, in any proportion he may see fit. The basis of supply being one inch to eight acres, and the period of rotation having been fixed at thirty days, the quantity to be delivered to each ten-acre tract for one day out of each thirty, is thirty-six inches of flow, and consequently the irrigation heads should be each thirty-six inches in volume. The distribution is made in heads, and a leading pipe, carrying any number of heads, may be made to divide its waters between other pipes by means of the apparatus described, giving to each one or more heads. For irrigation out-

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lets, a rising pipe, twelve inches in diameter, with iron regulating gate, substantially in the form found and described at Rialto, is used. There are no irrigation tickets or turns fixed in this system, but all is left to the *zanjero*, upon the basis of one irrigation head for one day of each thirty to each ten-acre tract; and he, simply keeping a list of the irrigators, follows a stated rotation in delivery of the waters. Thus far there have been laid about sixteen miles of distribution pipe, ranging from six to ten inches in diameter, and there are sixty service outlets. It is not known very closely what the cost of this whole work was, but it is believed to have been, for whatever was done in the way of water development, and for the flumes and distribution system, about $40,000, up to 1886, since which time the Improvement company has expended $9,000 in further conserving the waters, it is claimed, and extending the distribution system.

Water-supply and Use:—As to the measure of water-supply which the cañons above these works will yield, there is room for much difference of opinion. Concentrated and prevented from sinking, at an expense of some thousands of dollars, as has been the endeavor lately to do, the yield of surface water would doubtless be much greater than at any time when examined by this department in past years. By the terms of organization of the enterprise, the water delivered at the head of the distribution system was to be measured on the fifteenth day of July of each year for ten years from 1882. Under this provision it was measured for the colonists: in 1884 (noon), two hundred and eleven inches; in 1885 (7 A. M.), one hundred and seventy inches; in 1887, one hundred and eighty-nine inches; in 1888, three hundred and fifty-six inches. Of this latter amount, twenty-eight inches are allowed as new waters developed. The balance is said to be attributable to the cañon stream flow only, which is larger this year than formerly. The average result of these July measurements for seven years has been about two hundred and twenty-three inches.

At the time of organizing the enterprise, the waters were measured (September 1, 1882) by engineers for the promoters, and it is reported that the flow was found to be for Day cañon 165.99 inches, and for Garcia cañon, 78.51 inches; or a total of 224.50 (?) inches. On July 16, 1888, the waters were again measured by

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two engineers for the Improvement company, and their report made the delivery at the head of the distribution system, as follows: Morning measurements: discharge calculated from slope of flume, and section of water prism therein, 421.31 inches; discharge gauged by loaded floats, 376.3 inches. Noon measurements: discharge calculated, etc., 419.82; discharge gauged, etc., 375.26. These engineers were of the opinion, that owing to the arrangement of the flume in which the measurements were made (there being an undertow due to heavy breaks in grade), the float method was not applicable, and so they reported the results obtained by the calculation. In August, 1885, it was measured for the state engineer, over a weir in the flume, at the lower end, where rectangular, and shown to be about fifty inches. In August, 1888, it was measured by the state engineer personally at the same point, and found to be about one hundred and fifty inches. The conditions are such that an accurate gauging can not readily be made, but it is not probable that this result is far wrong. In 1879, it was reported for the state engineer that the old Garcia ditch, to which the present work is successor, was in June carrying two hundred and five miner's inches, and that year irrigated about eighty acres of land.

IRRIGATION:—In 1885 there were forty-eight land holders in this colony, of whom thirty-five were resident irrigators. The total area of irrigation was six hundred and fifty-two acres, of which one hundred and seventy-nine were cultivated in citrus fruit orchard, one hundred and eighty-six and a half in deciduous fruit orchard, two hundred and seventy-four and a half in vines, seven in alfalfa, and five in summer crops. In 1888 there have been sold in all one thousand two hundred and eighty acres, of which six hundred are irrigated, and the cultivation is the same as in 1885.

History of Water-right and Enterprise:—The utilization of waters which now serve the colony neighborhood of Etiwanda dates back to 1867, when George Day, occupying a piece of land immediately at the opening of the middle cañon heretofore described, and close against the foot of the mountain, constructed a ditch out from the west cañon, which is now known as Day's cañon, and filed a claim for all of the waters of that stream. This filing was renewed on several occasions, and in July, 1869,

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Day filed a claim for the waters of both the west and the east cañon waters. Still again, in July, 1873, Day and one William B. Pierce made claim to all the waters of the George Day cañon, to the extent of four hundred inches, to be used on their lands, specifying them. The waters being "the same as those theretofore used by Day for seven years," and the work to lead them out being a ditch two feet wide and one and a half feet deep. In August of the same year Day filed a claim for all of the waters of the middle cañon; and in July, 1873, one Smith made claim to all the waters of the east cañon, then known as Young's cañon. These several claims and utilizations became consolidated and in part attached to what was afterwards known as the Garcia ranch, and used through what was reported upon in 1879 and 1880 by the state engineer, as the Garcia ditch.

The Etiwanda Enterprise:—In January, 1882, George Chaffey and W. B. Chaffey acquired the Garcia property, together with the ditch and water-right thereto belonging, and also the other interests in the rights and utilizations of the waters of Day's cañon, and Smith or Young's cañons, and the ownership of the lands at the mouths of those cañons. In May of that year, they organized the Etiwanda Water Company, with a capital of $500,000, divided into five thousand shares. With this company they entered into a contract to deliver the waters of the Day's, Young's, and Middle cañons, and to construct works for their distribution; reserving for ten years the exclusive right of increasing the supply of water, as next explained. In return for these works and waters, the Water company was to issue to the Chaffeys its stock, at the rate of eight shares for each miner's inch of water delivered at a certain point at the head of the colony lands. At the time of closing the contract, one thousand shares of stock were issued, and on the first of September, 1882, the waters were measured, and five hundred shares additional, or one thousand five hundred shares in all, were issued, it appearing that there was water sufficient delivered under the contract to irrigate one thousand six hundred acres of land, on the basis of one inch to eight acres, namely, two hundred inches.

By the terms of the contract the Chaffeys obligated themselves to flume the waters of the cañons to the reservoir at the head of the colony lands, to complete such reservoir, and to conduct the water in cement pipes to the highest corner of each ten-acre tract,

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and there provide a suitable outlet for irrigation on such tract. It was anticipated that a volume of flow much in excess of that at first apparent would be acquired by concentration and consequent saving of the waters in their flow down the cañons, and in leading them in better conduits, if need be, artificially. This being done, it was the intention to endeavor to get a still greater supply by means of tunnels driven into the *cienegas*, and into the gravels of the cañon bed. This right being reserved to the promoters and contractors for ten years, it was provided by the terms of the agreement that the water-supply be measured on the fifteenth of July, 1883, and on the fifteenth of July of each year thereafter for ten years, at a point where it flows into the reservoir, and upon the basis of these measurements additional shares of stock should be issued to the contractors. But in no case could stock be issued to any one except the Chaffey Bros. or their assigns during that period, and then only upon the basis of eight shares to each additional miner's inch of water delivered into the reservoir.

In June, 1882, the Chaffeys organized the California Land Improvement Company, with a capital stock of $500,000, divided into ten thousand shares. To this company they deeded the lands which it was proposed to put into the colony enterprise, and all of their water-right property, and water claims, not specifically transferred to the Etiwanda Water Company; and they transferred to this Improvement company their contract with the Etiwanda Water Company, already explained. In return for these properties, rights, and privileges, they took the stock of the Improvement company. Upon this basis, as the Improvement company, they constructed the flumes and distribution system of works, and sold the colony property in tracts, varying from ten to twenty acres as a general thing; transferring with each acre one share of stock of the company, which was a proportionate ownership in the water contract and works, on the basis of one inch to eight acres. The control of the Land Improvement company has now passed into other hands, and there has been sold one thousand two hundred and eighty acres of the land, and with it one thousand two hundred and eighty shares of the Water company's stock. The land owners now control the Water company. Until within the past few months there has been no demand made by the Improvement company for an official measurement

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of the water, and an issue of additional shares of the Water company's stock, based upon an increased delivery of waters.

Recent Operations:—Within the past year the Improvement company has expended about $9,000 in the concentration of the waters of the cañons, bringing them together in narrower and more confined channels, thereby causing them to run more promptly forward, and thus avoiding waste by percolation into the gravels, and evaporation. On the proper date, in July, 1888, a measurement was made by two engineers employed by the Improvement company, who reported that they found, early in the morning, a flow of 421.31 inches of water; and at noonday a flow of 419.82 inches. Upon this basis the Improvement company claimed that they had, in compliance with their agreement, developed and delivered a flow in excess of that for which they had already received an issue of stock, and demanded a further issuance in compliance with the terms of the agreement. The directors of the Water company refused to make this award, alleging that additional stock was to be issued only upon and for additional waters "developed," and that the simple clearing of the cañon, or the acquirement of an additional flow from the surface supply, did not constitute development. They claimed that development meant tunneling, or bringing water to the surface which theretofore had run beneath the surface. The Improvement company offered to compromise upon the basis that they be allowed stock for an additional one hundred inches, and beyond that the whole question should be submitted to arbitration. This offer was refused, and now the question has been, or is about to be, carried before the courts. [August, 1888.]

Hermosa Colony Enterprise.

District and Works:—Two and a half miles west of Etiwanda, and two miles northeast of Old Cucamonga, in a decided depression in the plain, lying between the swelling ridges which have formed in front of Day's cañon on the east and Cucamonga cañon on the west, and about two miles south from the very abrupt footing slope of Cucamonga peak, we find the irrigated colony-tract of Hermosa, embracing four hundred and eighty acres of land. The works which effect these irrigations belong to the Hermosa Water Company, and derive their supply from Deer and Alder cañons, which lie in the mountain slope immediately north.

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Deer cañon is an exceedingly steep gorge in the mountain's side, whose perennial waters come largely from a group of springs which burst forth about one and three quarters miles from the cañon's mouth, at an elevation of about three thousand three hundred and seventy-five feet above the sea. Here they are taken six hundred feet in an iron pipe, and then a little flume, which is three thousand nine hundred and sixty feet in length and upon the enormously steep gradient of nine hundred feet fall in that distance, carries them down to a box at the head of the pipe-line. Other waters from a side ravine are here brought in by another pipe. Thence the main conduit consisting of six, seven, and eight-inch cement pipe, is laid down the steep cañon to its mouth, and thence down the plain's rapid slope, a total distance of three and a half miles, with a further fall of nine hundred and twenty-five feet to a small reservoir at the head of the colony tract. Just below the cañon's opening a branch pipe-line bringing its supply from Alder cañon joins this main pipe. The total cost of the delivery and distribution works was about $13,000 to $13,500.

Operation and Maintenance:—Distribution from the reservoir is effected throughout the colony lands by four and eight-inch iron pipes, of which about two and a half miles have been laid. The maximum pressure on these pipes is that due to one hundred and sixty feet of head. The ordinary irrigating hydrant for iron pressure pipes, which is described elsewhere in this report, is used for outlet purposes; and all outlets are four inches in diameter. The *zanjero* is the only paid employé of the company. His duty consists of occasionally looking after and keeping clear the intake works up in the cañons, and distributing water to the irrigators. He is paid only for actual time devoted to his duties, of which he keeps a record. At the end of a year an account is rendered, and the amount is paid by the stockholders in proportion to the extent of interest in the company. This cost has usually been about $100 per year, or about 40 cents per acre irrigated. The irrigating day is twenty-three hours of the twenty-four—one hour's flow being reserved solely for domestic and general farm supply for the entire colony. Irrigation water is distributed in "heads" per irrigation day, and apportioned by time to the cultivators, within a thirty-day period, in proportion to ownership of the stock of the company.

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Water-supply and Use:—This water-supply was measured in 1881, a dry year, by an engineer of repute, for the projectors of the enterprise, at forty-eight inches of flow. During August of the very dry year of 1883, it was reported for the state engineer as delivered to the colony reservoir at twenty-three inches of flow. In September, 1885, it was reported for the state engineer at thirty inches in volume. At this latter time there were eight cultivators in the colony, who irrigated in all one hundred and seventy-five acres, of which seventy-two were planted in vines, sixty-five in citrus orchard, and thirty-eight in deciduous fruit tree orchard. The largest individual irrigation was of forty acres, and the smallest, five acres. In 1888 there are two hundred and sixty-eight acres served with water during summer, and about one hundred acres additional irrigated for grain in early spring. There are twelve irrigators who cultivate sixty-eight acres in vines, ninety-nine and a half acres in citrus orchard, forty-one acres in deciduous fruit tree orchard, fourteen and a half acres in timber trees, fifteen acres in alfalfa, and thirty acres in summer crops. The largest individual cultivation is of forty-five acres, and the smallest, two acres. The water-supply is principally from springs in the cañons, and no works have yet been prosecuted for acquiring a greater flow. It is in contemplation, however, to drive a tunnel through a long, bedrock point, around which the stream winds, and thus underdrain the gravel bed of the cañon. At this point the slope of the stream is very great, and it appears that a tunnel about four hundred feet in length will easily tap the cañon below its rockbed.

History of Water-right and Enterprise:—In 1879, as reported for the state engineer, there was a ditch known as Reed's ditch, which appropriated all the waters of Deer cañon, and carried them out upon the plains to the immediate neighborhood of the present Hermosa tract, and where they were used in the irrigation of about forty acres of land. Mr. Adolph Petch bought the Reed water interest, ditch, and lands, with some other lands, in 1880; mapped out the colony enterprise in 1881, and finished the construction of the works in time for use during the season of 1882. In 1881 the water-supply was measured, and reported at forty-eight inches available as a supply to the proposed works. The Hermosa Land and Water Company, with a capital stock of

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$20,000, divided into one hundred shares, was incorporated in January, 1882. To it the lands and water-rights were conveyed by Petch, he taking the stock of the company in payment. There being forty-eight inches of water, four hundred and eighty acres of land were put into the enterprise, the proposition being to sell land with a water-right, which would be equivalent to an inch to ten acres. As a matter of fact, the lands were sold upon the basis of the apportionment of the available supply to the four hundred and eighty acres, and to each purchaser was conveyed a proportionate ownership in that supply, whatever it might be. The water interest, however, was held independent of the land, there being no stipulation as to the location of its use. The promoters reserved the exclusive right to use all the water for power purposes between the mountain sources and the reservoir, provided they should not occasion waste or loss by such use. The progress of the colony has been sufficiently shown in preceding paragraphs, giving an account of the use of waters.

Hermosa Water Company:—The Hermosa Water Company was incorporated in October, 1887, with a capital stock of $192,000, divided into one hundred and ninety-two shares of par value $100 each. This was an incorporation of the undivided interests in the water and works sold to the individual land owners. These individuals conveyed, absolutely, their water-rights and interests in the works to the company, receiving in return four shares of stock of the company to each forty-eighth interest, or, in other words, each ten-acre tract owned by them. The object was to unify the water interests, and be enabled to work together for the development or acquirement of more water. All the stock of the company being issued to the holders of the original rights, no other shares can be put out, and should the water-supply, in the future, exceed the necessities of the colony irrigations, it is the intention to sell water to the owners of neighboring lands, but not to dispose of any of the company's stock, to other than the owners of land in the Hermosa tract. Nevertheless, the company's stock is not made an appurtenance to the lands of the colony, and there appears to be no reason why it should not be acquired by any one to whom the land owners may choose to sell it.

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Sansevain's Ditch.

This little work obtains its supply from a small cañon immediately in the rear of the owners' residences on a bench-land point at the base of the mountain, about half way between Lytle creek and Day's cañon. It is half a mile long, one foot wide, and six inches deep; capacity about one cubic foot, per second. In May 19, 1879, it was discharging about one quarter cubic foot per second. The claim is for all the water of the cañon. The ditch in concrete cost about 10 cents per foot. In 1879 about thirty acres of land were irrigated by this work. The ditch runs into a concrete reservoir, having a capacity of one hundred and thirty-seven thousand gallons, which cost about $740. In the summer months, the full supply will fill this reservoir in twenty-four to twenty-six hours; in May it fills in about twenty-two hours; and in January and February in about fifteen or sixteen hours. In August, 1888, the place, cultivation, and irrigation works appear to be abandoned.

SECTION II.

CUCAMONGA CAÑON AND CIENEGA—SUPPLY WORKS.

CANON-WATER IRRIGATIONS.

Iowa Colony Enterprise.

District and Works:—A mile west and north of the Hermosa colony is found the Iowa tract of five hundred acres, irrigated by some waters brought from Cucamonga cañon, whose outlet from the mountain is about two and a half miles distant in a northwest direction. The lands of the Iowa tract are a part of the old Cucamonga Homestead Association's property; and the works for supplying the Iowa colony are, in part, the property of the Cucamonga Development Company. As seen to-day, the delivery work consists of three thousand four hundred feet of thirty and twenty-two-inch cement pipe, bringing the water out to the mouth of the cañon; about two miles of cement pipe ten inches in diameter, leading it thence diagonally down the head of the steep sloping plain to a little reservoir at the upper end of the colony lands; from which about two miles of four and eight-inch riveted sheet iron pipe, conducts it south, immediately down the slope of the

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plain through the irrigated tract. To break the head of pressure of this distribution pipe, two other small reservoirs are introduced at intervals in the line.

Operation and Maintenance:—The method of distribution and principle of division of water among the irrigators in this colony is the same as that described for the Hermosa settlement.

Water-supply and Use:—In 1885 this settlement was receiving in the dry season a supply of about twenty inches of water with which about one hundred and ten acres, planted chiefly in deciduous fruit tree orchards, were irrigated during summer; and there was a further summer irrigation of field vegetables to the extent of about one hundred acres, but which did not receive water regularly. There were nine land holders and irrigators who had acquired two hundred and forty acres of the lands in tracts ranging from twenty to forty acres each. In 1888 the water-supply is greater, owing to the works of the Cucamonga Development Company increasing and saving the flow. The entire tract is cultivated, and three hundred and one acres are now irrigated. These are cultivated, in citrus orchard forty-five acres, deciduous orchard one hundred and eleven acres, vines twenty-three acres, olives twelve acres, alfalfa fifty acres, and summer crops sixty acres. There are twelve irrigators, among whom the largest irrigation is forty acres, and the smallest two acres in area. In 1879, the water which has since been devoted for the most part to the Iowa colony tract, was all used on several small tracts sold by the Cucamonga Homestead Association. The irrigation thus accomplished was then about fifty acres in area.

Several Small Irrigations.

There are several other smaller irrigations in this neighborhood, receiving waters from small intervening cañons and springs along the base of the mountain. The most notable of these is that from Clarke cañon, whose waters serve about fifty acres of land lying above and east of the Iowa colony.

Cucamonga Development Company's Enterprise.

WATER DEVELOPMENT TUNNEL; *Cost*:—The Cucamonga Development Company is driving a tunnel through bedrock at a location about a mile from the opening of Cucamonga cañon, with

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the view of underdraining the gravelly bed of the cañon and securing the percolations of the stream. The tunnel is now about six hundred and thirty-eight feet in length, on a grade of two inches in one hundred feet, with a cross section two and three by six feet in solid rock. The contract rates for this driving were, for the first three hundred and fifty feet, $5 50 per foot; next three hundred and fifty feet, $6 50 per foot; this to cover all, except in case of extraordinary hard and flinty rock being struck, or in case of heavy streams of water being encountered, in either of which cases the rate was to be increased to $11 50 per foot. Between four hundred and five hundred feet an exceptionally hard and flinty rock was encountered, and at five hundred and fifty feet a porous seam was gone through, which, it is said, yielded a flow of sixty inches of water. This Development company has also laid the three thousand six hundred feet of large cement pipe thence down to the cañon opening, in which, as has been said, the Iowa tract colonists own a third interest, and through which they are receiving a supply to the head of their pipe. [August, 1888.]

History of Water-right and Enterprise:—The northern boundary of the Cucamonga rancho extends along the mountain's edge almost immediately at the opening of the Cucamonga cañon. In very early times the owners of this rancho, by appropriation and use, acquired rights to the waters of this stream, which were maintained, and some conflicting interests secured, until about fifteen or more years ago, several of these owners organized the Cucamonga Homestead Association, which had for its object the subdivision, irrigation, and sale of several thousand acres of the Cucamonga rancho lying next to the mountain base and in great part adjacent to the opening of the cañon. This association constructed quite a large flume and ditch, a mile or more in length, out to the northern limit of the homestead lands, but never provided any means for the distribution of waters to the ten and twenty-acre tracts into which they were divided. The association claimed all the surface flow in the cañon during the months of summer. The waters under this claim were divided into three hundred parts, and one part was to be sold with each twenty-acre lot. The obligation of the association was simply to build a main work and not to distribute the water. In 1879 about twenty such lots had been sold and about fifty acres were irrigated.

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The Iowa Colony:—In 1883 a syndicate of several individuals was organized under the name of the Iowa Tract Association, who purchased five hundred acres of the Homestead association's lands with one third of the unsold water-right, and one third interest in the existing works. This arrangement was based upon a gauging of the waters of the stream, made in the driest month of the very dry year of 1883, which, it is said, showed a total available supply of about one hundred and sixty to one hundred and seventy inches. Of this supply it was considered that there were about one hundred and fifty inches unsold and yet remaining in the Homestead association. And in taking one third of the unsold waters, the Iowa tract syndicate considered that they were acquiring a right to fifty inches of flow in years of drought. A flume was constructed, originally, where now is the ten-inch cement pipe, and the reservoirs and iron pipe-line were then put in. The lands were all sold to colonists, with a proportionate interest in the water-rights and in the part ownership of the upper works, purchased from the Homestead association by the syndicate.

The Cucamonga Development Company:—In July, 1887, a filing was made by one of the Iowa tract colonists, laying claim to all of the underflow, to the extent of two thousand inches, in the Cucamonga cañon, and alleging that it was the intention to develop or bring this flow to the surface by means of a tunnel, which should underdrain the gravel bed of the cañon. These waters were to be used upon the lands of the Cucamonga Homestead Association. The Cucamonga Development Company, composed of some members of the Cucamonga Homestead Association, and of the Iowa tract owners, was formed in 1887 with a capital stock of $120,000, divided into one thousand two hundred shares. To this company was transferred the claim to develop waters by the tunnel enterprise; and it is now driving this tunnel, as elsewhere described. This development is being made upon the land of a private individual, who will receive one tenth interest in all the water developed, as a bonus for the privilege. Of the balance, the Iowa colony will get one third, and the rest will go to the other stockholders of the Development company. Of the entire water supply in the cañon, developed and to be developed, after supplying the older obligations of the original Cucamonga company, the Iowa colony has eighty-six three hundredths.

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CIENEGA-WATER UTILIZATIONS.

Cucamonga Vineyard Company's Irrigations.

District; Water-supply and Use:—Lying immediately east of the path of flood waters from the Cucamonga cañon as they course in a broad wash down the plain, and about three or four miles from the foot of the mountain, is a piece of mesa land several hundred acres in area, and fifty to sixty feet in elevation above the plain at its base; and cut into by several ravines and arroyos. This hill appears to be the last remaining part of a former broad deposit of gravel, made probably by the Cucamonga and other cañon streams in some former geological period, and which has been in other places subsequently swept away. It is underlaid with a bed or beds of gravel, doubtless connected with the underlying gravels immediately in front of the cañons' openings. From these gravels in the ravines and depressions of the mesa, spoken of, burst forth many small springs forming *cienegas*, out of which flow fine little streams of water. The chief uprising of waters of this kind is in a broad opening at the head of an arroyo which is about in the middle of the hill. This is called the east *cienega;* while the west *cienega* lies at the foot of the hill on the western side, and there are a number of other smaller outbursts around the margin of the hill and in other small ravines.

From very early times in the history of the occupation of this country by white people, the major part of these waters have been utilized in irrigation in the immediate neighborhood. The old Cucamonga vineyard, comprising the larger part of the land thus watered, has been a notable cultivation as far back as the oldest inhabitant now living can recollect. Some years ago, the owners of the Cucamonga rancho, or at least some of them, organized the Cucamonga Vineyard Association, and separated this vineyard property from the rest of the tract. It has been since cultivated and operated entirely as a vine growing venture, the irrigation being carried on as a private operation, with waters rising upon the lands of the irrigators, which comprise the east *cienega*. For a number of years, the works were merely the rudest little open ditches; but of late, under an arrangement with the Cucamonga Fruit Land Company, they have been remodelled and made of more permanent and water-saving character. Being so consolidated with those of the Fruit Land company, they will all be described as of that company in the next article.

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IRRIGATION:—In 1879, the Vineyard company's ditch was about a mile in length, and was reported as irrigating about two hundred and fifty acres of land. In March of that year, it was carrying 113.5 miner's inches of water; in May, 111.5 inches. In 1885, this irrigation was reported as extending over three hundred and forty acres of vineyard and eight acres of orchard; and in the present year there are three hundred and fifty acres of vineyard and eight of orchard irrigated by it.

Cucamonga Water Company's Works.

District; Works;—WATER DEVELOPMENT:—This company owns the Cucamonga west *cienega* and a half interest in the waters of the east *cienega* less certain rights of settlers elsewhere explained. Its works are designed to distribute waters obtained from these sources over a tract embracing seven thousand to eight thousand acres, lying immediately east and south thereof. At present there are three sources of supply utilized. The natural output of the west *cienega* and flow from artesian wells therein; the natural flow from the east *cienega* as taken out from the creek a quarter to a half a mile below it; and the output of a couple of tunnels driven into the gravels under the mesa lying east of the chief part of the east *cienega*.

WATER DEVELOPMENT; TUNNELS:—The two tunnels spoken of branch out from a common starting point, with an angle of about 60 degrees between them, and are five hundred and five hundred and eighty-six feet in length, respectively. They are four feet wide at the top, six feet at the bottom, and six feet high outside of the timbering, which is eight inches square; and the contract price for the labor of driving was $2 50 per linear foot. They were commenced in September, 1886, and finished about the middle of 1887. There are two other tunnels, which are referred to as the east and the west tunnel, respectively.

The east tunnel was commenced in October, 1887, and is still in construction, with four hundred and sixty feet of length. It is of the same dimensions, and the rate for labor per foot is $2 75. It is driven into the edge of the mesa from the east side, about three fourths of a mile east of the middle tunnel. The west tunnel starts from a point at the southwest point of the hill, a mile west of south of the middle tunnel, and is being driven along and under the western edge of the mesa to underdrain the west *cienega*.

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It will have to be somewhat over four thousand feet in length to accomplish this. It was commenced in November, 1887, and is now in about one thousand two hundred and fifty feet. Its dimensions are the same as those of the middle tunnels, and the contract price, for labor alone, for the first six hundred feet, was $3, and the second six hundred feet, $4.

DELIVERY AND DISTRIBUTION WORKS:—The works for storing and distributing the waters consist of seven small rock-lined reservoirs and the pipe system described below. Three of these receive water from the west *cienega*, being situated one at the head of the line and the others at intervals of about a mile apart southerly along the pipe-line. Three receive waters from the east *cienega* natural streams, and are located at intervals of somewhat over a mile east and south of the head of their pipe system. And the seventh is located three fourths of a mile east of the middle tunnels, whence it receives its supply. The waters of the east tunnel are utilized upon a small tract above the last reservoir. The piping consists in all, of cement pipe, thirty-inch one fourth mile, twenty-two-inch five eighths mile, twenty-inch one half mile, sixteen-inch three and one half miles, twelve-inch three fourths mile; sheet iron-riveted pipe, five to twelve inches in diameter, twenty-two to twenty-three miles, beside that in the town sites of North and South Cucamonga. The vineyard association's branch is an open ditch paved and cemented a mile and a half in length; and the original settlements have an additional sub-system which would add about two and a half miles to the total length of conduits.

COST:—There have been expended thus far (August, 1888) on the works of the Cucamonga Water Company's system the following:

On tunnels and other water development works	$17,921 24
On the piping and conduit works	60,822 20
On the reservoirs and *cienegas*	8,352 92
Total	$87,096 36

Operation and Maintenance:—The works are arranged on a dual system—part of the pipes being under pressure and having hydrants for outlets (and this is the case with all the iron pipe work), and part not under pressure, and having the ordinary rising pipe and sliding gate turn-out, as general in cement pipe distributing systems described elsewhere. Water is distributed to

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the irrigators when called for on orders by heads of twenty inches each for twenty-four hours; but there are no means of measuring such heads, and the regulation of their volume is left to the judgment of the *zanjero*. A rate of fifty cents per head is charged to cover the salary of the *zanjero* and cost of maintenance of the works. It does not appear that this is an apportionment of maintenance and operating expenses amongst the irrigators, who are all stockholders of the company, but that it is the water-rate adopted for the present, the proceeds from which are to be applied to the payment of those costs.

Water-supply and Use:—In 1885 there were about one hundred and fifty inches of water being utilized from the east *cienega;* half of the water being due the Vineyard company, and half claimed by the settlers. The flow was measured in September, 1882, by an engineer in the interest of the settlers, who reported the volume at one hundred and thirty-five inches from the east *cienega*. The settlers thereupon held a meeting, and determined that half of this was not more than sufficient for the five hundred and twenty acres bought by them with "water enough," and so they took possession of it. In 1885 the flow was gauged, for the state engineer, at about two hundred inches available from the east *cienega*, of which fifty inches were not utilized but wasted down the stream, and one hundred inches in the west *cienega*, of which very little was used. In the middle of August of the present year (1888) the flow from these sources was: Natural stream from the east *cienega* about one hundred and fifty inches, output of the middle tunnels about two hundred inches, output of the east tunnel eleven inches, output of the west tunnel twenty-five inches. It is to be remarked that neither the east nor the west tunnels had reached the ground wherein it was expected to obtain a good flow of water.

IRRIGATION:—In 1879 this irrigation was reported to be one hundred and fifty acres in extent, and the flow of the ditches about one hundred inches. In 1885 there were in the settlement outside of the Cucamonga Vineyard association eighteen cultivators, who irrigated a total of five hundred and twelve acres, of which about three hundred and fifty were in vines, one hundred and twenty in deciduous fruit tree orchard, twenty in alfalfa, and the balance in citrus fruit orchard and other cultivations. Ac-

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cording to an apportionment by the county water commissioners, made that year, there were five hundred and twenty acres regularly receiving water, and one hundred and sixty-five acres occasionally receiving it; the latter, doubtless, cultivated in grain which received irrigation only in the spring. In 1888 there are thirty-five irrigators, and the total area of irrigation is one thousand nine hundred and forty acres, besides that of the Cucamonga Vineyard association.

History and Water-right:—Some time about fifteen years ago, all of the Cucamonga rancho, which had not been put, as spoken of in the preceding article, into the Cucamonga Homestead Association tract, and which had not been merged into the Cucamonga Vineyard company's operations, and excepting also the *cienega* lands which yielded water to the Cucamonga vineyard, as already described, was sold to an organization composed mostly of San Francisco capitalists, and known as the Cucamonga Land company. This sale comprised the western part of the rancho, including the water-rights and ditches from San Antonio creek, and that part of the rancho lying south of the San Bernardino base line not occupied by the Vineyard association tract. In this sale was also included an undivided half interest in all the waters already flowing from, and that might thereafter be developed and caused to flow from the *cienegas* and *cienega* lands. This constituted a division of all the east *cienega* waters between the Cucamonga Vineyard association and this Cucamonga Land company. The west *cienega* had been previously sold, or merged into the Cucamonga Homestead Association tract. This company then sold lands lying east of the vineyard, to settlers, in tracts of ten to eighty acres, and to a total amount of five hundred and twenty acres; conveying with each piece of land an altogether indefinite and almost indefinable interest in the company's share of the waters. Some deeds recited that the purchaser was to have "water enough," others, that he was to have water "sufficient for semi-tropic culture," and there were other expressions equally vague and practically meaningless.

Cucamonga Fruit Land Company:—In 1887, all unsold lands of the Cucamonga Land Company, together with its remaining interest in the waters of the east *cienega*, were purchased by the Cucamonga Fruit Land company, which company was incorporated in

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April, 1886, with a capital stock of $200,000, divided into two thousand shares. This purchase comprised the southeastern portion of the Cucamonga rancho, the west part having been previously sold by the Cucamonga Land company to the promoters of the Ontario Colony enterprise. The Cucamonga Fruit Land company afterwards purchased the Cucamonga west *cienega* tract from the Cucamonga Homestead association, or its assigns, and so it became possessed of the exclusive right to the waters of the Cucamonga west *cienega*, and a half interest in the waters of the Cucamonga east *cienega*, less those undefined interests which had been sold to the settlers. These, after much negotiation, were finally determined to represent in the aggregate 33.84 inches of water; and upon this basis the cultivators in the Cucamonga settlement each received a defined water-right, in proportion to his land ownership, from the new company.

Cucamonga Water Company:—The individual members of the Cucamonga Fruit Land company then, in 1887, organized the Cucamonga Water company, to which it deeded all of its water properties, works, and rights; under an agreement that the Water company was to recognize the previous obligations of the Fruit Land company in the matter of water-rights due to the Cucamonga settlers, and to others to whom the Fruit Land company had, in the meantime, sold lands. Under this agreement the Fruit Land company transferred all the waters then flowing from the two *cienegas*, except the half interest owned by the Vineyard company in the east *cienega*, amounting to 456.89 miner's inches, and the Water company issued its stock to the amount of 4,568.9 shares—ten shares for each inch of water—in satisfaction of the obligations of the Fruit Land company. With the older settlers, this adjustment was not made on a uniform basis; some insisted on receiving an inch to eight acres, others an inch to six acres, others were content with an inch to ten acres. To those who had bought of the Fruit Land company, a share, or tenth of an inch, was issued upon each acre.

The Fruit Land company reserved from the sale to the Water company, all their right to develop waters upon the east *cienega* tract, and all their interest in the west *cienega* tract, obligating themselves, however, to transfer these rights and properties within twenty years.

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Irrigators' Water-rights:—Upon the development and delivery of more water by the Fruit Land company to the Water company, the latter is obliged to issue its stock to the former at the rate of ten shares to each additional inch so delivered, and these shares the Land company proposes selling with its remaining lands, at the rate of one share to each acre, or one miner's inch to ten acres. This anticipated additional issue is to be limited to 5,431.1 shares, which, with the 4,568.9 already issued, establishes a limit of production at one thousand inches, plus the one half interest of the Vineyard association in the flow from the east *cienega*.

The available waters are to be measured every year between the tenth and twentieth of July, by arbitrators selected by the Water company and by the Fruit Land company, and on the basis of their report the additional stock is to be issued. If at any time prior to the conveyance of all rights to the Water company, any such measurement shows a less supply of water than is required to fulfill obligations under the terms of stock certificates already out, the Fruit Land company shall immediately proceed to acquire by works for development or otherwise, enough to make up the full amount theretofore reported; or should they fail to proceed with work within ten days, the Water company may itself go on with them, and, in the meantime, any stock, standing in the name of the Fruit Land company, is not to be entitled to its share of water. The "inch" described in this agreement is defined as being the amount of water which will pass through an inch square opening in an inch thick board, with four inches of pressure over the center of the opening, and the measuring out of a stream of a number of inches must be done with such a head of pressure as to discharge that quantity of water equivalent to the proper multiple of the inch as separately measured. The Cucamonga Water company is charged with the maintenance of the works, and may, under the agreements, collect any reasonable water-rate to meet such expenses.

Several Small Irrigations.

Between Deer and Cucamonga cañons, and close up against the foot of the mountain, are found six small irrigations supplied with water from the natural flow in the little cañons at whose mouths they are located, or from tunnels driven into the sides or beds of the cañons. The total volume of water thus utilized is about thirty to forty inches; the largest stream being about thir-

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teen inches in volume, and the smallest two inches. The total area of irrigation is sixty to seventy acres; and the cultivation is for the most part in oranges, vines, and deciduous fruit tree orchard, in the order named.

SECTION III.

THE ONTARIO COLONY ENTERPRISE.

San Antonio Water Company's Works.

District and Works:—Lying immediately west of Cucamonga cañon wash, and extending from the mesa at the foot of the mountain on the north, down to about the line of the Southern Pacific railroad on the south, a distance of six miles, and occupying a width varying from one to three miles east and west, lies the colony neighborhood of Ontario. The plain on which these irrigations are found rises from nine hundred and sixty feet of elevation at the southern border to one thousand eight hundred and fifty feet at the northern line, at rates varying from sixty to one hundred and seventy feet per mile. This tract receives its irrigations from the San Antonio cañon, which comes from the mountains about a mile and a half west of the central axis of the colony property; and the waters are conducted and distributed by works which are the property of the San Antonio Water company.

DELIVERY WORKS:—Commencing at a point on the east bank of the creek, nearly a mile up the cañon from its extreme opening, and at about two thousand three hundred and fifty feet of elevation, a rock-lined cement ditch leads out from the creek to the eastern hillside, and extending around the base of the steep slopes a distance of a little more than half a mile, it delivers waters into a masonry chamber, whence they are taken by a cement pipe.

Canal; Cost:—The canal is five feet wide on the bottom (except at points where grade is excessively steep, and where it has been narrowed to about three feet), is six feet wide on top and two and a half feet deep, and has a ruling gradient of 0.5 in one hundred, with several drops of about half a foot each. It is paved

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and walled up to a minimum thickness of eight inches, with rocks laid in hydraulic lime mortar, and this lining is plastered over to the plane of the outermost rock faces, with a cement mortar. This work was built in 1882–3, and cost about 60 cents per linear foot, including everything—the labor employed being Chinese, at the rate of $1 25 per day. Rock was handy to the work; lime cost $1 per barrel, and White's cement $4 25. The mortar used was one part of lime to five of sand. This lime has notable hydraulic qualities, and there is an old rock dam laid up with it, near the head of the present work, the masonry of which is to-day, where not undermined and swept away, in an excellent state of preservation and solidity. The cement plaster of the canal was mixed one to three of sand and with lime water, and the facing was finished on the bottom with a thin coat of cement and sand in equal parts.

Pipe-line; Cost:—From the masonry chamber at the end of this canal a twenty-two and sixteen-inch pipe-line lies around the steep mountain's side, falling one hundred and ninety feet in a distance of five eighths of a mile; thence the waters now are carried in an earthen ditch a short distance farther on the mountain side, and then turning to the left, through a short tunnel, the work passes out on the upper edge of the mesa or bench lying immediately at the foot of the southern slope of the mountains, and easterly to the upper edge of the colony tract a distance of about three thousand feet. The company is now replacing this earthen ditch, for the distance of three thousand feet, with a conduit of concrete, oval in form, four feet high, and three feet wide interior diameter, and made in halves dovetailed together. The contract price, laid, but exclusive of the excavating, is $1 75 per linear foot. From the end of the present ditch the waters are taken in an iron pipe, twenty-two inches in diameter, a distance of about two thousand feet; and then in a cement pipe, of the same diameter, across the head of the colony, a distance of nearly a mile. At the head of the canal are the ruins of a cement and rock masonry structure, built in 1883 by the San Antonio Water Company in conjunction with the Pomona Land and Water Company, for the division of the waters of the creek between these two companies, and which was, in great part, destroyed by the flood of 1883–84, but which is now made to serve its purpose in a rude way.

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WATER DEVELOPMENT TUNNEL; *Cost*:—In addition to this water-supply, the San Antonio Water Company has that derived from a tunnel driven into the gravel and bowlders of the cañon bed, a distance of about two thousand eight hundred and fifty feet, which commences at a point about three fourths of a mile below the point of surface diversion from the stream, and at an elevation of about two thousand two hundred feet. About three feet four inches clear width on the bottom, two feet at the top, and six feet high, this tunnel was intended to be in a straight line for about two thousand feet; and thence, having a slight angle to the right, to continue on in a straight line along what was supposed to be the central axis of the cañon bed, until it struck bedrock. The alignment has not been preserved, there being several bad turns in it, made, apparently, to meet the working and air shafts which had been sunk. Its grade was intended to be one inch to the rod, but in fact the grades range from less than that up to two and two and one half inches per rod. This tunnel was commenced in January of 1883. In December of 1885 it had been driven about two thousand five hundred feet, and timbered with eight by eight redwood, in bents at four-foot spaces, and with two-inch lagging, top and sides. At this time work was stopped, and was resumed in June, 1886. Early in the spring of 1888, when it had been carried to its present length, a serious cave occurred, since which time the work has been prosecuted with great difficulty in trying to pass through or get around the loose mass of matter, but up to the middle of August without much success.

Driving this tunnel cost at first, from $4 50 to $5 per linear foot, over all. The labor (Chinese) was paid $1 75 to $2 50 per day. This was reported for the first two thousand five hundred feet. Beyond that point, the contract price for labor alone is reported to have been between $7 and $8 per foot. The present contract price for the labor, in the endeavor to pass through or around the difficult ground, is $20 per foot; and beyond that, in ordinary ground, should the work reach it again, $8 per foot. During the past year this tunnel has been lined inside the lagging and between the timber bents, as follows: The floor was first paved with concrete slabs, four inches in thickness, and set in cement, out to the side lagging; upon this was laid, on each side between the timbers, a concrete base, eight inches thick, and six

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to eight inches high; on these foundations, walls were built up between the timbers, with bowlder rocks laid in cement to the height of about four feet; on these walls rests a concrete arch, composed of molded half-arch pieces, eight inches thick, and dovetailed together in all joints. This cement-concrete and rock lining cost about $2 50 per foot; and the three hundred and fifty feet, from two thousand five hundred to two thousand eight hundred and fifty-foot station, inclusive of the labor, timbering, and cement and rock lining, cost about $14 50 per foot. Under the present contract, the grade is to be limited to a maximum of three fourths inch per rod, and a minimum of half an inch per rod. The total cost of this water development work, from its beginning in 1883 to August, 1888, is reported to have been about $50,000.

From the mouth of this tunnel the waters are led in a rock and cement-lined ditch, about three and a half feet wide and one and a half to two feet deep, a distance of somewhat less than one thousand feet, to a junction with the main conduit from the creek, at a point just below the end of the sixteen-inch pipe heretofore described.

DISTRIBUTION WORKS:—The waters of the San Antonio Water Company are distributed through the Ontario colony by means of cement pipes, ranging from eight to twelve inches in diameter, for the most part following down in parallel lines, an eighth of a mile apart. Of these there have been laid in all about one and a half miles of seven-inch, thirty-three miles of eight-inch, twelve and one half miles of ten-inch, and several miles of twelve and fourteen-inch. This system reaches the full length of the tract, a distance of six miles. The turn-outs consist of single lengths of twelve-inch rising pipe, set on end into the leading pipe, which is about two feet underground. The leading pipes of course do not run under pressure, but act simply as open channels, though buried in the ground. A small wrought iron gate, sliding in concrete grooves against a concrete filling of one half the area of the rising pipe, serves to wholly or partially cut off the onward flow, and to cause the water to rise and pour over the top of the turn-out pipe for irrigation.

The domestic supply system in the town of Ontario consists of about ten miles of two, three, and four-inch wrought iron riveted pipe, and one and a half miles of six-inch cast iron main, the cost of which is included in the second accounting given below.

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COST:—About the middle of the year 1885, the reported cost of these works to date was: Tunnel and canal, $37,714; cement distribution pipe (twenty-six and one half miles), $43,000; dam of diversion in cañon, $2,500; total, $83,214. The total cost of the works, from the beginning to August, 1888, is now reported by the managers of the company to have been about $210,000, of which about $50,000 has been for water development (tunnel), $10,000 for canals and mains, and $150,000 for distribution pipes and outlets. The company is now expending a large sum for the new main conduit, and for advancing the tunnel.

Operation and Maintenance:—The work of distribution is in charge of a *zanjero*, who delivers water to each irrigator in heads of thirty inches for twenty-four hours each thirty days, for each ten acres owned, which is equivalent to a continuous flow of one inch to ten acres. The secretary of the company and the *zanjero* are the only regularly paid employés, but laborers are at times employed to work under the *zanjero's* direction in caring for and repairing the works. During the four years of operation the assessments, per acre, for current expenses have been, for 1885, 50 cents, for 1886, 70 cents, and for 1888, 70 cents. These rates have thus far covered all expense of operation and maintenance, and represent the annual cost of water to the irrigator.

Water-supply and Use:—By the terms of the agreement between the Water company and the Land company, the water-supply available for this work is to be measured on the fifteenth of July of each year for fifteen years from 1882. These measurements have been made, as provided for, except in 1884, which was a full-water year, and the supply was known to be abnormal, and in 1887, when the works were not in good shape, for some reason, and the Water company did not ask for a measurement. The results have been[1]:

[1] The manager of the company reports, at a late date, that these figures relate to half of the flow of the creek—Ontario's share—as measured in the San Antonio company's canal; except that in 1885, as reported by the engineer, about six hundred inches were escaping down the creek, half of which was due to the Ontario side, which, with that in the canal and fifty-three inches in the tunnel, made seven hundred and fifty-three inches for the supply that year. Also, that the cause of the flow being so small in 1885, was the fact that several months previously a cloud-burst had sent a heavy freshet down the creek, tearing up its bottom, and so destroying the cemented filling of gravel, which forms between its bowlders, as to cause excessive loss in the gravels and bowlders above the point of diversion; and that this was corrected soon afterwards by dumping clay into the stream at a higher point.

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July 15, 1882, flow in canal . . . . 450 miner's inches.
July 15, 1883, flow in canal . . . . 365 miner's inches.
July 15, 1885, flow in canal . . . . 205 miner's inches.
July 15, 1886 flow in canal . . . . 400 miner's inches—Tunnel, 53; total, 453.
July 15, 1888, flow in canal . . . . 500 miner's inches—Tunnel, 116; total, 616.

An unofficial measurement of the entire flow of the stream, September 3, 1883, showed a flow of three hundred and five and a half inches, of which half was available to the San Antonio Water company. Another unofficial measurement made on August 20, 1885, showed a discharge of three hundred and twenty-two miner's inches, or one hundred and sixty-one inches for the Ontario supply. About August 20, 1888, there was flowing in the canal from the creek, three hundred and eighty-nine inches, and from the mouth of the tunnel, forty-five to forty-seven inches, or a total of four hundred and thirty-six inches, miner's measurement, which is slightly different from and larger than the inch of the Ontario tract.

IRRIGATION:—In 1885 there were ninety-five holders of Water company stock, as follows: Tracts sold, sixty-seven; resident cultivators, thirty-six; largest holding, seventy-two and one half: smallest holding, two and one half; total sold, one thousand two hundred and fourteen acres. In 1888 there are irrigated a total of one thousand seven hundred and fifty acres, of which eight hundred and eighty-six are cultivated in citrus fruit orchard, five hundred and eleven in deciduous fruit orchard, three hundred and twenty-nine in vines, ten in olives, and eleven in pampas grass and berries.

History of Water-right and Enterprise:—The original appropriation of the waters of San Antonio creek is believed to have been made by the construction of the old San José ditch, taking water from the west side of the stream, and which will be spoken of in connection with the Pomona irrigation works. The first utilization of waters on the east side of the river was made by the construction of the Cucamonga Rancho ditch by the original owner of that grant, in quite early times also. It took water from the stream at about the point now tapped in supplying the Pomona and Ontario works. In 1879 it was owned by the Cucamonga Land Company; was diverting water at the same point where the Kincaid ditch headed, was two miles in length, two to three feet wide on the bottom, four feet on the top, and two feet deep, and irrigated about thirty acres of vineyard in the extreme

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northwestern corner of the Cucamonga ranch, on the first bench in the opening of the cañon mouth. In May of that year it was carrying seventy-five miner's inches of water per second, and had the appearance of having been much neglected.

In September, 1872, M. M. Kincaid filed a claim for one third part of all the water running in the San Antonio cañon, and constructed a ditch in accordance with his claim. In 1879 his ditch was about a mile in length, two feet wide on the bottom, and three feet on top, and one foot deep, irrigated about forty acres of vineyard and orchard in the mouth of the cañon; and in the latter part of May of that year was carrying two hundred and ten miner's inches of water per second. In December, 1872, John B. Dalvez recorded a claim to "all the waters of the creek formerly owned by R. H. Meyers," to be taken out at the mouth of the cañon on the east side of the stream to the extent of four hundred inches. In July, 1874, Charles Lindley and J. S. Thomson made claim to all the waters of the cañon to the extent of four hundred inches, to be diverted and carried in twenty-two-inch pipes, or three-foot flumes and ditches to a reservoir on the Cucamonga rancho, and thence distributed in irrigation. In 1879 there was in existence a ditch above the Kincaid and old Cucamonga company's ditches which was utilizing about twenty to thirty inches of water on about twenty acres of land. This ditch has since by decree of court been allowed a preferred claim to twenty inches of flow by reason of prior appropriation. This claim is known as the Dexter ditch and water-right. In 1879 there were two other ditches in existence on the east side of the San Antonio creek, known as the Hancock Upper and Lower ditches. The upper ditch took water from a point near the cañon mouth, and carried it down to the neighborhood of the present town of Ontario, a distance of six miles. It was two and a half feet wide on the bottom and one and a half feet deep. The lower ditch took water at a point about three miles below, and carried it a distance of about three and a half miles to the same neighborhood. The claim to supply for these ditches was limited to the "waste-water" of the creek, and they usually irrigated one hundred and sixty to two hundred acres of land, cultivated principally in grain.

The Ontario Colony Enterprise:—In November, 1882, the Messrs. Chaffey, who had been the promoters of the Etiwanda project, consummated the purchase of a large tract of land, comprising a

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portion of the Cucamonga rancho, together with all water-rights and ditches situated thereon, and relating to or deriving their supply from San Antonio creek. They also purchased the Kincaid property in the mouth of the cañon, with the ditch and water-right used on it, and they acquired all conflicting claims to water on the east side of the creek. After long and tedious negotiations, they came to an agreement with the Pomona Land and Water Company, which had acquired all claims to water on the west side of the creek, whereby it was settled that they were each entitled to one half the surface flow of the stream, and would jointly construct a work for its division at or near the head of the old Kincaid and Cucamonga ditches. In October, 1882, they organized the San Antonio Water Company, with a capital stock of $1,500,000, divided into fifteen thousand shares, and with the provision that each share of such stock should represent one tenth of an inch of the water-supply at the command of the company. In November of the same year the Chaffeys and the San Antonio Water Company entered into an agreement, which was really in the nature of a contract on the part of the first parties to deliver certain properties and water-rights, and construct certain works, in consideration of their being paid the stock of the Water company. This instrument is so instructive, in the light of subsequent experience, that the substance of it is here presented quite fully.

It recites that whereas the contractors were the owners of certain water, water-rights, water-privileges, and appurtenances, flowing from the Cucamonga mountains by the San Antonio cañon and creek, to the extent of one half of all the water thereof. And whereas the Water company was desirous of obtaining title to the same, it had determined to enter upon the contract. The contractors agreed, at their own cost and expense, to construct a reservoir on the northern part of the colony of Ontario, upon a site which should be mutually agreed upon, and which reservoir should be substantially constructed, and "of a capacity to hold sufficient supply for distribution over the lands sold and to be sold by the contractors, in said colony;" and that they would "flume, pipe, or by other means, convey the one half of the water from the cañon or creek, and all the waters to be developed therein, into said reservoir as rapidly as the land sold by them should be ready for irrigation, and to the highest corner of each ten-acre

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lot owned by the stockholders of the company, placing on each line of pipe turnouts so constructed as to measure accurately the water to be delivered to each tract, and also to and over the town tract of Ontario." And they agreed to convey on July 15, 1883, by deed of grant to the Water company, "all the waters to the extent of one half thereof, and all the waters to be developed, flowing in and through San Antonio cañon and creek; and the rights and privileges appurtenant thereto." And also the works constructed by them for the conducting and distributing of waters in the colony. But they reserved the right of using the water for power purposes above the proposed reservoir, provided there was no loss occasioned by such use.

The directors of the Water company agreed to issue the stock of the company to the contractors on or before the fifteenth day of July, 1883, on demand and upon the following basis: "All water flowing from San Antonio cañon or creek shall, on the fifteenth day of July, 1883, be measured at the place of discharge into said reservoir. An inch of water for all purposes mentioned herein is defined to be in a stream which will flow through an aperture one inch square in a one-inch plank, under a four-inch pressure from the center of such aperture. And one share of stock shall be issued for each one tenth of an inch of water so measured." One hundred and sixty shares of the stock were to be delivered to a trustee in trust for use in the town of Ontario; and then followed two clauses concerning future water development and transfers, which are here transcribed verbatim:

"*Third*—From and after July 15, 1883, the parties of the first part may improve or further develop water in said cañon, or any other cañon in the vicinity or on any other land owned by them, or obtain water by purchase, or otherwise, from any party, provided that the water so developed, purchased, or owned, can be put in the said reservoir by pipes or flumes, as herein before described; and at the end of each year for fifteen years, on each succeeding fifteenth day of July, the additional water so delivered in the said reservoir, over and above that measured in the preceding year, shall be measured in the same manner as set forth in article second herein, and additional shares of stock shall be issued therefor on the same basis as above set forth, provided that the said parties of the first part shall at the same time convey by deed of grant to the said party of the second part, all water so devel-

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oped, purchased, or owned, and the pipes and flumes appurtenant thereto, and the right of way thereof. It being understood that further development can be continued on the same land or on that purchased or owned, in each year for fifteen years from the fifteenth day of July, 1883, by said parties of the first part, and additional shares of stock issued to them for the same, upon the same basis and subject to the same conditions and provisions as herein set forth. It being further understood that said party of the second part have possession and control over all distributing pipes from the reservoir as soon as the same shall be constructed and laid.

"*Fourth*—During the aforesaid term of fifteen years from the fifteenth of July, 1883, the said party of the second part hereby binds itself not to issue or dispose of any stock in its company to any other person or persons than those hereinbefore mentioned. It being understood that on the fifteenth day of July, 1897, the parties of the second part shall be in full possession by deed of grant from the parties of the first part of all sources of water-supply, all water and water-rights, reservoirs, flumes, and pipes of supply and distribution, and all rights of way therefor, herein mentioned, and after said fifteenth of July, 1897, the said party of the second part shall have the exclusive right to develop waters on the tracts of land heretofore described, and may purchase any water or water-rights after said last date from any person or persons, and may develop the same, paying therefor in stock or otherwise. If in stock, then at not less than upon the same basis of one share for each one tenth of an inch of water so purchased, or for any other consideration than for further water-supply; and parties of the first part agree that right of way and over and through any lands owned by said parties of the first part shall be granted free of cost for all waters so developed or purchased. This agreement shall bind the heirs, executors, administrators, successors, and assigns of the respective parties hereto."

The waters flowing in the creek were measured in July, 1883, as provided in the agreement, and it was found that the one half of the stream available under the rights acquired by the contractors measured three hundred and sixty-five inches; and upon this basis stock for three hundred and fifty inches, or three thousand five hundred shares, was issued to the contractors. In July, of 1883, these promoters deeded the lands, which it was proposed to put in the colony enterprise, to five trustees, of whom they, them-

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selves, were two. They transferred to these trustees their contract with the water company, already recited, and stock of that company received by them as above. In consideration of all of which, they were to receive two thousand five hundred certificates of ownership in the property, of the par value of $100 each, and which should be negotiable. The holder of any such certificate might select land in lieu thereof, and paying in cash any balance there might be, and receiving credit for interest at the rate of 8 per cent on certificates from the time of issue. There were certain provisions limiting the power of the trustees, and forbidding them to contract any indebtedness without the consent of the holders of at least three fifths of the certificates. A certain number of these certificates were left in the hands of the trustees for sale; the moneys derived from which to be applied to the construction of the works contemplated, and any balance there might be was to be divided among the certificate holders in the way of dividends.

In March, 1886, the Ontario Land Company was incorporated, which, by purchase, succeeded to the rights, contracts, and property held by the original organizers of the Ontario enterprise and their board of trustees, and this company has since carried it on.

OTHER NOTEWORTHY IRRIGATIONS.

San Bernardino County.

There are other noteworthy irrigated and irrigable districts and supplying works in San Bernardino county.

Those of the *Rancho Chino*, deriving their waters from artesian wells across the line in Los Angeles county, will be spoken of in closing the chapter on the Pomona district, whence they draw their supply.

Those of the *Upper San Timoteo* region, embracing the Elder creek, Banning, and other neighborhoods southeast of San Bernardino basin, and

Those of the *Mojave River* and the *Hesperia* districts, the state engineer has not been able to personally examine, but some data concerning them will be embodied in this report it is hoped before closing.

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IRRIGATION IN SOUTHERN CALIFORNIA.

LOS ANGELES COUNTY.

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LOS ANGELES COUNTY IRRIGATIONS.

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SECTION I.

IRRIGABLE AND IRRIGATED DISTRICTS.

San Gabriel Valley.

A general outlining of the irrigable region of Los Angeles county has already been offered in the chapter under this heading, whose detailed parts relate to San Bernardino county. The present sections take up the subject in Los Angeles county, where then

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dropped to deal somewhat with its details. The irrigable region of Los Angeles county, with which this report has to do, is embraced in the San Gabriel and San Fernando valleys, and the region to which reference has been made as the coast plain. The San Gabriel valley, the middle division of the great interior cultivable valley of Southern California, is twenty-three miles in length, east and west, eleven miles in width, north and south, with a broad outlet somewhat west of the middle point on its southern side, and it is but little less well defined as a basin than that of San Bernardino. We find the surface of the plain, in the Paso de Bartolo outlet, at elevations about two hundred and ten feet above sea-level. At the lowest point on the higher side of the valley, next the mountain base, eleven miles north and two miles east, the ground elevations range between six hundred and twenty-five and six hundred and seventy-five feet. At the extreme northwest corner they are between one thousand five hundred and one thousand seven hundred feet; and at the other extremity of the valley, next the mountain's base, the plain is one thousand to one thousand one hundred feet above the sea.

Together with its mountain and hillside catchment areas the San Gabriel valley embraces a territory about five hundred and sixty square miles in extent. Of this total, three hundred and ten to three hundred and fifteen are covered by the mountain watersheds of the Sierra Madre, thirty-two to thirty-four are occupied by the northern slopes of the Coast Range hills, twenty-three to twenty-five by the San José and other outstanding hills in the valley, while the mesa, benches, plains, washes, and bottoms composing the valley itself cover about one hundred and ninety to one hundred and ninety-five square miles, or, say, one hundred and twenty-two thousand five hundred acres. Of this amount, seven thousand to eight thousand acres are occupied by comparatively modern river and cañon washes of bowlders, cobbles, gravels, and sands, not fit for cultivation; about the same superficial area is occupied by ancient washes of similar materials now partially mixed with soils, and in some degree cultivable; about fourteen thousand to fifteen thousand acres are wet, moist, and semi-moist lands, principally in the bottom of the basin, and not generally requiring irrigation; while the balance, say, ninety-two thousand five hundred acres, are highly cultivable and productive lands, but requiring irrigation, at least for some crops,

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as we shall hereafter see. Of the three hundred and ten to three hundred and fifteen square miles of mountain water-shed, the San Gabriel river has about two hundred and twenty square miles tributary to it; the cañons coming off the mountain face into the valley east of the San Gabriel have collectively about forty-four square miles, and those west have together about forty-seven square miles. This includes the drainage area of all streams from and inclusive of San Dimas cañon on the east, to but excluding Millard cañon, the lowest tributary of Arroyo Seco, on the west.

San Fernando Valley.

The San Fernando valley is the westernmost division of the great interior valley of the south in California. Its general position and surroundings have already been spoken of. Twenty-four miles in length from east to west, twelve miles in greatest transverse width, it slopes with heavy grades from north to south against the base of the Cahuenga range, and then with gentler gradients its drainage waters find escape around the eastern point of this range at the extreme southeast corner of the valley. It does not so much impress the observer with the idea of a bowl or basin which has been filled with vast alluvial washings, as do the basins proper of San Bernardino and San Gabriel, but nevertheless, it is eminently of this character, although the artesian features which are so strongly marked in the case of the valleys eastward are not here developed. At the upper end of the Los Angeles pass—the lower end of the valley proper—we find ground elevations ranging between four hundred and five hundred feet. At the far western end of the valley the plain holds to, about eight hundred to one thousand feet above the sea; while on the northernmost side and about midway east and west ground heights of one thousand to one thousand one hundred prevail.

The catchment basin, comprising the San Fernando valley with all the mountains and hillsides that send their drainage waters down into it, is about five hundred and seventy square miles in area. Of this total about forty-six are occupied by the northward slope of the Cahuenga range; sixty-six to sixty-eight, by the eastern slope of the Santa Susana mountains west of the valley and the southern slope of the San Fernando mountains north of its western half; one hundred and seventy-nine to one hundred and eighty-one, by the sheds of the Sierra Madre tribu-

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tary to the large cañons that enter the valley near its upper eastern corner; twelve to thirteen, by the cañons of the Sierra Madre that drain into the Verdugo; twenty-three to twenty-four, by those of the same mountains, including and tributary to the Arroyo Seco, which joins the output of the valley just at its outlet—making a total of about three hundred and twenty-seven to three hundred and twenty-nine square miles of surrounding drainage area that is tributary to the valley outlet at Los Angeles. There are within the valley as thus held, the San Rafael hills occupying seventeen to eighteen square miles, the Verdugo hills or mountains covering twenty-five to twenty-six square miles, and the arroyos and passes of the Cañada, Verdugo, and Arroyo Seco, between these hills and the mountains, and occupying about seventeen square miles. Finally, the lands of the valley proper and its outlet pass cover about one hundred and eighty-two to one hundred and eighty-four square miles, or, say, one hundred and seventeen thousand acres. Several immense washes of gravels and sands are found in San Fernando valley which cover an aggregate area of about four thousand to five thousand acres. There are besides this about seven thousand to eight thousand acres of very poor quality lands—from excessive admixture of sand, gravel, and bowlders in their soils; and about six thousand acres which are moist or wet and cultivable without irrigation; so that there are in the neighborhood of ninety-nine thousand acres of really good lands requiring artificial watering for the production of all crops generally irrigated in the southern counties.

The Coast Plain.

That portion of Los Angeles county lying between the sea and the southern and southwestern limits of the San Bernardino, San Gabriel, and San Fernando water-sheds, as marked by the crest lines of the coast and Cahuenga ranges, and joining lines across the passes, already described, embraces an area of about one thousand four hundred and seventy-two square miles. Of this territory about four hundred and seventy-two square miles are covered by the water-sheds and slopes of the mountains named, immediately tributary to the coast plain and mesa and the sea, and extending along from the county line on the northwest to that on the southeast; about one hundred and eighty-nine and a half square miles are covered by the coastwise mesa, rolling and

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rough hills, and their inclosed small valleys and plains at the southeast end of the region; about nineteen square miles by the high outstanding hills known as the Palos Verdes; and, finally, the coast plain proper, with its adjacent bench-lands, lower mesas, low, outstanding, rolling hills, etc., embraces about seven hundred and twenty-one and a half square miles.

Of the one hundred and eighty-nine and a half square miles of higher and rougher country southeast of the great plain proper, about nineteen thousand six hundred acres are valley lands proper, chiefly of the San Juan Capistrano and Alisos; about thirty-eight thousand four hundred acres are higher plains and mesas suitable for irrigation if water-supply were afforded, and the balance is of much less adaptability to such use and gradually merge into mountainous hills.

Of the seven hundred and twenty-one square miles, or say four hundred and sixty-one thousand acres, about nine thousand four hundred acres are occupied by high outstanding plains or remains of old mesas near the southern limit of the region; about twenty-six thousand five hundred by the tops and slopes of the low rolling hill belt which extends, as elsewhere fully explained, lengthwise through the region; about eight thousand eight hundred by the sandy and light soil ridge bordering the coast of Santa Monica bay from Ballona flats to the Palos Verdes; about nine thousand four hundred by estuaries, of which Wilmington harbor is the chief example; about five thousand eight hundred by salt marsh, of which the Ballona marsh is an example; about three thousand eight hundred by fresh-water tule swamps not reclaimed, lying principally in the southeast quarter of the region; about one thousand nine hundred and fifty by cienega swamps, of which those on the Cienega rancho are the most pronounced examples; about two thousand eight hundred and fifty by very wet lands of various kinds bordering swamps and marshes and river beds; about six thousand one hundred by sandy river beds and washes; about one thousand two hundred by beach-blown drift sands; about forty-seven thousand eight hundred by alkali lands, elsewhere described; about sixty-eight thousand by moist and semi-moist lands not specially requiring irrigation nor well suited to cultivation by it; while the remaining two hundred and sixty-nine thousand four hundred acres are composed of cultivable lands, of plain, delta, mesa, and bench-land character, generally requiring irriga-

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tion, and for the most part well suited for it. Finally, of this area about sixteen thousand five hundred acres are occupied by that portion of the city of Los Angeles not on the hills, and by various towns; and another, perhaps larger, area has been divided up and dedicated as town sites.

All of this region, except the hills in the extreme southeast quarter, is below five hundred feet of elevation; nearly all is below four hundred feet; full nine tenths is below three hundred feet; full three fourths is below two hundred feet; full half is not over one hundred feet; and there are. as may have been observed above, some thousands of acres within reach of or under the influence of sea water. The soils and other characteristics of the cultivable lands will be spoken of in the fourth section of this chapter.

SECTION II.

Rainfall and Arterial Drainage.

Rainfall Distribution.

There is little to be said concerning the general subject of rainfall and arterial drainage in Los Angeles county that has not already been reviewed in the section under this heading and relating to San Bernardino county. The same general phenomena are observable as to distribution of rainfall—with certain exceptions presently to be noted—and similar general features appertain to the arterial drains of the divisions of the interior valley, which are in Los Angeles county, to those which give character to the valley of San Bernardino. So that the practical outcome—as affecting the measure of, and manner and location of presentation of irrigation water-supplies—affords very nearly a parallel case. The scope for variation is greater, however, in Los Angeles than in San Bernardino; the field is larger, and then we have the coast plain district, which has no counterpart in the latter county.

The rule as to distribution of rainfall, as affected by the mountain ranges, which was dwelt upon in reference to the irrigable region of San Bernardino, is emphasized in Los Angeles—the heavy downpour is on the slopes of, and on the plains and bench-lands at the base of the ridges, on the side next the direction from which the storm clouds are brought. Considering a section through

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from Wilmington or San Pedro, across the coast plain, the Cahuenga range, the San Fernando valley, and the San Fernando mountains—at the southern base of the Cahuenga range and only four hundred or five hundred feet above the sea—we have a downpour averaging fourteen to fifteen inches per year, while several miles south on the plain, at altitudes not much less, the average drops to nine or ten inches. Immediately over the range, in San Fernando valley, at elevations between five hundred and seven hundred feet, the average is lowered to ten or eleven inches; but it again rises to fourteen or sixteen at the base of the San Fernando mountains, on the north side of the valley, and at only about one thousand feet of elevation; while at Ravena, at the base and under the shelter of the high part of the San Fernando mountains, on the north side, the average drops to ten or eleven inches, although the elevation is over two thousand three hundred feet above the sea.

Considering a section farther east, and crossing the San Gabriel valley instead of the San Fernando, in a direction northeast from Wilmington: On this line we pass through the broad gap in the coast range—here a range of rolling hills only—and we find no such increase of rainfall at an equal distance from the coast and at equal elevations, as is presented on approaching the base of the Cahuenga range—there is nothing to arrest the storm clouds here. But, continuing on in the same direction, we encounter the base of the Sierra Madre at Azusa, and immediately the average precipitation, for several miles out on the plain and at elevations ranging between six hundred and eight hundred feet, is raised to about twenty-two inches per year. And this is the case all along the base of the Sierra Madre bordering the San Gabriel valley: On the bench-lands at the base of the mountain and for a distance of a couple of miles out from its base, as a general rule, the rainfall is 50 to 100 per cent greater than in the valley, ten miles distant and only five hundred to seven hundred feet lower.

Another noticeable phenomena in the matter of rainfall distribution is the seeming concentration of pluvial effort at the mountain and hill points and passes. Los Angeles at the outlet of San Fernando valley—the point of the Cahuenga range, and just at the entrance to the gap between it and the Verdugo and the San Rafael hills—receives a downpour of eighteen to twenty-two inches, when in the valley at no materially less altitude a few

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miles south the average is lowered to ten or twelve inches; in the valley above, at greater altitude, it drops also to ten or twelve inches; on the benches at the foot of the Cahuenga range, a few miles west and at greater elevation, it is only fourteen or fifteen inches; and on the low hills east at greater elevation, the average falls to twelve or fourteen inches. This rule is observable in the pass between the San José hills and the base of the Sierra Madre. Here a very materially greater rainfall prevails than at the base of the mountains east or west of it; yet the San José hills are on a very low range. Still, again, in the cañada between the Verdugo hills and the base of the Sierra Madre, a heavy average rainfall is found, with a very material diminution of downpour at the base of the main mountain, each way.

Of the irrigable and cultivable portions of Los Angeles county which are embraced within the field of this report, the San Fernando valley and the coast plain are materially the driest sections, and the bench-lands and mesas, at the bases of the Cahuenga and the Sierra Madre, receive much the greatest rainfall. San Gabriel Valley, as a whole, probably receives 50 per cent greater rainfall than does the San Fernando, and 80 to 90 per cent more than does the valley of San Bernardino. The reasons for these differences are found in the following facts: San Gabriel valley has no high mountain range in front of it, and has a high range immediately back of it. San Bernardino valley, notwithstanding the fact of the higher range behind it, has also quite a high range in front. San Fernando valley has a moderately high range in front of it, and only a moderately high range behind it for more than half its length.

Drainage Characteristics.

Not any of the streams of Los Angeles county flow through to the sea perennially. All of them that come from the mountains lose their waters in the gravels within a few miles of their cañon mouths, during fully eight to ten months (including the irrigation months) of almost every year. All but two or three of the larger cañon streams do not, naturally, even bring their waters outside the cañon mouths, for six months of almost every year. The waters are lost in the bowlders and gravels in the one basin, to reappear in the springs and *cienegas* which produce the Los Angeles river, rising in the plain, as the output of San Fernando

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valley; and, in the other basin, the lower San Gabriel river, which comes to the surface at the outlet of San Gabriel valley. Then, besides these two lower streams, wholly of Los Angeles county, there is available for the coast plain, the waters of lower Santa Ana river, which rise in the cañon outlet of San Bernardino valley.

Hence, there are two classes of streams serving irrigation in this region, namely: those which have their independent mountain drainage areas, and come to the interior valley through deep gorges or cañons, and then sink; and those which rise at the outlets of the three main divisions of the interior valley, namely: the Los Angeles, Lower San Gabriel, and Lower Santa Ana rivers. These and others will now be severally described.

SECTION III.

RIVERS AND STREAMS.

SAN GABRIEL BASIN WATER-SHEDS.

San Gabriel River.

The San Gabriel with about two hundred and twenty-one miles of Sierra Madre drainage, ranks next to the Santa Ana in area of high mountain country tributary to its flowing, but there is little similarity in the character of the two water-sheds. We have seen the Santa Ana with two mountain valleys four thousand to six thousand feet above the sea, collecting and holding its waters at these high altitudes in a comparatively well timbered country, before they take their plunge through barren cañons and join for exit by a deeper gorge upon the valley of San Bernardino. We find the San Gabriel without any such governing feature in topography. There are no valleys or mountain plateaus in its water-shed. Its profiles are in general terms the reverse of those of the Santa Ana—its waters first plunge down excessively steep ravines in the mountain sides to main forks deeply held in narrow, barren cañons, and then flow on lesser grades by bowlder filled beds to the main stream.

Speaking generally, the Sierra Madre is in this quarter composed of two east-and-west ridges whose crests are from seven to ten miles apart. The southernmost of these is that which is seen from the cultivable plains of Los Angeles, while the northern

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ridge appears as the Sierra Madre when it is viewed from the desert side.

These are joined by a transverse ridge lying next west of San Antonio cañon, on the east, and in which stands the Old Baldy peak. Twenty-four miles west of this, where stands Wilson's peak, the next highest mountain of the local range, another joining ridge starts across from the southern ridge, by a winding course to that on the north. The territory thus held between the main ridges of the range is the water-shed of the San Gabriel, whose cañon breaks through the southern ridge about midway of the region described. Close behind this southern ridge and within one and a half to three miles of its crest, lies the main east-and-west trough of this mountain basin, and wherein are found the east and west forks, respectively, of the river, and these come together about seven miles northeast (in a direct line) of the main cañon opening. The side cañons come into them at nearly right angles. All is broken, sharp, rugged, shattered, and precipitous. Very much is barren. Not a little, bare bedrock. Valleys, plateaus, glades, of any considerable size and of really good qualities, there are none.

After emerging from the mountains the San Gabriel river flows southwest, diagonally across the San Gabriel valley, a distance of twelve miles, where it escapes through the Coast Range—at this point sunk to the grade of high rolling hills—by a pass about a mile and a half wide and two miles in length.

Just in the narrowest part of this pass where the stream is over near the eastern hills, it divided into two channels, called respectively Old and New river. Old San Gabriel river turned abruptly west to the other side of the pass, and thence turning southwest joins the Los Angeles river channel about sixteen miles away, and these flow together nearly south, a further distance in a direct line of about six miles, to the sea. New river courses from the point of division more nearly south, keeping two to four miles east of Old river, and formerly entered the sea about six miles east thereof, and eighteen miles from the point of bifurcation. This was the case in 1880 when these streams were reported upon. But in 1886 New river, at a point about half way to the sea, deserted its channel and crossed the country, southwesterly, through a tortuous course, running into the combined Old river and Los Angeles river channel about a mile below their point of joining.

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Now the condition of affairs is, that the connection between Old and New rivers at their former point of division in the pass is entirely obliterated. The flood waters from the upper valley take the New river channel and go by the new lower cut-across into the Los Angeles.

Through the San Gabriel valley the waters occupy at times of flood various channels within an immense wash of bowlders, gravels, and sands, generally about half a mile, but at one locality full a mile and a half in width. Then through the pass the channel loses the character of a steep sloping "wash," so called in Southern California, and assumes that of a sandy, shifting river bed several hundred feet in width, with low alluvial banks, margined by bottom-lands overgrown with willows where not cleared and cultivated. Out upon the coast plain it retains this general character, but without any bottom-land fringing, until it approaches the sea shore, where it is less wide and sand-filled. Its grades are seventy to eighty feet to the mile at the cañon opening; then average forty-five feet to the mile for six miles of their medium course down the valley; average fifteen feet to the mile thence for eight miles through the pass and out on to the coast plain; and thence to the sea shore, fourteen to fifteen miles farther, the average is eight to eleven feet to the mile.

After the subsidence of the spring freshets, which sometimes occurs in May but ordinarily in June, the waters of the San Gabriel river naturally sink into the gravels of its wash within three or four miles below the cañon's mouth, and thence on for six miles, during the irrigation season its bed is dry. Here, approaching the Coast Range, they commence to rise again, and for three miles farther, through the pass, they break forth in many places.

Both New and Old river channels are important summer irrigation feeders. The former has the direct flow of rising waters in the pass, and the contributions of San José creek coming around the point from the east, as elsewhere described; and Old river has its full share of the rising waters, and also a supply from the Rio Hondo, a perennial stream rising around the western hill's edge, and evidently receiving the percolation drainage from the western portion of San Gabriel interior valley.

The San Gabriel waters, doubtless, are not the only waters which are thrown to the surface in the Paso de Bartolo; for those of all the cañons that come to the upper edge of the San Gabriel

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valley, each side of its main river, sink within a few miles of the point of their advent on the plain, and only in extraordinarily wet winters flow through above ground and visibly join the surface-escaping floods.

Cañons East of the San Gabriel River.

The large cañons which enter San Gabriel valley, east of San Gabriel river, are the San Dimas and Big Dalton; while Marshall's cañon and Wood's cañon are very small stream beds just east of the San Dimas; Sycamore and Cunningham's cañons are of the same class, between the San Dimas and Big Dalton; and Little Dalton, Englehardt, Needham's, Little Harrow, Harrow, Bender's, and La Fetra's are again drainage ways of the smaller class found in the above order between Big Dalton and the San Gabriel's opening.

San Dimas Cañon.

The San Dimas has a water-shed of the best order for this class of cañons. It is about seven and a half miles in length; opens out, fan-shaped against the higher back-lying ridge, to about five miles in width, but comes to a narrow neck for two miles of its lower course, so that its area is but seventeen and one half square miles in extent. It laps in behind the smaller cañons east of it, and adjoins the shed of the San Antonio for several miles, and in the same way it is separated from the Big Dalton, on the west, only by their common ridge. With these qualities, if situated farther east, it would, by comparison, already rank as an irrigation supplying source of considerable value. But the great mountain basin of the San Gabriel river comes in behind the San Dimas—the latter cañon gets its water wholly from the southern face of the southern ridge, already described; it rapidly runs down, and its flow is exceedingly feeble for several months of each year—at no point within three miles of its cañon opening exceeding about fifteen miner's inches. It is confidently asserted by those who have interests in this supply that the low-water volume is very much greater at higher points, but this fact is not otherwise known to the state engineer.

As the San Dimas has, next to the river, the largest water-shed of the San Gabriel group of streams, so it has next to the largest wash. Entering the valley at the extreme eastern end, this wash runs a little south of west for perhaps ten miles, as a distinct belt

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of gravel and sand, near a quarter of a mile wide, through the cultivable lands, and then in a measure is lost in the sandy plain that borders the river on the east about midway down the valley.

Big Dalton Cañon.

The water-shed of Big Dalton cañon is of nearly oval form, about four and a half miles in length from its opening back to the crest of the main ridge, and about three miles in width. It is between nine and ten square miles in area and rests upon the main south mountain ridge; but at this locality this ridge has fallen very materially from the high crest-line which it has farther east, so that the character of the Big Dalton water-shed is not nearly so good on this account as that of the San Dimas. For several months each ordinary year its natural surface flow falls as low as seven to eight miner's inches at times when water is most needed, and in some years it dries up altogether for several miles up the cañon. The wash of the Dalton is quite broad and pronounced for a mile or more below the cañon opening, fully as much or more so as that of the San Dimas, but striking against a long, narrow hill in the plain, it is deflected to the west, much diminished in size, fails to join the San Dimas, and pursues a parallel course, with only a half mile or less of space between the two, also to become lost in the lower plains.

Other and Smaller Cañons.

All the other smaller cañons named as being in this group are of that class which dry up as streams, regularly, during the irrigation months, and simply afford opportunities at their little springy spots to develop flowings, generally of one to three inches in volume, by means of tunneling. Those east of the San Dimas, occupying a frontage of about one and a half miles, together have a water-shed four and one half square miles; those between the San Dimas and the Dalton occupying a frontage of about four and one half miles have a combined catchment area of about four and six tenths square miles; and those west of the Dalton with about four miles of frontage drain about five square miles of the mountain side.

Cañons West of the San Gabriel.

West of the river the cañons whose drainage areas extend back to the main ridge south of the San Gabriel are Fish creek, Saw-

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pit cañon, Santa Anita, Little Santa Anita, and Eaton cañons. There are a number of smaller ones intermediate between these, and named elsewhere.

Fish Creek.

Fish creek comes out of the mountain within a mile west of the San Gabriel cañon itself, and becomes a tributary of that stream in its wash about a mile below. It has a narrow drainage area which extends between two sharp ridges nearly four miles back, and is about three square miles in area. Its volume of flow at the cañon opening ranges between eight and ten inches during the dry months, and, in proportion to drainage area, it is above the average in low-water flow.

Sawpit Cañon.

Near four miles west of Fish creek Sawpit cañon brings its stream to the head of the plain. The drainage area of this cañon has an extreme length of four miles back to the top of the main ridge, a maximum width of nearly three miles, and an area of about eight and one tenth square miles. It spreads out behind the smaller cañons between it and Fish creek on the east and Santa Anita on the west, and next to the latter stream is the most important member of this group. Its flow during the crucial months is less liable to extreme fluctuation than that, even, of the Santa Anita. Its wash extends due south, forming about the westerly limit of the upper Duarte irrigations, and in time of flood its waters join the San Gabriel wash about three and a half miles down the plain in the lower Duarte district.

Santa Anita Cañon.

Two miles west of Sawpit the Santa Anita cañon opens from a fan-shaped water-shed four miles in depth, back to the crest of the ridge, and five miles in width along that ridge. It laps over behind the smaller cañons each side of it, so as to abut against the Sawpit on the east and Little Santa Anita on the west. Its drainage area is almost exactly ten square miles, of which a large part lies high on the mountain side and well exposed to receive the storm clouds and their precipitation. Its low-water flow, as is the case with all streams of its class, entirely disappears at the edge of the plain when not diverted by works. Its wash covers a width of about a quarter of a mile, extending southerly, and, being joined by that of the Little Santa Anita, turns southeast,

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then dividing and spreading into several arms the waters of floods reach the San Gabriel five or six miles from the cañon's mouth.

Little Santa Anita Cañon.

The Little Santa Anita, coming to the plain about a mile west of the Santa Anita, has a water-shed not over a mile in width, which reaches back somewhat over four miles to the crest of the main ridge, turns in behind the smaller streams west of it, to abut against the shed of Eaton cañon for about a mile at the upper one, and is about four and one tenth square miles in area. Its wash turns southeast, and within about a mile and a half joins that of the Santa Anita.

Eaton Cañon.

A little more than three miles west of Little Santa Anita, the opening of Eaton cañon, sometimes known as *Precipico*, or Precipice cañon, is found. This gorge drains a water-shed somewhat similar in form, but in reverse position, to that of the Little Santa Anita, and which is about three miles in length with an area slightly less than three square miles. Its wash extends southeasterly, having a width of half a mile, for some distance, and joined by that of Davis cañon on its eastern side, appears to be lost in the plain five or six miles from the cañon mouth. Only at time of very high and prolonged flood do the waters of Eaton creek reach the river, eight or ten miles away.

Bailey, Davis, Rubio, Los Flores, and Smaller Cañons.

Between Fish creek and Sawpit cañon is a mountain-side area of about five and four tenths square miles, drained by several small cañons of no importance as irrigation feeders. In the same way there are still smaller drainages coming out between Sawpit and Santa Anita, and between Santa Anita and Little Santa Anita.

West of this latter stream is found, however, Bailey and Davis cañons; the former having a drainage area of about one and four tenths square miles, and the latter a drainage area of about one and nine tenths square miles. The Davis cañon stream during summer comes almost entirely from springs out of bed-rock, and, hence, the fact of its supply being out of all proportion to drainage area.

West of Eaton cañon, Rubio and Los Flores cañons come out to the head of the high, sloping Pasadena mesa, with drainage

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areas of about two, and one and three quarters square miles, respectively.

This completes the catalogue of streams, which are worthy of mention as irrigation feeders, bringing waters from the Sierra Madre to the San Gabriel valley. There are other little cañons, as, for instance, Indian cañon, at Carterhia, and Kinney's cañon, at Kinneloa, where fair developments of water have been made by tunneling; but the natural streams themselves are almost nothing. This class of cañons will, in some instances, be further mentioned in connection with the irrigations served by their developed waters.

Cienega and Spring Streams.

San José Creek.

There is another stream of no small importance, however, tributary to the San Gabriel with waters drawn, in part secondarily, from the Sierra Madre, and actually filched from the water-shed of the San Bernardino. This is San José creek, which rises around the eastern end of San José hills, above Pomona, turns the point of this range, and naturally flows south and west, between it and the Coast Range foothills—entering San Gabriel valley at its extreme southeast corner, and joining the San Gabriel river in the Paso de Bartolo. This stream has no high mountain drainage area of its own. There are about nine square miles of the San José hills sloping to its valley from the north, and about twenty-five square miles of the Coast Range, in a long, very narrow strip, sloping to it from the south. But its principal water-source seems to be the great gravel bed at its head, which constitutes the artesian belt of Pomona, elsewhere described, and whose permeable strata probably lap around the point of the outstanding hills, and down into the San José gorge—thus supplying San José creek in that pass. The waters of this stream rise at a number of points along its course, and their approximate volume will be stated in connection with the ditches they supply.

The San Gabriel–Santa Anita Group.

The lower edge of the formation which I have called the Pasadena mesa extends in nearly a direct line across the northwestern quarter of the San Gabriel valley, from the eastern point of hill

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immediately below the upper end of the Arroyo Seco lower pass, trending a little north of east, and joins the footing of the main mountain's slope between the Santa Anita and Sawpit cañons, nine miles away. There is a distinct, narrow belt along this course, wherein a sudden drop in the plain or slope is found, and below which drop the character of soil changes. Towards the western end of this belt the drop is sudden—a bluff or series of benches, at localities having fifty to seventy-five feet of quick descent. Gradually, towards the east, this character is lost, until, for two or three miles about midway of the belt, the drop is but a steeper part of the sloping plain. Then the bluff-like character again appears just before the Santa Anita wash is reached, and beyond this wash a high edge of mesa is again found directly in line with the formation described.

The hills southwest of this range are sandstone. An outstanding hill of sandstone occupies a position in the edge of the break in the plain a mile east of this point. Sandstone croppings are discovered in several of the deeper cut arroyos in the edge of the bluff for a couple of miles farther eastward. In the plain, a mile or more south of the western end of this range, is a hill of chalky limestone, and at the extreme eastern end of the range, in the structure of the base of the mountains, the sandstone and limestone are found occupying similar relative positions.

The mesa formation is a vast deposit of bowlders, gravel, and sand, overlaid with soils as elsewhere more fittingly described. The original mesa soil has been in places covered in by more recent washings from the mountains, and in other places has been entirely swept away and replaced by such washings. Doubtless much of the heavier materials of this old formation have also been swept away by modern torrents we now see, for there are still low hills, or islands in the plain, as it were, of table-like form, observable in the line of the old mesa edge, around which the washings have passed; and we can plainly see what a great washout the Santa Anita cañon has made in the table-land that once evidently extended across the locality of its present opening.

Out of the gravels of this old mesa, at intervals along the line of its lower edge, as now described, no less than seventeen or eighteen groups of springs break forth. Towards the western edge of the formation, these are found, naturally, in the ravines cut by surface drainage in the edge of the bluff or steeper descent, and

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at the base of the slopes. Where the mesa's edge is less well defined, along the medium part of its course, the waters rise in swamps or *cienegas* on the plain or slope. Again, farther east they break out into the ravines of the bluff or at the top of the slopes. Along the medium third of this belt artesian borings made in the line of the *cienegas* or springs, or within a quarter or third of a mile above that line, have been rewarded with good flows of water, obtained at depths ranging from one hundred to three hundred feet.

The general elevation of this line of springs at the western end is about six hundred and seventy feet above the sea, and at the eastern end five hundred and sixty feet. There is a nearly gradual slope between these two extremes, along which, as a general rule, the waters appear. This grade-line is not at the base of the break-off from the mesa surface to the lower plain, but is on the slope between the two. The exceptions to the rule are where waters rise at the foot of the slope, and in some cases, at about its crest.

Borings, generally within half a mile above the line of these springs, reveal the existence of clean sands and gravels underlaid by a bed of large bowlders, too big to successfully work through with ordinary well-boring apparatus, at levels but little lower than the elevation of the plain's surface below the break-off. And other borings back on the mesa afford data, which, connected by leveling, show the plane of this underground water, standing in the gravel on a slope from northwest to southeast, or away from the mountain's base, and nearly at right angles with the line of the mesa edge and outbreak of the springs and of the underlying impervious strata. Borings in the plain below the line of the springs show different formations, and are rewarded by no rising waters.

From these facts and others with respect to the structure of the Pasadena mesa and the sinking of streams along its upper border (which are elsewhere adverted to), it seems rational to conclude that the San Gabriel-Santa Anita springs are fed by the waters which sink into the upper edge of the Pasadena mesa and are held in its gravels as in a reservoir—gradually percolating to these *cienega* outlets. At a number of points the volume of flow has been increased, or concentrated, and new flowings have been developed by tunneling into the mesa edge, and these waters

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as well as those of natural flow and of the artesian wells are utilized, as will hereinafter be narrated; and in connection with these accounts some data of volumes of supply will be submitted.

San Fernando Basin Water-sheds.

Westward from the margin of the San Gabriel mountain basin the two main parallel ridges of the Sierra Madre still are found, both, however, being set two or three miles farther north than the position where direct extensions would locate them. Between these lie the mountain basins of the Big Tejunga, Little Tejunga, and Pacoima creeks; the first-named occupying about three times as much space as the other two combined, and all draining westward into the northeast corner of San Fernando valley.

Big Tejunga Creek.

Big Tejunga creek ranks next to the San Gabriel river in extent of Sierra Madre catchment, and occupies a balancing place in the plan of mountain structure, to Lytle creek at the opposite end of the main part of the range. Lying directly west of that of the San Gabriel, its drainage area, between the two main mountain ridges, is about eight miles in width for twelve miles of length, and then is pinched down to a point six miles farther on by a northeast-and-southwest spur from the northern ridge. The main cañon lies within a couple of miles of the crest of the southern ridge, receiving large tributaries at right angles from the north, which drain the northern ridge. The stream thus has about one hundred and twenty-six square miles of he roughest imaginable tributary territory, quite similar to that of the San Gabriel, but, if possible, even more rugged in character. It escapes, at the southwest point of its shed, into the western end of the cañada opening, behind the Verdugo hills, and thence westward into the main valley of San Fernando. It has made several broad and deep washes, which, turning south, joint the Los Angeles river six or eight miles west of the eastern end of the valley. The low-water flow of the stream seldom runs much beyond the opening of its cañon, and only in time of flood do the waters reach the main river above ground.

Little Tejunga Creek.

Next beyond the diagonal ridge, which cuts off the Big Tejunga's extension, as above spoken of, we find the water-shed of

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Little Tejunga creek, lying nearly ten miles in extreme length, and nearly four miles in extreme width, in a northeast and southwest direction, between two ridges which put down from the main mountain range to the valley's edge. The cañon occupies a position about midway between its flanking ridges, receiving tributaries from either side, so that the whole area is a deep, serrated trough in the mountain's structure, none the less rugged than the others described as farther east. The area of this shed is about twenty-eight square miles, and it delivers its waters out of a precipice-walled cañon, nearly four miles west and north of Big Tejunga cañon. Its wash extends out into the main valley, divides and joins a branch of that of the Big Tejunga on the east, and the Pacoima on the west. Its waters seldom flow beyond the opening of the cañon later than in June, and only in time of high flood do they run above ground all the way to the trough of the main valley.

Pacoima Creek.

Immediately next to the Little Tejunga, lying parallel with it, between its western ridge and the main range, which here has swung around from a westerly to a southwesterly course, we find the mountain drainage area of Pacoima creek nine and one half miles in length and two miles in maximum width. This is even more pronounced as a narrow gorge between two parallel ridges than is the Little Tejunga. It is about seventeen and one half square miles in area, and as rough and inhospitable as any part of this very forbidding range. Its waters come to the valley near its extreme northern quarter, about our miles northwest of the opening of Little Tejunga creek, and flow in a broad wash far around into the middle of plain. As to its habit of flow and loss of waters, exactly the same remarks apply as in the cases of the two streams last described.

San Fernando and Santa Susana Mountain Cañons.

West of the outlet of Pacoima creek the range, distinctly known as the San Fernando mountains, drops to a much lower altitude and narrows to a degree such that its southern slope for ten miles is nowhere more than four miles in width, and at one point is only a mile and a quarter wide; then it suddenly widens out to about six miles, and immediately the cross range known as the Santa Susana mountains leads south to the Cahuenga range.

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San Fernando Creek.

The San Fernando mountains are drained by quite a number of small cañons, only one of which attains to any importance as an irrigation feeder. This is San Fernando creek, which has a drainage area about five miles deep, from the point of its strongest summer flow back to the crest of the mountain range. But this point is in a pass through a low outstanding foothill spur of the range. Thus, although to it the stream has a drainage area of about eight and a half square miles, not more than four square miles are on the mountain slope. The supply to this stream is somewhat complicated with the artesian feature so frequently met with farther east—for behind the outstanding ridge, above spoken of, are several square miles of territory underlaid with gravels which serve as a reservoir, and give out waters not only to the creek during summer, but also to several *cienega* springs elsewhere described. The waters of this stream, then, during summer are not altogether what we have called "cañon" waters.

Mormon Cañon.

West of San Fernando creek are Aliso, Limekiln, and Mormon cañons, and Walnut creek. Mormon cañon is the most noteworthy of these. It has a drainage area of about fifteen and a half square miles, located in the elbow made by the San Fernando and Santa Susana mountains, and a low-water flow of about twenty miner's inches. Some data of others of these streams will be given in summarizing the subject of water-supply in a future chapter.

Cañons East of Big Tejunga.

Draining off the southern face of the ridge west of Los Flores cañon of the San Gabriel basin, and east of the outlet of the Big Tejunga, we find a group of cañons whose useful waters become confused in their lower courses with rising supplies the exact origin of which is not to be traced with certainty. These are the Arroyo Seco and Verdugo creek, with their tributaries.

The Arroyo Seco.

The water-shed of the Arroyo Seco occupies the space made by a jog in the southern mountain ridge west of a portion of that of the San Gabriel, and south of that of the Big Tejunga. It swings

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around easterly behind that of its main eastern tributary, Millard cañon, which itself swings in behind Los Flores and Rubio cañons of the San Gabriel group. This mountain area is about five miles deep in a direct line back to the top of the ridge from the cañon opening, and extends along that ridge a length of about six miles. It occupies sixteen to seventeen square miles of territory which is the most destitute of soil of any portion of the mountains. Bare granite slopes, great crumbling masses of rock, and glistening ridges innocent of a tree, are the ruling features in the landscape.

This stream comes from the mountains into the San Gabriel basin as defined by the more commanding hills, but its waters go through a gorge in those hills and join those of the San Fernando, so it is ranked as a member of the San Fernando drainages. Opening at the extreme northwest corner of San Gabriel valley, at an elevation of about one thousand three hundred feet above the sea, the Arroyo Seco cuts deep around the west side of the Pasadena mesa, crossing the opening of the cañada pass, skirts along the eastern base of the San Rafael hills in a due south course for nearly six miles, and then turns southwesterly, by a deep arroyo in an open pass, joining the Los Angeles river as the main outlet of San Fernando drainage, near the extreme lower end of its pass to the coast plain. It receives an insignificant drainage of about three and a quarter square miles from the eastern end of the cañada pass north of the San Rafael hills, and also some slight accession of waters at time of flood, from about six and a half square miles of the eastern and southerly slopes of the same hills all the way along on its southerly course; but there is no territory on its eastern side below the cañada worthy of mention which drains into it above ground. The Pasadena mesa, which borders it from the upper to the lower cañon, for the most part slopes easterly away from it, and the water-shed from the hills through the lower cañon or pass is insignificant.

A mile and a half below the main cañon after extending across the opening of the cañada pass, which lies northwesterly from the head of the Pasadena mesa behind the San Rafael and Verdugo hills, the Arroyo Seco encounters the northeastern point of the San Rafael hills. The hill formation here is granite. The deposit which forms the mesa has partially covered in the extreme point of the rock-in-place for several hundred yards, as may be seen by the outcrop in the face of the mesa bluff.

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The creek finds escape by a gorge through the rock, seventy to eighty feet deep, and at one point not over thirty feet in width at the bottom. This gorge is known as Devil's Gate. Above it the arroyo presents the appearance of a great gravel-filled basin a mile and a half long and half a mile wide—the eastern rim being a nearly perpendicular gravel bluff seventy to one hundred feet high, the western side a series of lower benches of similar formation rising to the mesa in the cañada. Except in time of flood the waters of the stream sink into the gravel in the mouth of the cañon or near the upper end of this basin into which it opens. There is also a drainage area tributary to it, lying west in the cañada, as elsewhere explained. Out of the gravels of the basin near its lower end and within a few hundred feet of the Devil's Gate, two groups of springs rise; that just west of the gorge, being known as Ivey springs, and that just east, as Thibbet springs. Naturally, their waters join in one channel at the gorge, flow on through it and again sink into the gravels of a second basin immediately below.

Devil's Gate gorge is seven hundred to eight hundred feet through to the head of the second basin, where the arroyo suddenly widens by the retreat of the mesa's edge eastward. This leaves a neck of mesa formation about eight hundred feet wide, lying between the upper and lower basins, and forming the eastern point of land making the gorge. Its flat top is about seventy feet in elevation above the surface of the gravels in the upper basin where Thibbet springs rise, and about ninety-five feet above those in the head of the lower basin. Along the foot of the gravel bluff and out of it, fifteen to twenty feet above its base and for several hundred feet of length on the lower side of this point, burst forth other springs known, as a group, by the name of Flutter Wheel springs. It is probable that these waters are from the same source as those which form the two groups above the gorge, and, naturally, they join them in the bottom of the arroyo and are lost in the gravels of the second basin.

The second basin has the steep sides of the San Rafael hills bounding it on the west, and the mesa bluff bordering it on the east. It is two and a half miles long and three quarters of a mile wide. Its bottom is not all a recent gravel wash—there is a second and low bench, through which the arroyo proper cuts in a deeper channel—but underlying all is the same gravel bed.

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At the lower end of this basin the arroyo cuts, for several hundred feet, through another bedrock point of the hills which lie west of it—the mesa formation overlying the extreme point on the east, as in the case at Devil's Gate above.

Just at the entrance of this gorge (which is due west of the main part of the city of Pasadena and immediately on its borders), another group of springs appear out of the gravels of the arroyo bed. These are known as Sheep Corral Springs. Their waters naturally flow above ground through the narrow pass below, and within several hundred yards are lost in the gravels of a third arroyo basin. At about a mile below there is another uprising of waters of much less moment, and to which the name Bennett springs is applied. And, finally, at the entrance of the arroyo to the lower cañon, where it turns west through the hills towards the San Fernando basin, some rising waters are again encountered.

It is not to be supposed that the waters thus found at successive points down the arroyo are the same identical waters which are thrown to the surface by succeeding obstructions of bedrock. At each point those which rise are all diverted, as will hereafter be explained, and carried far out on the mesa for irrigation, domestic, and municipal use. It is not known, though, how much water may pass through the gravels in the several gorges, that is not thrown to the surface. And so the problem is yet undetermined as to the immediate source of these several springs. Are their waters all due to the Arroyo Seco? No; not by percolation from the mountain basin, certainly, because the bedrock has been exposed in the main cañon at the opening of the mountains, and there is very little water to be found in the gravels there. The probability is that the springs of the Arroyo Seco are fed by the great gravel bed of the cañada at its upper end on the west, and by that of the Pasadena mesa lying alongside of it on the east, for six miles or more. This vast gravel deposit along its upper edge receives the waters of a number of cañons during winter and spring that seldom run through to any surface outlet. It is a reservoir of waters which gravitate slowly towards the outcroppings of its more permeable strata. The Arroyo Seco is a deep gorge cut in this deposit. Its course is at the several points named crossed by bedrock ridges. The waters of the great gravel bed are intercepted by these and brought to the surface at the

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lowest adjacent points, which are in the arroyo's bed. Other outbursts of water from this same general source are spoken of as the San Gabriel-Santa Anita *cienega* springs.

Millard Cañon.

Lying nearly east and west between the sheds of Los Flores and Rubio cañons on the south and the Arroyo Seco on the north, we find Millard cañon with a mountain shed about four and a half miles long, something more than a mile in width, and about four and nine tenths square miles in area. It is tributary to the Arroyo Seco just at its cañon opening, but its waters seldom flow as far as this junction during their low stage.

Verdugo Creek.

The Verdugo is the main drain of the cañada pass country. It has a small, independent drainage area near the western end of the pass, flows down to and across the pass to the foot of the Verdugo mountain, turns at right angles along its northwest base, and flows southeasterly through the pass about four miles, and then escapes southerly by an open cañon, between the Verdugo and San Rafael hills, into the San Fernando valley at its extreme eastern end. It receives tributary cañons from the main mountain face, which with it have a combined drainage area of about twelve and six tenths square miles. And it also receives the water-shed from about eleven and seven tenths square miles of territory occupied by the northern and eastern slope of the Verdugo mountains. This with six and four tenths square miles of mesa formation composing the cañada and the lower cañon, and about one and a half square miles of the San Rafael hills drainage, give it a total tributary territory thirty-two and two tenths square miles in extent.

Los Angeles River.

Although not any of the number ever reach this main outlet with their waters above ground, except at time of flood, the Los Angeles river is the resultant of all the creeks and cañon streams which have now been described as of the San Fernando group and which flow to and sink around the margins of this basin. The valley, subsoil, is a vast filtering bed of sand and gravels, which, swallowing up the flow of streams at elevations of eight

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hundred to one thousand two hundred feet above the sea, gradually and evenly gives them out again to the surface, along the lower side, next the Cahuenga range and in the pass between it and the San Rafael hills, at elevations ranging from five hundred and fifty feet to four hundred feet above the sea.

Thus, the Los Angeles river rises in the low lands of San Fernando valley, flows along its lowest depression and is the stream which carries away its surplus waters—receiving at the upper end of the narrow outlet the flow of the Verdugo, and at the lower end, that of the Arroyo Seco, as already described. There is a narrow strip of mountain water-shed constituting the northern slope of the Cahuenga range, twenty miles long, nowhere over two miles wide, and embracing about thirty-one and a half square miles of territory, which is directly tributary to the Los Angeles, lying almost immediately at its foot, but this does not yield any considerable part of the river's flow; nor does it, indeed, send any water to it above ground except at time of flood.

Escaping from the San Fernando, the river extends almost directly south by a sandy bed, a total distance, in a straight line, of twenty-one miles, where it enters San Pedro roadstead. Except in time of flood all its waters which rise, as above described, and amounting to sixty-five to eighty cubic feet per second, naturally sink and are lost in its sandy bed and the substrata of the surrounding plain. But there is a considerable area of land kept moist and even wet thereby, and an extensive artesian basin, fully developed, is also, doubtless, thus in part supplied.

SECTION IV.

Irrigable and Tillable Lands; Soils.

The tillable lands of our irrigable portion of Los Angeles county may be classified very much in the same terms as have been those described of San Bernardino county, with the additions that must be made in referring to those of the coast plain. There is very marked difference, however, in the prevalence of certain notable soils; and those of Los Angeles are less well defined as to origin and generally more cultivable.

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San Gabriel Valley.

The main mountain range bordering San Gabriel valley has been edged with a mesa formation of very much the same character as that described as fringing the San Bernardino valley, but in this Los Angeles division of the interior valley the mesa land is less pronounced in its red clayey character, and it has, to a greater extent, been cut away and given place to washings from the mountain side. The basin lands of the San Gabriel are much less heavy in character of soils, are more evenly moist over a large area, and with less area of very wet or *cienega* land than are those of San Bernardino. The intermediate plain lands are of better grades, with richer, finer soils, less area of barren sands, and are less cut up by broad washes of sand and gravel. On the whole, San Gabriel valley lands are more evenly cultivable than are those of San Bernardino valley—speaking now of the latter valley as including all east of the San José hills.

Lying immediately east of the San Gabriel wash, which has been referred to as extending diagonally across the valley, is a strip of country having poor soils. For five or six miles down from the cañon and a couple of miles out from the wash, it is of a heavy, gravelly, rocky character. In the same belt further down the river, until the base of the hills at the pass is approached, the soil is sandy and alkaline. But east of this comparatively barren belt is a plain of the richest kind; a gently sloping, even surfaced body of land composing the bulk of the eastern end of the valley, whose soils grade from the heavy, gravelly loam of the bench-lands at the mountain base, and mixtures with red mesa soils, down to light alluvial sediments, then to a broad plain of rich, sandy loam, and then gradually merge into a rich, black adobe as the base of the hills are approached at Puente and in the outlet of San José pass.

Considering the lands of the valley west of the river's wash, we find no such area of poor, gravelly, and rocky soils. Bordering the river wash, next the mountain, is that district of fine, gravelly, loamy soils known as the Duarte. Then in the lower Duarte and below it to the "Island" is found a rich, sandy loam. Farther down is a narrow border of light, sandy alluvial soil next to the river; outside of which comes a body of about six thousand acres of light mixture of loam and alluvial washings, composing the

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moist lands of the San Gabriel basin, and which reach down to the pass through the Coast Range.

Surrounding this moist basin on north and west, is a body of eight thousand to ten thousand acres of fine, rich, sandy loam. Next comes a heavier, gravelly loam in a belt extending around from the lower Duarte to the Alhambra. Lying south of these two last belts and next to the hills, is a body of heavier, clayey loam. Outside of this belt of loamy soils is found the edge of the Pasadena mesa, along the base of whose bluff are spots of black and red adobe and heavy *cienega* soils. At the extreme western end of the valley, below the mesa, is a body of several thousand acres of black adobe, tenacious and intractable.

The edge of the Pasadena mesa shows the red clay of the mesa formation, found more plentifully farther east; but as we ascend the mesa we find it has been covered in and its soils mixed with the gravelly loams and more recent washings from the mountain face. Finally, all along the mountain's base are points of the red mesa, ridges, and benches of gravelly loams, and flats of admixtures of these soils in all conceivable proportions; and these are cut through by the cañon washes of gravels and sands which are sometimes bordered by narrow belts of light, sandy alluvium.

Lands and Soils; San Fernando Valley.

Considering the San Fernando valley, we find no such great variety of soils, and a comparative absence of those of heavy character. There is a body of moist and semi-moist land lying in a belt next to the slope from the north side of the Cahuenga range, and out from this the Los Angeles river gradually gathers. Leaving this basin and considering the lands around the rim of the valley, we find scarcely any of the red mesa formation, and very much less of the gravelly loam bench-land than along the rim of the San Gabriel valley.

Before this valley was filled in with the great alluvial deposit, which forms the bulk of its structure, so far as can be seen, it would appear that there were two ranges of hills crossing it in a northwest and southeast direction; one of these, a continuation in line of the Verdugo mountains or hills, formerly cut off the extreme northeastern corner of the valley; another, less easily traced, stood out in the valley, parallel to the first, and about three miles therefrom. These are now both, to a great extent,

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washed away or covered in. But their former presence is attested by their visible beginnings, both at the western and eastern end of the upper one, and at the western end of the lower one; by occasional "croppings," as it were, of their tops through the soils of the present plains surface, and by the form and character which the plain has been given as the washings, which for the most part compose it, have been deposited over these old ridges.

The Pacoima and Tejunga washings have utterly destroyed or covered in the central part of the upper ridge, and all the eastern and central part of the lower ridge, and made immense deposits of gravels and sands extending far out into the valley. But above the western end of the upper ridge is a valley of rich, fine, and heavy loam, placed by the smaller cañons from the lower mountains, over a great bed of gravels and clean sands, with layers and dikes of clay. Resting against this old, impermeable gravel and cement hill the more recently placed deposits form one of those artesian basins which have been so frequently referred to in the course of this report. It is one of the smallest of its kind, but perfectly well marked, and its general character developed by the borings which have been made in it. The drainages from the little cañons around the mountain face, from Pacoima to San Fernando creek, all sink around the upper rim of this basin; their waters percolate the lower gravels, are held there by the presence of the cross ridge, now partly covered in by the surface soils, and prevented from escaping into the great body of loose material in the valley below. Thus is formed a fine body of moist land in the corner of the valley above San Fernando, and thus are to be accounted for the old San Fernando Mission *cienegas* or springs, which are the uprisings at the point of, and gaps through the ridge described, of the waters held in the sloping gravel mass under the moist lands of the upper valley.

This is the only well defined instance of an artesian basin and of moist artesian lands in San Fernando valley, except the wet lands of its main basin already adverted to. Lying southwest of the ridge, which has given character to the lands just described, extending down to the "croppings" of the other old ridge, and lying between the Pacoima creek wash on the east, and that of San Fernando creek on the west, is a body of magnificently fine land, whose soils are graded from a gravelly clay (closely resembling the mesa formation farther east) lying next the base of the

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hills, down to a very fine loamy alluvion resting against the ridge in the plain, several miles away as before described. This ridge is again of a clayey character, gravelly towards the west, and there resembling the mesa lands of San Gabriel valley, but free from grit, and boggy when wet, at the eastern end and where it disappears under the plain.

Southwest of the ridge the plain drops forty to sixty feet lower, and here stretching away down to the basin is a large body of land with even surface and fine, deep alluvial soils. East of this is the Pacoima wash and sandy lands made thereby; then another narrow strip of good, fine loamy alluvium, and then the Tejunga wash and its sandy belts. Returning to the west, the gravelly clays, partly covered in, and mixed with loamy and gravelly alluvions, extend around the margin of the valley, outside of the light, loamy alluvions of the plain, all the way to the west end of the valley. Finally, there is another body of land of fine, gravelly alluvial nature, and resembling the bench-lands of San Gabriel valley, lying at the base of the Verdugo hills, on the east side of the narrow part or outlet of the valley.

Lands and Soils; Coast Plain.

Commencing in the highest part of the mesa resting against the foot of the Cahuenga mountains, between their eastern point and the head of the Santa Monica plain at the coast, which point is in the Wolfskill rancho, several miles from the coast, there extends in an almost due southeast direction and parallel with the Coast Range, a line of low rolling hills in the plain. These hills are clearly traceable through to the coast, eight miles east of Wilmington. Another outcrop of the same formation appears in line, immediately on the coast, ten miles farther, in the Rancho la Bolsa Chica. And, then, still immediately in line, and about eight miles farther, is found the point of the rolling lands north of Alisos creek. And this last named high ground joins in formation with the hills beyond the Alisos.

The presence of this ridge gives character to the lands of the coast plain. Inside of, and between it and the base of the Coast Range hills is a vast alluvial deposit, doubtless in large part brought down by the Los Angeles, San Gabriel, and Santa Ana rivers, whose channels now course across it. Outside of the ridge, from Wilmington northwest to the Santa Monica mesa, is a region

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of heavy loams, adobes, clays, and beach-blown sands, with mixtures of these in various proportions. This last described region comprises the San Pedro, Redondo, and Centinela valleys or basins. As a convincing evidence of the continuance of this ridge as an impervious body in the sub-formation from the Santa Monica mesa through to the Alisos hills, an extended artesian water-bearing belt exists immediately inside of it for the full length of the plain, while just over it, in some cases only a quarter of a mile away, artesian waters cannot be found.

As we have seen, the waters of the Los Angeles, San Gabriel, and Santa Ana rivers rise as they come through the Coast Range, and then sink again into the upper margin of the coast plain. The sinking of waters, so apparent when the flow is small, is far greater in volume when the river is in flood; and these flood waters thus lost replenish the supply in the gravels and sands of the artesian basin. The area over which rising waters may be obtained by artesian borings reaches from a point just north of the Centinela hills, at about the northwest corner of the Cienega rancho (five miles west of the southwestern corner of the pueblo limits of Los Angeles), to a neighborhood two or three miles beyond the channel of the Santa Ana river—a distance of about thirty-seven miles. This area, varying in width between one and two miles for the first eight miles at its northwest end, rapidly, as the ground falls in the basin to lower levels, widens to six or seven miles, and again widens to eight or nine miles for eight miles of its central part, and then narrows to its southeastern limit, embracing in all about two hundred and forty square miles.

About one hundred and thirty feet above the sea at its northwestern end, where this basin rests against the Centinela hills, the surface of the ground along its southwestern boundary, following against the base of the ridge already described, gradually drops to within about ten feet of the level of the sea in about twenty-four miles of its length, and then extends at this low level to the limit of the basin. Its northeastern boundary, as developed by the borings, is found to follow almost a level contour through the length of the plain, swinging out in front of the San Gabriel pass through the Coast Range, as that river has built the plain before it—swinging in between it and the Santa Ana—and again swinging out around the delta of the latter stream—and then suddenly turning diagonally down the slope and joining

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with the western boundary at the coast line. Within this region of "water-bearing" lands a number of large *cienegas* are found, notably those of the Cienega rancho at the northwest end of the belt, and those of the rancho Tajauta on the line of the Wilmington and Los Angeles railway, nine miles southwesterly therefrom. Around these and elsewhere also are areas of moist lands, not requiring irrigation for some crops. And, again, there are large marshes requiring reclamation before they can be cultivated, at the southeast limit of the belt.

Through the entire length of the belt extends a strip of light sandy soil, here and there spotted by or mixed with bluish black adobe or clay, and all heavily charged with alkali. This soil occupies the entire area of the artesian belt for its narrow part at the northwest end, and covers full half of it thence to its other extreme. Along the northeast margin this soil gradually merges into:—

(*a*) Light sandy alluvial loam, as at Anaheim, a soil thought to produce the best wine grapes in the southern country, but which, however, runs down in strength and needs fertilizing within a few years after cropping commences. It drinks up water rapidly; requires large heads to be used in irrigation; and calls for irrigation more frequently than the heavier soils. The subsoil appears to be nearly a pure sand extending to depths of fifty to one hundred feet, and gradually changing into gravel, cobbles, and even bowlders, as attested by artesian borings. This class of soil gradually merges into the sandy wastes of the river washes on the one hand, and into the heavier sandy loams on the other.

(*b*) Heavy sandy loams, such as predominate south of the Santa Ana river, especially in the area comprising the settlements of Orange, Tustin, and the northern part of Santa Ana. An alluvial loamy sediment, containing fine granite sand, friable clay particles and much vegetable matter. It is firm in natural deposit, but most easily worked and brought to a high state of cultivation, retains moisture well, and receives irrigation readily with moderately large heads of water. These are the soils thought to be specially well adapted to the growing of raisin grapes.

(*c*) Heavy gravelly loam, resembling the heavy sandy loams, except that gravel stones up to the size of hens' eggs are found in varying proportions mixed throughout the mass. In the natural state this soil is very firm and makes excellent roadways; when

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first cultivated and irrigated it is excessively greedy of water, but afterwards packs and is served with less than either of the two above described. When next to the foothills it generally rests on a red clay substratum four to eight feet below the surface, which gives place farther down the plain to a coarse sand with some clay particles.

(*d*) Red clayey loams, resembling the mesa soil of the interior valley, not however carrying so much gravel, nor so red and rich in color or plant food. The term loam is scarcely applicable to these soils, comparatively speaking, but they are not tenacious enough to be called clays, in common parlance, as is generally the fact with the interior mesa soils. These soils are more or less mixed with coarse sands, fine and coarse gravel, and in some places with adobe—the last being the case where washed and redeposited of late years. They are moderately difficult of cultivation by irrigation, requiring special knowledge of their characteristics to guide the farmer's judgment, in order that his work may be to best advantage—to prevent washing, baking, etc. They are generally deep—the change being very gradual to heavier clay, to gravel subsoil, or, in some instances, to a curious dry sand that runs almost like quicksand.

(*e*) The adobe soils of the coast plain are not so unctuous, stiff, and intractable, as a general thing, as are those of the interior, and are more suited to cultivation by irrigation. Yet they are far from being well suited for such use, except when, as is quite frequently the case, they have become well mixed with some of the sandy loams, and then they lose the distinctive character of adobes. In nearly pure state they dry out completely, crack open most freely, and fall to pieces—thus filling the cracks before the season is over. When well worked some of these soils are quite deceptive in appearance and may be made, seemingly, to take on the qualities of heavy black loams. They are sometimes, but not frequently, alkaline, and, as a general thing, are not mixed with other soils.

Bearing in mind these leading soil characteristics, and looking along the portion of the coast plain between the light alkaline soil-belt and the base of the Coast Range foothills—which is *the* district of irrigation in this big region—we find: In front of the pass from which comes the Los Angeles river, a region of light sandy loams, with heavier loams flanking and around next to

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the foothills, and with streaks and ridges of very light sand extending through. The same sandy loam surface formation is in front of the Paso de Bartolo, whence comes the San Gabriel river, nine miles southeasterly; but in this pass and for several miles out upon the plain in front of it, a marly hardpan underlies the loams as a general thing, within five to eight feet of the surface. The surface alluvions extend out as a wide open fan, soon joining those of the Los Angeles, but not reaching those of the Santa Ana, which comes out of the mountains eighteen miles distant, until the spread is far down into the alkali belt. Finally, the same soils are found in front of and adjacent to the opening of the Santa Ana cañon, and the contours of the plain show the country to have been similarly built out by the river. Between these modern deltas, and north and south of their extremes, and next the foothills, lie the heavier loams, the gravelly loams, the red soils, and the adobes.

The outstanding ridge which forms the limit of the basin is of clays, heavy gravels with clay and with large patches of adobe. Towards the northwestern end it has much the characteristics of the old mesa formation; at its southeastern end it joins the coastwise mesa lands.

The region west of this line of ridge is—commencing at the base of the Cahuenga range—the Santa Monica plain, in some respects like a mesa formation, but of much lighter soil. Then the Ballona marshes, with drift sands encroaching upon them along the shore. Then the shore is bounded with a ridge apparently an ancient sand drift, whose texture has become changed to a coarse sandy loam, and lying inside of this, extending to the artesian ridge, we find the Centinela and Redondo valleys whose soils have already been spoken of. These last valleys and the eastern portion of the larger plain from Los Angeles to near the Alisos, are for the most part admirably adapted to cultivation by irrigation upon a broad scale, while the bordering mesa and rolling lands are well suited to irrigation in smaller farming and horticulture. The data of this section will be summarized in a subsequent part of this report in considering the demand for and possible extent of irrigation.

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CHAPTER XV.—LOS ANGELES[2]; WORKS AND PROJECTS[12].

CUCAMONGA PLAINS IRRIGATIONS.

THE GROUPING OF WORKS—LOS ANGELES. POMONA GROUP[1].

SECTION I.—*Pomona Old Settlement Irrigations:*
The Alvarado Ditch;
The Palomares Ditch;
The Los Angeles Company's Ditch;
The Tonner Private Ditch.

SECTION II.—*Pomona Land and Water Company's Works:*
The Pomona System;
The Palomares System;
The Del Monte System;
The Cañon System.

SECTION III.—*Sundry Other Works:*
The Packard System;
The Smith System;
The Rohrer System;
The Chino Rancho System.

INTRODUCTION: THE GROUPING OF WORKS.

For convenience of description and reference, the present and probable irrigations of the portion of Los Angeles county in the last chapter described as its irrigable region, may be classed in groups as follows: the arrangement being governed by (1) drainage area in which situated; (2) general character of water-supplying source; and (3) individuality or remoteness of source or work.

I. Irrigations in San Bernardino valley, yet within Los Angeles county—called Pomona Group (1).

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II. Irrigations in San Gabriel valley, deriving supply from cañon streams—called Sierra Madre Cañon's Group (2)—and, for further convenience, arranged in sub-groups, in succession westward, as follows:—

(*a*) San José sub-group, embracing those situated on or adjacent to the San José ranchos, and between San Antonio creek and San Gabriel river;

(*b*) San Gabriel river sub-group, embracing those supplied by the river at or near its cañon opening;

(*c*) Santa Anita sub-group, embracing those supplied by cañon streams on or adjacent to the Santa Anita rancho;

(*d*) San Pasqual cañons sub-group, embracing those supplied by cañon streams on or adjacent to the San Pasqual rancho.

III. Irrigations in San Gabriel valley, supplied by waters rising within its plain, or in the lower arroyos tributary to it—called San Gabriel Basin Group (3)—and, for further convenience, arranged in sub-groups as follows:—

(*e*) San Gabriel-Santa Anita sub-group, embracing those deriving supply from the line of springs and *cienegas* which extend across the northwest quarter of San Gabriel valley at the foot of the Pasadena mesa.

(*f*) San José creek sub-group, embracing those deriving supply from the springs and *cienegas* of San José or Puente creek.

(*g*) Rincon sub-group, embracing those within the San Gabriel valley or Paso de Bartolo, and deriving supply from the rising waters of San Gabriel basin.

IV. Irrigations in San Gabriel valley, but supplied by waters which naturally flow to and join those of the San Fernando output—called San Gabriel-San Fernando Group (4).

V. Irrigations in San Fernando valley, deriving supply from cañon streams and rising waters not in the basin of the valley or directly tributary to the Los Angeles river—called San Fernando Group (5)—and, for further convenience, arranged in sub-groups in succession as follows:—

(*h*) Cañada sub-group, embracing those situated in the Cañada pass, and supplied by cañon streams tributary thereto.

(*i*) Verdugo sub-group, embracing those deriving supply from the rising waters in Verdugo cañon, and from other cañons in the Verdugo range.

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(*j*) Tejunga-Pacoima sub-group, embracing those deriving supply from cañon streams flowing from the Sierra Madre, in the northeast corner of the valley.

(*k*) San Fernando sub-group, embracing those deriving supply from sources fed by drainage from the San Fernando and Santa Susana ranges on the north and west sides of the valley.

VI. Irrigations in the lower end of San Fernando valley, in the pass leading out therefrom, and on the Coast plain beyond, supplied with water from the Los Angeles river—called Los Angeles Group (6).

VII. Irrigations on the Santa Monica plain and mesa and in the Ballona valley—called Santa Monica-Ballona Group (7).

VIII. Irrigations upon the Coast plain and deriving waters from the San Gabriel river—called the Lower San Gabriel Group (8).

IX. Irrigations upon the Coast plain and deriving waters from the Santa Ana river—called the Lower Santa Ana Group (9).

X. Irrigations upon the Coast plain and deriving supply from Santiago creek—called Santiago Group (10).

XI. Irrigations on the Coast plain and deriving supply from other sources.

SECTION I.

Pomona Old Settlement Irrigations.

The Pomona Neighborhood.

The town and surrounding irrigation neighborhood of Pomona is situated at the western end of the San Bernardino division of the interior valley. From the center of the town the foothills of the Coast Range are but a mile and a half southwest, and a point of the San José hills stands less than a mile and a half distant north and west. Directly away between these two ranges extends westward the narrow valley of the arroyo of San José, dropping into the San Gabriel valley, and constituting the pass through which the Southern Pacific railroad winds. North and east, seven miles distant, is the opening of the San Antonio Creek cañon coming from the Sierra Madre as already described. Eastward stretches the great plain of Cucamonga, and southeast that of the Chino, sloping to the Rincon basin.

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Pomona is at a governing point in the topography of the country, and occupies a commanding position with respect to water-supply. As in the case of the creeks of San Bernardino valley proper—that portion of the great valley immediately surrounding the San Bernardino artesian basin—so the waters of those coming from the mountains above Pomona sink and for the most part are lost in the gravels which extend forward under the plain. The San José hills and the Coast Range foothills constitute obstructions in the pathway of these percolating waters, and, hence, we find them beneath the Pomona plain under pressure and prompt to rise to the surface whenever a rent is made in their overlying impermeable strata. Thus, there have always been in this neighborhood a number of artesian springs which formed large *cienegas*, and many artesian wells have been bored and strong flowings secured.

The irrigation water-supply of the neighborhood comes from the San José creek, which takes its waters from *cienegas* lying against the northeast base of the San José hills, rounds the point of these hills and extends westerly; from other *cienegas* of this same group; from artesian wells, and from the San Antonio creek in the cañon mouth eight miles away. The more notable developments and works are those of the Old Settlement; those of the Pomona Land and Water company; those of the Chino Rancho management; the Packard system; and the Smith system.

The Old Works and Irrigations.

District and Work:—What is known as the Pomona Old Settlement, formerly called Palomares, covers an irregular tract of the plain, near one and a half miles east and west, and half a mile wide, north and south, embracing four hundred and fifty-five acres in area. It lies immediately north of the town proper, and extends westerly to and close along the San José creek where the channel rounds the point of the San José hills as heretofore described. The Old Settlement ditch takes its supply from the northeast side of San José creek about half a mile above the point of hill referred to, is located within a few hundred feet of the creek channel southeasterly and southerly for about three quarters of a mile, and then divides into three branches which radiate in as many directions, from southeast to southwest, making a total channel length of about two and a quarter miles. It is a primi-

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tive earthen ditch of about one hundred inches capacity in the main part, but commands only a portion of the Old Settlement lands. Those not thus commanded and supplied, receive their irrigation waters through what is now known as the Pomona Land and Water Company's Pomona ditch as will hereinafter be explained.

Operation and Maintenance:—The owners of the Old Settlement lands hold this old ditch as a common property. Their association is voluntary and altogether without fixed organization. Each year three commissioners are elected by the votes of the irrigators—a vote to the individual, without reference to extent of interest owned. These commissioners, as a board, select some person to make out water tickets during the year and to see to clearance of the ditch. This person is not regarded as a *zanjero*, nor yet as a secretary; neither are his duties as broad nor as full as those of either of these functionaries in other primitive water organizations herein described. Once a month the apportionment of waters is made and tickets issued to irrigators, naming for each the day and hour at which his turn to take the ditch flow will commence. When that time comes, the irrigator himself diverts the stream to his lands, and keeps it running there until it is taken by the next in turn, or until he has enough water, when he turns it to waste. The cost of maintenance of the ditch has generally been paid by the individual irrigators in labor, and has amounted to about $150 per year, or 30 cents per acre irrigated, and this represents the full annual cost of the water to the irrigator.

Water-supply and Use:—The supply from this source has always been abundant for these irrigations, which have had first claim upon it. The water-right has been recognized, in adjustments between the Pomona Land and Water Company and these claimants, as amounting to fifty inches under a six-inch pressure, an equivalent of about sixty-five inches under a four-inch pressure, which, for the four hundred and fifty-five acres of the settlement, is an inch to seven acres. But as a matter of fact, all of the lands of the settlement have not been regularly irrigated, and the supply utilized, except in the driest years, has been greater than the measure of the right, so that there has been no

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such high duty accomplished by the water as these figures would indicate.

At a meeting held in 1873 it was determined that each acre irrigated should represent an hour's flow of the ditch, and upon this basis the allotments of water have since been made. Thus, the period of rotation has varied in lengths as irrigations have increased, and is now four hundred and fifty-five hours or eighteen days and twenty-three hours long. This year (1888) all the Old Settlement lands are irrigated. There are forty-three owners of the water-shares or rights, the largest holding being for twenty-five acres, and the smallest for half an acre, and the average ten and a half acres. The cultivation is in citrus fruits, vines, deciduous fruits, walnuts, alfalfa, summer crops, and olives, ranking in extent of area of each about in the order named.

History of Settlement and Water-right:—Commencing about 1840, and in succeeding years, Ignacio Palomares, owner of that part of the Rancho San José covering the site of these irrigations and extending for some miles around, sold off a number of small pieces of land, composing the present Old Settlement tract, in pieces of a very few acres each, together with rights to water for irrigation from the San José creek. The first settlers were the Alvarado family, who, about the year first above named, dug a ditch which, being enlarged as the settlement grew, and used by all in common, became the present Old Settlement ditch No. 1. Palomares, continuing from time to time to sell land with water-rights altogether undefined as to measure, the settlers, in 1872, denied his right to spread such privileges over a greater area of land—forcing them thereby to share the water with others. At this time four hundred and fifty-five acres had been sold, and to this these water-rights have been limited.

Early in 1875 a movement was made by certain local persons, in their individual capacities, to start another settlement south of the old one, and, deriving water from the same source, the flow from which it was proposed to develop and increase by artificial means. This led to the formation of the Los Angeles Land Improvement and Coöperative Association, which was incorporated a few months thereafter. This association bought from the Palomares all their unsold water-rights in the San José creek flow, and its *cienegas* above the Old Settlement ditch, together with the waters of several other *cienegas* in the neighborhood, and the right

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to develop water in the *cienegas* and throughout a large tract of the artesian land whose location was just then becoming known. It also acquired, for colonizing purposes, a tract of land lying south of the Old Settlement from J. S. Phillips, a former purchaser from Palomares. This was subsequently known as the Phillips tract.

In that year this association took out a ditch from a point about half to three quarters of a mile above the Alvarado Old Settlement ditch, and brought into it waters from other *cienegas*, the chief of which was that since known as the Palomares *cienega*, and lying three fourths of a mile northeasterly. From this latter source there had been for some years a small ditch taking water to the Palomares residence, and hence the flow had become known as the Private stream. Previous to this time not more than one hundred and fifty acres had been irrigated in the Old Settlement—one reason being that the original ditch was too low to command much of the lands which had been sold with water-rights, as already described. Owners of these lands and rights now acquired the right of receiving their waters through the new work, and so a large part of the Old Settlement tracts becoming dependent upon it, in after years it has become known as the Old Settlement, or Old Pomona ditch, while the original one is frequently called the Alvarado ditch.

The Los Angeles Land Improvement and Coöperative Association immediately commenced the development of waters by clearing out and cutting into the *cienegas*, by way of drainage work, and boring artesian wells. Its organizers also formed the Pomona Water Company, to which were transferred their water-rights and privileges. And as lands were sold by the first association, the stock of the Water company was issued to the purchasers at a rate which represented a right to an inch of water for each ten acres. About three hundred acres with water-rights were thus sold, when, in 1879, the association becoming embarrassed, its lands reverted to Phillips, from whom they had been purchased, its undisposed-of water-rights were taken by P. C. Tonner as a creditor, and these latter thence afterwards passed by sale also into the hands of Phillips. The present Pomona Land and Water Company succeeded to Phillips, as will be narrated in the next article. This, meanwhile, left the Old Settlement people in the use of the two old ditches, already described, for the delivery of their share of the water.

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SECTION II.

The Pomona Land and Water Company's Works.

The Four Water Companies and Systems.

District and Works:—The irrigations promoted by, and works of the Pomona Land and Water Company, derive their supplies from the San José creek and its *cienegas*, from other neighboring *cienegas*, from a large number of artesian wells, and from the San Antonio cañon, and distribute them over a district about five miles square, although not nearly all of the lands thus embraced are irrigated. The waters from these sources are brought together into four main works, each having its distributaries, and known severally as the Pomona, Palomares, Del Monte, and Cañon systems. For each of these systems a water company has been organized, and these are known, respectively, as the Irrigation Company of Pomona, the Palomares Irrigation Company, the Del Monte Irrigation Company, and the Cañon Irrigation Company.

The Pomona System:—The works of the first of these organizations take water by means of the Old Settlement ditch No. 2, already spoken of, from the San José creek and its *cienegas*, from the Palomares *cienega*, from the Private stream, and from three groups of artesian wells, known as the Palomares, Mero, and Sparks groups, and numbering in all thirty-two wells, of which thirty-one are now flowing. In general terms, this is the supply collected at and within a mile of the eastern point of the San José hills near to the town. It is conducted southeasterly, an outside distance of two and three quarters miles, and is distributed southerly from this main line, on lands surrounding the town of Pomona.

The Palomares System:—The next system of works under control of and constructed by the Pomona Land and Water Company receive their supply wholly from artesian wells, located but half a mile north of the most northern of those supplying the Pomona system. These are the Hutchinson, Lopez, and Williams wells, five in total number. The main conduit from these leads away southeasterly, parallel to and about three fourths of a mile from the main line of the Pomona system, a distance of three and three quarters of a mile, serving lands in the strip between

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the two mains, above and also east of the Pomona system irrigation.

THE DEL MONTE SYSTEM:—Still farther northeast, and two miles from the Hutchinson and Lopez wells, is found the Martin *cienega*, formed by a natural outburst of artesian waters, and a mile southeast of this is the Del Monte *cienega*, a similar group of springs in marshy ground. In the Martin *cienega* there are seven flowing wells, and in the Del Monte *cienega* eight; and these, with the drainage waters of the latter group of springs, afford the supply for the Del Monte system, the main line of which extends southeasterly through the two *cienegas*, a total length of near two miles, and the distribution pipes lead from it at various points, due south, a maximum distance of two and three quarters miles, serving a region north of the east end of the Palomares sub-district, and east of the area irrigated by waters brought from the cañon as next described.

THE CAÑON SYSTEM:—Lying east and north of the sources of supply to the Pomona and Palomares systems, as already mentioned, and embracing an area whose greatest dimensions are about two and one half miles, north and south, by two miles, east and west, is a sub-district served with waters brought from San Antonio cañon. This area laps over, and is partly within the Palomares sub-district, but for the most part it is above the Palomares line, and between it and the western source of supply to the Del Monte line, and to some extent lies above that source. The main line of supply is a sixteen and twenty-inch concrete, and twenty and twenty-four-inch wrought iron riveted pipe conduit, brought from the point of diversion in San Antonio cañon, already described in the article relating to the Ontario works, southwesterly, down the plain, a distance of about four and a half miles, to a concrete dividing chamber. Here the waters are partitioned between two twelve-inch concrete pipes, and carried thence about a mile and a half farther, to where distribution commences in similar pipes of smaller sizes.

MAIN AND DISTRIBUTION PIPE-LINES:—The following summarization shows the lengths of each size and character of pipe, etc., in each of the four systems:

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System.	Cement or Concrete Pipe.					
	6-Inch.	8-Inch.	10-Inch.	12-Inch.	16-Inch.	20-Inch.
Irrigation Company, Pomona	243	30,585	28,174	14,498	13,191	....
Palomares Irrigation Company	....	15,153	450	....	9,841	8,902
Del Monte Irrigation Company	....	11,211	17,926	8,967	....	3,930
Cañon Irrigation Company	....	....	1,380	21,255	27,691	14,974
Totals	243	56,949	47,930	44,720	50,723	27,836

System.	Iron Pipe.			Cement or Concrete Canal.
	6-Inch.	7-Inch.	20 to 24-Inch.	
Irrigation Company, Pomona	2,640	4,490	....	....
Palomares Irrigation Company	....	....	....	....
Del Monte Irrigation Company	....	....	100	3,382
Cañon Irrigation Company	....	....	775	225
Totals	2,640	4,490	875	3,607

System.	Total Length of Conduit. Feet.	Number of Irrigation Outlets.
Irrigation Company of Pomona	93,821	102
Palomares Irrigation Company	34,046	40
Del Monte Irrigation Company	45,546	41
Cañon Irrigation Company	66,300	17
Total: 45.46 miles	240,013	200

In addition to the above, the Pomona municipal pipe system, belonging to the same general system, embraces about thirty miles of iron pipe ranging from eight and a half down to two-inch.

Cost of the Works:—The total cost of the irrigation works above described is reported to have been about $275,000, of which about $90,000 represents the cost of well boring and water development works, and the balance the cost of main conduits and

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distribution works. This does not include the Pomona City works, which are reported to have cost, approximately, $100,000 additional.

Operation and Maintenance:—The works and distributions of waters by all these four systems are as yet under one general management—that of the Pomona Land and Water Company—although it is intended that as the extent of irrigation by each system approaches completeness, its management shall be turned over to the special Water company whose water-rights serve it. There is a general superintendent of all these works, and *zanjeros* under his direction, who manage the flow and distribution of water.

Irrigators' Water-rights:—In making contracts for the sale of lands the Pomona Land and Water Company at first agreed to convey a water-right by deed with the lands, at the rate of one inch of water to ten acres, which water-right was to be exchanged for stock in a water company to be formed thereafter. The water company, for each system of works being now formed, the contracts for sales recite that the company agrees to convey ten shares of stock of the Water company (naming it) supplying the district in which the tract is situated, with each acre of land and "representing one inch of water, under four-inch pressure measured from center of aperture," to each ten acres of land; said stock to be delivered by the company and accepted by the purchaser "subject to the by-laws of the Water company, when payment in full is made" for the land described.

The provisions of the by-laws to which the above specially refers are as follows: "The stock of this company cannot be transferred, except on the transfer of the land on which the water represented by the stock is used, or of a portion of the land, in which latter case so much of the stock as corresponds to the amount of land sold may be transferred; providing, however, this corporation may, or any of its stockholders may, transfer its or their stock to the Pomona Land and Water Company, or to a trustee for the benefit of the Pomona Land and Water Company, without any transfer of lands; and provided further that said Pomona Land and Water Company, or its trustees, may transfer any of the stock of this company without any transfer of lands." Thus, the water stock is inalienable from the lands to

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which it is attached, except that it may be transferred, without the lands, to the Pomona Land and Water Company, and this company may sell such stock without lands. The stock of the several water companies is at first placed in the hands of a trustee, to be transferred to purchasers designated by the Pomona Land and Water Company. That of the Irrigation company of Pomona is for two thousand four hundred and fifty acres; that of the Palomares Irrigation company is for two thousand acres; and that of the Del Monte Irrigation company is for four thousand acres.

Water-rates and Heads:—Another important provision in the by-laws of each of the water companies is to the effect that the directors shall annually, in April, fix water-rates to be collected from actual consumers, chargeable from month to month if need be, but to have uniform operation in each month upon all consumers according to amount of consumption. It appears, however, in practice, that a fixed and uniform rate of ten cents per hour for a run of water is charged, as a *zanjero's* fee, each time a head of water is turned on to an irrigator. The "heads" used in irrigation are thirty, forty-five, and sixty inches in volume, but the rate charged is the same for all, so that the double volume afforded by the sixty-inch head costs no more than that afforded by the head of thirty inches, for the twenty-four hours. The actual cost of water to the irrigators per acre ranges between 72 cents and $1 92, and averages about $1 30 per year. The by-laws provide also that water shall be furnished only to stockholders, or those who have contracted for stock in purchase of lands from the Pomona Land and Water Company, and that no more shall be charged for water than sufficient to keep the works in order, and properly administer them, except as this may be authorized by a vote of two thirds of the stock of the company.

Old Settlement and Loop-Messerve Distribution:—The Pomona company delivers to the Old Settlement ditch No. 1 and to the old settlers who take water from the Old Settlement ditch No. 2, the continuous flow in bulk to which the settlement is entitled, and the settlers divide and distribute it among themselves as already described.

In the purchase of the cañon water-supply, as hereinafter explained, the Pomona Land and Water Company agreed to deliver

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to those from whom the purchase was made a continuous flow from that source, equivalent to one inch to eight acres for two thousand acres, or two hundred and fifty inches. This water is delivered in bulk at the dividing chamber or "partitioner" before spoken of, and is distributed for the most part in open ditches, under the administration of the organized irrigators of the Loop-Messerve tract, which embraces nearly all of the cañon supply sub-district, already described.

Water-supply and Use:—The supply of water for these irrigations, coming as it does, from a number of sources, and carried in a somewhat complicated system of pipes, is not readily observed and kept track of. Indeed, unless much trouble is taken in the way of unearthing pipes, and specially arranging cut offs, it is difficult even to make an inspection of all the flowing waters, and while one may overlook one supply, some other supply may be twice measured.

San Antonio Creek Supply:—The data given as to supply from San Antonio creek to Ontario should be equally applicable in the present case, seeing that an equal quantity is supposed to be delivered at the headworks to the Pomona company. The creek waters have been specially measured for the Pomona company at various times with results of which the following data, representing half the cañon flow on the dates given, are typical examples of ordinary extremes:

1885.		1886.	
Date.	Flow. Miner's Inches.	Date.	Flow. Miner's Inches.
July 6th (about) . .	410	July 6th about) .	661
August 3d (about) . .	200	August 2d (about) .	589
September 8th (about) .	190	September 6th (about)	444

The company has also a supply of fifteen to twenty-five inches from Kimball cañon, piped and connected with the main cañon pipe-line. The results of the observation and calculations of the state department, on this subject of water-supply, will be given in a subsequent general chapter.

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Cienega and Artesian Well Supply:—This is the part of the total supply which it is difficult to get at with certainty. Moreover, it is variable, to some extent by wells failing, but principally because more wells are continually being bored and connected with the systems. Gaugings made in August, 1885, showed results between four hundred and seventy and four hundred and eighty-five miner's inches as the full flow from all artesian wells and *cienegas* in the settlement.

Gaugings made in October, 1886, showed a total of about three hundred and seventy to three hundred and ninety miner's inches as the aggregate amount of flow from such sources due to the Pomona Land and Water Company's systems.

IRRIGATIONS:—The irrigations under the Pomona Land and Water Company's systems, for the present year (1888), are about as follows: Pomona system, one thousand eight hundred and eighty acres; Palomares system, four hundred and eighty; Del Monte system, five hundred and twenty acres; Cañon system, two thousand and forty acres. Of the last amount about one thousand eight hundred acres are in the Loop-Messerve tract, wherein distribution is not under control of the Pomona Land and Water company, but for which they contract to deliver a constant stream of two hundred and fifty miner's inches. In addition to the foregoing, is the irrigation of about four hundred and fifty-five acres under the Pomona Old Settlement works, making in all, for the settlement, five thousand three hundred and seventy-five acres. There are no exact statistics available as to the cultivation in this neighborhood, but it is thought, from close observation, that commencing with deciduous fruits at somewhere between one thousand five hundred and one thousand seven hundred acres as a maximum, and ending at summer crops at somewhere between two hundred and three hundred acres as a minimum, the cultivation is about proportionally divided between deciduous fruits, vines, citrus fruits, alfalfa, and summer crops, in the order named. There are in the entire settlement about four hundred and fifty-five individual irrigators, of whom about forty-five are of the Old Settlement tract, and as many more in the Loop-Messerve tract, leaving three hundred and fifty-five to three hundred and sixty, to whom the Pomona Land and Water company distributes direct from its four systems.

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History and Water-right:—About 1847, Ignacio Palomares, one of the owners of the Rancho San José, took out a portion of the waters of San Antonio creek in an open ditch. After using it for about three years, he temporarily abandoned its use, consequent upon there being abundant rainfall and damage to the work. About 1852, N. Alvarado took up a squatter claim on the San José ranch, near the course of an arroyo flowing from the San Antonio creek, and took out a ditch from the creek to his squatter claim, which he called Rancho San Antonio. The Palomares ditch was taken from the cañon proper, and the water was brought thence, in a southwesterly direction, to the old San José Rancho house, which was located at a point about two to three miles north and east of the present site of Pomona. Alvarado the elder abandoned his ditch and claim, and in 1862 Alvarado the younger took out another ditch and re-claimed the old ranch. Alvarado's ditch took water several miles below the San José ditch and brought it to Indian Hill, a bit of old mesa left standing in the plain four miles northeast of Pomona. Palomares finally bought out Alvarado's squatter claim and took possession of the Alvarado ditch, about 1863 or 1864. Palomares in the meantime continued at times to use the original San José ditch, and subsequently used both the old ditches, as occasion required. In 1874, Palomares sold two thousand acres of the San José rancho and all his interests in the San Antonio cañon, and from that time to 1882, the purchasers, Loop and Messerve, used the original San José ditch to furnish water for summer irrigation, and also used the Alvarado ditch, out of San Antonio arroyo, in winter.

The Pomona Land and Water Company was incorporated in October, 1882, with a capital stock of $500,000, divided into five thousand shares. It acquired the lands and water-rights of the old Los Angeles Land Improvement and Coöperative Association, which, as explained in the foregoing article, had passed into the hands of Phillips. It bought the old San José ditch, with its appurtenant water-rights, in San Antonio cañon, and has since obtained the exclusive right to develop water by means of artesian wells over a considerable portion of the lands believed to be "water-bearing" in the neighborhood of the original *cienega* supplies. After some litigation a compromise was effected with the San Antonio Water company, which had secured the claims and riparian rights to water on the east side of San Antonio creek, so that the supply should be equally divided, up to the capacities of

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the respective works; and thus the Pomona company has half of that supply, undisputed. But in this arrangement it was agreed that each of the two companies were to take care of certain adverse claims, each on its own side of the creek; and so the Pomona company has recognized several claims, and delivers small supplies in distribution under them.

The Pomona Land and Water Company managers have organized four water companies into whose hands to transfer its several water interests and works as elsewhere explained. These are: (1) The Irrigation Company of Pomona, incorporated July, 1886, with a capital stock of $245,000, divided into twenty-four thousand five hundred shares, and with the provision that its system and water-rights may be extended to cover two thousand four hundred and fifty acres of land. Ten shares of stock being issued with each acre sold; there have thus far been four thousand one hundred and forty-four shares transferred to purchasers, but a larger number are under contract to be transferred when the lands with which they are sold are fully paid for. (2) The Palomares Irrigation Company was incorporated February, 1887, with a capital stock of $200,000, divided into twenty thousand shares. The stock is issued at the rate of ten shares to the acre sold, and thus far one thousand one hundred and forty-three shares have been issued, with contracts out for more, as in the case above. (3) The Del Monte Irrigation Company was incorporated in February, 1887, with a capital stock of $400,000, divided into forty thousand shares, with the proviso that the water-rights might be spread over four thousand acres of land at the rate of ten shares of stock to the acre. In October, 1880, there had been transferred to purchasers of lands four hundred and forty shares of stock, contracts being out for a greater number. (4) The Cañon Irrigation Company: details not available at time of writing.

SECTION III.

Sundry Other Water Developments.

In the Pomona Neighborhood.

There are several independent water developments and irrigations in the Pomona neighborhood, of which those known as the Fleming and Rohrer, the Packard, and the Gird or Chino rancho,

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are the most notable. The location of these is here indicated. Data of water-supply and use will be given in the closing summarizations under these general headings.

Fleming and Rohrer Works.

A half mile east of the line, in San Bernardino county, and just east of the wash of San Antonio, there is one of those remaining parts of the old mesa formation cut away by denudation, to which reference has already been made. Due west a mile and a half and west of the creek is another such bit of mesa, known as Indian hill. A flow of water has been obtained by tunneling into each of these. The enterprise at the eastern location is that of Messrs. Fleming and Rohrer. The waters are piped thence and used some on the east side in San Bernardino county, just north of Ontario, but the greater part is carried across into Los Angeles county, and used north of the Loop-Messerve tract of the Pomona neighborhood.

The Packard Works.

The water developments in Indian hill are of the Packard system. The waters are piped and used in the northern part of the Pomona neighborhood. The Packard Orange Grove tract is situated west of the Old Settlement tract, and in the opening of San José pass. Its waters are derived from artesian wells, in the belt above Pomona, already described, and piped to the location of use.

The Chino Works.

District and Work:—For irrigation and domestic use on lands of the Chino ranch, lying southeast of the Pomona districts, and bordering the Ontario neighborhood on the south, an artesian-well supply is being sought within the Pomona artesian belt. The district to be served is in San Bernardino, but the waters being of this Los Angeles county source, the works are spoken of at this place. The lands are amongst the richest in San Bernardino county, lying favorably for irrigation, and with soils which cultivate well by the system. Sloping down from the higher plain whereon is Ontario, to the moist belt along Chino creek, and in the Rincon, as described in Chap. VI., ground waters are found throughout a large section of this tract, which in all is something over twenty thousand acres in area, within thirty feet of the surface, and thorough cultivation renders a high duty of water, in irrigation, possible.

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ARTESIAN WATER-SUPPLIES:—In the western part of the tract, within the moist-land belt, at elevations between seven hundred and seven hundred and twenty-three feet above the sea, there are five artesian wells, having a combined flow of forty-two to forty-five miner's inches; but the supply from these commands only lands which do not absolutely require irrigation. Again, at a point about three miles southeast, and near the edge of the moist-land belt, another artesian flow has been obtained, but this also is not available where most needed. And so, flowing waters, doubtless, can be had over a very large part of this plain, but, within this tract, not high enough to irrigate its dry lands.

Under these circumstances a supply was sought for on higher ground and within the Pomona and artesian belt. The right to develop water was bought upon quite a large tract there, and boring work has been in active progress with four or five artesian well outfits during the present year. The locality of these developments is about a mile or more east of the Palomares and other groups of wells of the Pomona, or lower, system of the Pomona Land and Water Company. Here, where the ground elevations are between nine hundred and seventy and nine hundred and eighty-five feet, rising water is found in a number of strata at one hundred and fifty to five hundred feet of depth.

An examination made in August, 1888, showed that there were of this Chino system six wells, nine and a half inches in diameter each, which were yielding above the ground's surface an aggregate flow between sixty-five and seventy inches, and there were several other old wells of much less output which belonged to the same enterprise. More wells have since been completed, and all have been tapped at six or eight feet below the surface, so that there probably now is a greater supply at command.

MAIN PIPE AND DISTRIBUTION:—The waters thus obtained are collected from the several wells which are half a mile or more apart from the extremes, and carried southeasterly in a cement pipe conduit to a central point on the northern line of the Chino tract sought to be irrigated. Here there is a small reservoir from which distribution is being made southerly, also by a pipe system.

At the time of inspection about nineteen thousand feet of sixteen-inch and three thousand five hundred and fifty feet of twelve-inch cement pipe had been laid for the main conduit, and work was in active progress on the distribution works.

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IRRIGATION:—As yet there is no irrigation from these works, which are just in progress of development. The waters from two of the wells down on the Chino ranch are taken by a small iron pipe to the Chino ranch house, a distance of about three and a half miles, and there used for domestic purposes and irrigation of a small orchard and garden.

ARTESIAN WELL IRRIGATIONS.

San Bernardino County.

There are nearly five hundred artesian wells in the San Bernardino basin; most of which are small, two and three-inch wells, sunk for domestic supply only, in the city of San Bernardino. A large number, outside of the city—of between one hundred and fifty and two hundred—varying in diameter from seven to eleven inches, and in depth from sixty to five hundred feet, are each in some degree utilized in irrigation. The principal groups of these have been spoken of in describing works and irrigations to which they contribute. There are others of considerable irrigation importance, as, for instance, those of the Waterman private estate just east of San Bernardino. The data of about four hundred of these wells has already been published in the volume of Physical Data and Statistics of California, issued by the state engineer in 1886. It is hoped that a resumé on this subject of artesian wells and irrigation therefrom, will be embodied in this report before closing, and therein will be found much additional information on the subject.

[This paragraph should be read at the close of chapter XIII, and should be on p. 364 *ante*.]

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CHAPTER XVI.—LOS ANGELES[3]; WORKS AND PROJECTS[13].

SAN GABRIEL VALLEY IRRIGATIONS.

SIERRA MADRE CAÑONS GROUP[7].

SAN JOSÉ SUB-GROUP[8].

SECTION I.—*San Dimas Cañon Works:*
San Dimas Land and Water Company;
San José Ranch Company;
San José Land and Water Company.

SECTION II.—*Dalton Cañons Works:*
Glendora Water Company;
Alosta Water Company.

SECTION I.

SAN DIMAS CAÑON WORKS.

Rights to the waters of San Dimas cañon are claimed by the San Dimas Land and Water Company, the San José Ranch Company, and the San José Land and Water Company. The two first organizations work in harmony, and the last is a rival association in conflict with the others.

The San Dimas Land and Water Company.

District; Work; Irrigation, etc.:—Previous to 1885 the water-rights of San Dimas cañon were held by three individuals who had constructed a work out for the use of the waters on the east side of the cañon, upon the bench-lands there lying close to the mountain's base. These rights were in that year consolidated into the San Dimas Land and Water Company, which is operated exclusively as a water company—furnishing waters to its stock-

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holders only. Its capital stock is $60,000, divided into one thousand two hundred shares, which are held by eighteen stockholders. Of this number eight are actual irrigators, whose aggregate cultivation by irrigation covers about one hundred acres, for the most part planted in citrus fruits. The works and water-rights of this company have been sold, under certain conditions, to the organization next spoken of, as will be presently explained.

San José Ranch Company.

District and Works:—The San José Ranch Company controls a tract of several thousand acres lying south of the San Dimas wash, and extending from the crest in the plain between the San Bernardino and San Gabriel valleys down the western slope into this latter valley, and to the borders of the district which will hereafter be described as served in irrigation by the Covina ditch. Its water claims cover the flow of San Dimas cañon, with certain developments in Sycamore Flat cañon, and the output of Mud Springs, a *cienega* supply at the base of the San José hills about two miles south of the San Dimas cañon opening.

DEVELOPMENT AND DELIVERY:—The company has driven four tunnels in Sycamore Flat which have developed twelve to fourteen inches of water. This work has just begun, it is claimed, and a further prosecution is in order during the coming season. The tunnels are three hundred, four hundred and fifty, fifty, and five hundred feet in length, respectively. In the upper portion of San Dimas cañon the company has expended several thousand dollars in works of trenching and piping and construction of roads preparatory to tunneling there, for the purpose of water development. But litigation with the San José Land and Water Company, as elsewhere explained, has stopped the work for the present.

Main Pipe-line:—The San José Ranch Company has a contract with the San Dimas Land and Water Company whereby it is to take the works and rights of the latter association, and to supply its stockholders in return with a constant flow of thirty miner's inches of water delivered out upon the mesa and at a point about the head of present distribution by the San Dimas company. The work of the old San Dimas Land and Water Company consisted of about eight thousand feet of ten-inch pipe, in part of iron and part of cement, extending out from a masonry head-work in the

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creek bed just below the cañon mouth. The San José Ranch Company has laid out from the same point a fourteen-inch pipe, in part of iron and in part of cement; and has laid for distribution of their waters derived from this source as well as from Mud Springs *cienegas* and artesian wells, about twelve miles of eight to ten-inch pipe principally of cement.

Water Development Tunnel; Artesian Wells:—In the Mud Springs *cienegas* there have been eighteen to twenty artesian wells sunk, of which thirteen are flowing. These wells pass through beds of water-bearing sands and gravels, alternating with clay, to depths ranging from two hundred to two hundred and twenty feet, where they encountered a shale, and were stopped. A tunnel about seven hundred feet in length has been driven from below the *cienega* lengthwise through it, with the view of drawing its waters out at a lower level, and of tapping the artesian well tubes twenty-five or thirty feet below the surface of the ground. The total amount of water thus far developed by this tunnel is about twenty-five miner's inches; the wells yield ten to fifteen miner's inches, so that the total output from this source does not exceed forty inches. The company has thus far expended in water development, pipe laying, etc., about $115,000.

Operation and Maintenance:—The plans of this company are not fully developed in the matter of organization and distribution. It was incorporated solely as a land company, but its by-laws provide that it shall act as a water company in acquiring and developing and piping water until such time as a water property has been obtained sufficient to justify the formation of a water company to manage it. The plan is to form this water company in the immediate future upon the basis of ten shares to each inch of water, and these shares will be issued to the land purchasers in exchange for the water-rights which have thus far been issued. Pending the development of water-supply, the contracts of purchase which the land company made with its customers give the purchaser a guarantee of supply of water at the rate of one inch continuous flow to ten acres, and give him the option, in case the company fails to obtain sufficient water to meet its contract, to cancel the contract at the expiration of certain times named, taking back the purchase money, or to take the land without water, with a certain rebate on account of non-delivery of

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water. The company obligates itself to use every reasonable endeavor to obtain or develop a water-supply for all lands thus contracted to be sold. Several thousand acres have thus been disposed of in small parcels.

Water-supply and Use:—There were during the past season seven actual irrigators and about one hundred and twenty-five acres under irrigation. The towns of La Verne and San Dimas lie within the scope of this company's operations, and are served by it. The water-supply is elsewhere reported.

History; Claims:—The San José Ranch Company was incorporated in 1886, with a capital stock of $300,000. It claims the water of the San Dimas cañon, upon the basis of its claims to land embracing this cañon for several miles of its course through the mountains above, and upon the basis of its contract with the San Dimas Land and Water Company, heretofore referred to.

San José Land and Water Company.

District; Work; Irrigation, etc.:—This company has several hundred acres of land in the gore north and west of the San Dimas wash near the mouth of the cañon, and south of the mountain slope, and owns a tract of land embracing the bed of the cañon, about two miles from its mouth. At this latter point it has driven a tunnel through a spur of the mountain, around which the cañon bends, with the intention of cutting the gravels of the channel near to bedrock and thereby developing or drawing out the underflow of the stream. The tunnel is about six hundred feet in length, of which a hundred feet are in loose debris and five hundred feet in solid bedrock; it is three and a half and two and a half by six feet in area, and the contract price is $8 per linear foot for the work alone—the company furnishing everything. The work is not yet completed and a stream of about eight miner's inches has thus far been obtained. From this point a wrought-iron riveted pipe thirteen inches in diameter has been laid at a length of twelve thousand feet out to the lands of the company. As yet, the water has not been used by this system and no organization for its distribution has been effected. The claims of this company are in direct conflict with those of the two next before spoken of, and there is litigation pending as to the merits of the respective claims.

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SECTION II.

The Dalton Cañons Works.

Glendora Water Company.

District and Works:—The Glendora irrigation neighborhood is situated immediately west of the opening of Big Dalton cañon, and extends from the mountain's abrupt base down the sloping plain, a distance of about a mile and a quarter, to the line of the California Southern railway, and includes the town of Glendora. It is at the extreme head of San Gabriel valley, in its northeast corner, and occupies a bit of bench-land which slopes down to, and commands a pleasing outlook upon, the lower plain. The soil is generally an ashen brown alluvial of various grades, which accepts water freely and does not wash readily. Next the mountain base the gravel-filled bench-land soil predominates, and in the lower part the soils of the tract are more sandy. As a whole they are suited for cultivation under irrigation, and under thorough cultivation retain moisture well.

Development and Delivery:—The Glendora Water Company's works take the waters of Big Dalton cañon, for domestic supply and irrigation, to and upon this tract, which is seven hundred and seventy-six acres in area. The work embraces two water development tunnels in the cañon, a pipe-line thence out to and around the head of the tract, several small reservoirs along the route, and a system of pipes for distribution.

Water Development Tunnels:—At an elevation about one thousand and eighty-five feet above the sea, the lower tunnel is somewhat over a mile within the cañon, which is quite open that far, and of grade not exceeding about ninety to one hundred and twenty feet per mile. The tunnel starts in the bed of the cañon, soon gets through the gravel into bedrock, passes under a point of the mountain on the east side of the cañon, a total length of one thousand three hundred and ninety-four feet, and is to be extended forward to underdrain a side valley which enters a few hundred feet farther on. It was not intended so much to acquire the waters of underflow in the cañon gravels as to drain out those which it was believed from the appearance and character of the mountain side were to be had from fissures in the rocks there.

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The upper tunnel, situated about three thousand eight hundred feet farther up the cañon, is three hundred and eighty-five feet in length, and was driven to underdrain the gravels of the creek.

Main Pipe and Reservoirs:—A six-inch cement and two-inch gas pipe leads from the upper tunnel to a shaft dropping into the lower tunnel about two hundred and fifty feet from its head, a distance of two thousand seven hundred feet, and with a fall of about one hundred feet, and thus carries all the water yielded by the upper tunnel during the dry months when the tunnel supplies are required. Into this shaft surface waters of the creek are also dropped by means of a diverting box and short piece of flume, so that the lower tunnel becomes the main conduit of the work, for all waters taken by it, thence to the head of the pipe-line which is about two hundred feet within the tunnel mouth. Thence a twelve-inch cement pipe is laid to and along the mountain's foot on the west side of the cañon, a distance of seven thousand four hundred and three feet, to reservoir No. 2, with a fall of about one hundred and fifteen feet, and then the conduit is ten inches diameter for six thousand three hundred and fifty-five feet to its end, at reservoir No. 5, which is about two hundred and fifty-five feet below the main tunnel mouth. There are five little reservoirs excavated in the bench at the foot of the mountain slope at points along the last mile and a half of the route, whose aggregate capacity is three million four hundred and fifty thousand gallons—the smallest holding half a million and the largest a million and a quarter gallons. They are lined with rock and cemented, as elsewhere described for others. The distribution pipe system for the irrigation of the tract generally is not yet laid. The town supply is delivered in iron pipes, of which about fifty-six thousand feet, ranging in size from four-inch down to small house-service pipe, have been laid.

Cost of Works:—The total cost of works, including tunnels, main, and distributing pipes, reservoirs, etc., has been about $52,000. This includes also certain water-rights and lands covering portions of the cañon. The main tunnel cost $12,227, or $8 76 per foot on the average. The upper tunnel cost about $6 per foot, or $2,110. The main pipe-line from lower tunnel to reservoir No. 5 cost $10,235, or about 74 cents per linear foot.

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Operation and Maintenance:—The Glendora Water Company has not adopted any system relative to the issue of water-rights, other than to transfer its stock to the owners of the several parcels making up the tract to be served; and it is not yet determined just what will be done in this regard. The individual owners of the lands may simply sell their stock with land, or there may be an arrangement for the company to supply water to irrigators, and the stock remain with the original holders as a separate property.

Water-supply and Use:—The season of 1887–1888 is the only one in which the work has been in use. The water-supply during the winter, and as late as the end of June, 1888, was abundant for all demands. By the last of September it had fallen to about ten miner's inches, including the flow from both tunnels. There is no irrigation service as yet and no practice under the works. Thus far they supply only the inhabitants of the town of Glendora for domestic purposes.

History and Water-rights:—The Glendora Water Company was formed in March, 1887, with a capital stock of $62,500, divided into one thousand two hundred and fifty shares. Its organizers were those persons who owned the lands embracing the opening and bed of Big Dalton cañon for about two miles within its mouth. These pooled their interests, transferred them to the water company, and took its stock in payment. They were seven in number, and the stock is yet held by them. The company acquired the rights of several very small ditches which had before been used by some of its projectors in individual orchard irrigations, and upon these and its ownerships of the lands covering the flow of the cañon stream during the summer rests its right to the waters. The seven individuals who formed the water company each owned some irrigable land on the bench adjoining and west of the cañon opening. A tract of seven hundred and seventy-six acres thus owned was made up of adjoining parcels, and to it, by agreement preceding the formation of, and afterwards ratified by the company, the waters were made appurtenant in the proportion in which the several owners subscribed to the stock of the company, which was nearly, but not quite, in proportion to the extent of their ownership of the land. Three of these Glendora Water Company owners merged two hundred and ninety-

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six acres of their lands into the Glendora Land Company, and on this tract was established the town of Glendora.

The water being an appurtenance to the lands named, the water company cannot sell or rent water to be used on lands other than those specified, until the owners and inhabitants thereof are first supplied. The agreement says: "If the waters at any time should be more than sufficient to supply the lands and the inhabitants thereof, to which it is made appurtenant, or to which it is first distributed, then the said Glendora Water Company shall distribute to certain other lands of its organizers;" and after this lands of outside parties can be supplied.

The Mountain Base Water Company was incorporated with a capital stock of $75,000, divided into five thousand shares, in April, 1887. This company had acquired one hundred and twenty acres in part covering the Big Dalton cañon above the lands of the Glendora Water Company, and had done some work of water development there. The Glendora Water Company acquired nearly all the stock of this company in March or April, 1888. So that the Glendora Water Company is the controlling stockholder in the Mountain Base Water Company. This particular portion of the water-right of the Glendora Water Company is not tied, under the agreement, to the land of its organizers below; and, as a matter of fact, under this right that company is now supplying the railway company with water at Glendora station. The works of the Glendora Water Company were commenced in March, 1887, and completed, as described, in March, 1888.

SUNDRY SMALL IRRIGATIONS.

There are along the mountain's base within the scope of country to which this chapter applies a number of quite small water developments and irrigations, some data concerning which will be presented in later special chapters and summarizations.

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CHAPTER XVII.—LOS ANGELES[4]; WORKS AND PROJECTS[14].

SAN GABRIEL VALLEY IRRIGATIONS.

SIERRA MADRE CAÑONS GROUP[2].
SAN GABRIEL RIVER SUB-GROUP[b].

SECTION I.—*Azusa Irrigation District Ditch:*
The Old Settlement;
The Dalton Zanja;
Equality of Water Apportionment;
The Old Azusa Water District;
The New Azusa Irrigating Company.

SECTION II.—*Azusa Water Development and Irrigation Company's Canal:*
The Higher Grade-line Work;
Construction of the Cement Canal;
Cemented Distribution Ditches;
The Water Development Tunnel;
Formation of the A. W. D. & I. Co.;
The Duarte-Azusa-Covina Ditch War.

SECTION III.—*Duarte Mutual and Beardslee Company's Works:*
The Duarte District;
Joint Canal and Partitioner;
Distribution Principles and Practice;
Ancient Mission Irrigation Work;
The Old Duarte and Beardslee Ditches.

SECTION I.

THE AZUSA OLD DISTRICT IRRIGATIONS.

The Dalton or Azusa Ditch.

District and Work:—The Azusa irrigation neighborhood lies south and east of the San Gabriel cañon opening and of the wash of the San Gabriel river which extends thence southwesterly into the valley. Immediately next to the wash is a belt of very poor,

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gravelly, and rocky land—an ancient wash of the stream—well over a mile in width, and east of this lies the cultivable lands of the country. The upper end of the tract is within the Azusa rancho for two miles and a half from the cañon mouth; east and south of which are lands preëmpted for a mile or two, and known as the Old Settlement lands, and further south are lands of the Rowland rancho. The old Azusa or Dalton ditch serves lands of the Azusa rancho, and lands of the Old Settlement. The Azusa Water Development and Irrigation Company's canal serves land of the Old Settlement, some higher lying lands east thereof, and lands of the Rowland rancho farther south.

MAIN AND LATERAL DITCHES:—The Azusa ditch is, considering the importance of its irrigations, the value and possible extent of its water-right, and the accessibility of its district, amongst the poorest in Southern California. It is, except as to its heading, yet no better than it was years ago when the whole southern country was in a primitive condition. The ditch is still a rude excavation, much grown up with weeds and most wasteful of its waters.

Head Works:—In connection with the Duarte Mutual and the Beardslee companies, who lead their shares of the waters across the river, the Azusa people have of late years constructed a new heading to their ditch, but this is the only noticeable improvement or departure from the old ways.

The San Gabriel cañon opens from the mountains, while lying in an east and west direction, and then hugs the mountain's footing westerly. The mountain base, from its south side, extends due south about a mile, and then swings off to the east towards the Glendora country. The three old ditches, the Azusa, Duarte, and Beardslee, receive their waters by a tunnel driven through this point of mountain where its base swings sharply away from the cañon opening. This tunnel is seven hundred and ninety-five and one half feet in length, through solid rock, is six feet high, five feet wide, and with its top in arch form. Starting at the level of the bench at its lower end, which is eight or ten feet above the river bed several hundred feet north, it is driven nearly level through the point and taps the main channel of the river about two feet below the level of its bed there. The contract price on this work was $9 per linear foot, but extra charges brought it up to nearer $9 50 per foot.

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Immediately at the lower end of this tunnel the Covina (A. W. D. & I. Co.'s) canal is located close along the base of the mountain. Across this the Azusa ditch waters are carried in a flume, as elsewhere described, and to the Old Azusa ditch several hundred feet away, where they are divided—those of the Duarte and Beardslee apportionment going on westward, and those of the Azusa share dropping into the Old Azusa ditch.

The Old Ditch:—This old work then follows southerly along the flat land, several hundred feet from the mountain's base, for about a mile and a quarter, swings around the point easterly on the plain about an equal distance, then trends on grade southerly about three and a half miles; having a total length, allowing for windings, of about six and a half miles. Its branches take off to the west and south, down the slope of the plain. Of these the Squatter's, Maxey, Justice, Neal, Buchanan, Vaughn, and Azusa Extension are the most important, and have an aggregate length of about sixteen miles. All of these, like the principal work itself, are simple earth-excavated ditches.

The main ditch has capacity, depending on its condition, to carry between seven hundred and a thousand one hundred miner's inches; but it is doubtful whether it could at any time with fair degree of economy, even for a ditch of its class, actually deliver in irrigation over four hundred and fifty to five hundred inches. For about one and one third miles it is located over a bowlder bed, on grades of about sixty feet per mile; thence for about two and a half miles it has a grade of about seventeen feet per mile; and thence, to the end, on varying grades, according to the slopes of the country, ranging at about twenty feet per mile. Its cross sectional dimensions are very variable and significant only when taken in connection with local grade slopes carefully ascertained. Its largest dimensions are four feet bottom width, two and a half feet depth, and seven feet top width.

Operation and Maintenance:—In the Azusa old district the principle was long ago laid down that each irrigator, no matter what the extent of his land holding, was entitled to no more water than any other irrigator, no matter how small his tract, down to the limit of twenty acres. This measure of land was made the gauge of the water distribution system—each irrigator was accorded enough water to irrigate a twenty-acre patch, up to

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the limit of the supply. If a large tract was divided amongst several owners, each was accorded a share of water to the same extent as every other irrigator in the district; but no one might, by acquiring irrigated land, reverse the order of things and obtain for his own use more than one share of water, even though he bought out several other irrigators. The rotation periods have varied between ten and fourteen days. When the supply has been short and the period became longer than fourteen days, the runs have been shortened to reduce the period.

All this is now being changed, however. The old ditches are under control of the new Azusa Irrigating Company, and the distribution is for this season being made in proportion to acreage cultivated by irrigation, without restriction as to the extent of such cultivation any one may carry on. The water is distributed in "heads," which theoretically are one hundred miner's inches. In time of plenty these heads are more than the standard. In time of scarcity they are always less, and particularly so towards the lower ends of the ditches, where the loss in delivery is greatest. The distribution has been made in "runs" to each individual, which in seasons of plenty were twelve hours in duration, in ordinary seasons were six hours, and in very dry years only three hours long. But now, as already stated, the system is being changed, so as to distribute by schedule, according to acreage irrigated.

The charge for water as yet is $1 50 for a day run, and 75 cents for a night run, regardless of the length of the run. In some past years, 1880 for instance, the charge for water has been as low as $1 per head for a day run, and 50 cents for a night run. The charge is to cover cost of operation and maintenance only, and is applicable only during the irrigation season, from May to October, inclusive. There is no charge for water during the other six months of the year, and the demand being light, the irrigators take it at will.

A *zanjero* is in charge of distribution during the irrigation season, and his pay constitutes the larger part of the cash expenditure incurred for management of the works. The annual outlay amounts to: For *zanjero* and assistants, $800 to $850; for repairs, etc., to gates, etc., $100 to $150; totals, $900 to $1,000. Besides this, each irrigator is expected to work twelve days per year on the work of cleaning the ditches and reconstrucing the works at

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the head, etc. This extra labor on the ditches has ranged from two hundred and fifty to five hundred days per year, which has been rated at $1 50 per day. This would add $375 to $750 per year to above costs of maintenance and operation, making the total, say, $1,600 per year. In this season about one hundred irrigators are supplied through the old ditch and about thirty-eight of the old irrigators receive their waters through the new (Covina) ditch, making one hundred and thirty-eight in all.

The Azusa Irrigating company supplies water only to its stockholders; these are prohibited by the by-laws from using it on lands to which their stock is not attached; and the water is made an appurtenance to the lands, to the extent that it, practically, has to be deeded back to the company before it can be attached to any other lands.

Water-supply and Use:—Except in years of most extraordinary drought and except of late years since rival appropriators have divided the flow, the water-supply for this ditch has always been quite abundant. If there has been at times general scarcity for the irrigations, the fact has been largely due to the great loss of water in transit from the river to the lands. The stream has, in all but two or three years of extraordinary drought, presented an abundant flow to serve all the lands yet watered, if only it were taken out and delivered with any reasonable amount of economy of the supply.

IRRIGATION:—Irrigation commenced under this ditch at an early period in the development of this southern agriculture. In 1879 there were about two thousand acres thus under cultivation. In 1881, according to statistics collected for the state engineer, there were ninety individual cultivators by irrigation in this district, whose total area of irrigation was two thousand two hundred and forty-five acres. The total area cultivated by these farmers was five thousand eight hundred and ninety-two acres, of which two hundred and seventy-five was in orchard, ninety-four in vineyard, one thousand two hundred and fifty-seven in summer crops, six hundred and eighty-seven in miscellaneous crops, of which the castor bean was the most prominent, and the balance was in cereals and pasture or hay.

In 1887, carefully collected data gave approximately the following results: Number of irrigators, ninety-seven; extent of district,

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four thousand nine hundred and fifty acres; waste, brush and wash land, one thousand two hundred acres; leaving three thousand seven hundred and fifty acres cultivable; of which two hundred acres were cleared but not cultivated, leaving three thousand five hundred and fifty acres cultivated; of which four hundred and fifty acres were lying fallow, leaving three thousand one hundred acres cultivated for the season; of which five hundred and fifty acres were in grain, leaving two thousand five hundred and fifty acres irrigated during the summer; and this was cultivated, nine hundred and thirty acres in summer crops, two hundred and sixty in alfalfa, four hundred and thirty in deciduous fruit trees, three hundred and seventy in oranges, and five hundred and sixty in vineyard. This was by the use of a little over two thirds of the water due to owners in the ditch, the balance being run through the Covina ditch.

History and Water-right:—The grant of the Rancho Azusa was made in 1842 to Luis Arenas, who in the following year constructed a small ditch carrying about one "head" of water (one hundred inches, approximately), practically on the line of the present ditch, for irrigation near the mouth of the cañon. This ditch was enlarged in 1852 or 1853 by Dalton, into whose ownership the rancho had come, to carry about two heads of water, and so remained until 1868. In the meantime, the extent and boundaries of the rancho were in dispute: Dalton claiming several leagues, covering pretty much the whole valley. Settlers came in and squatted on the lower portion of the rancho as thus claimed. The United States commission, appointed to adjust disputed boundaries of Mexican grants, accorded Dalton only one league of land. The very fields he had in cultivation by irrigation were declared not to be on his grant. Other settlers rushed in to preempt, but the major part of the irrigated lands were taken up by Dalton's friends, relatives, or connections, and, as was supposed, primarily for his benefit. Subsequently these lands were sold by these claimants to other parties, Dalton, it is said, assenting to the sales, and verbally acknowledging the rights, by use, to water for irrigation, which went with the lands.

Matters now went on smoothly as to irrigation and water-rights under the Azusa ditch until 1866, when, consequent upon the passage of a law by Congress, reopening questions as to the limits

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of Mexican land grants in California, Dalton again laid claim to all lands formerly claimed by him, and refused to run water for irrigation through his ditch to the fields of settlers below.

The Azusa Water District:—Questions as to water-rights as well as land titles were thus again brought into litigation, and all was in confusion. In March, 1871, on petition of the settlers, the San José water district or township was established by the county supervisors, under the act of legislature of 1854, and the Azusa ditch and the distribution of water therefrom was taken in hand by the water commissioners of the township. The first election of commissioners was in September of that year, when fifty-nine votes were cast in the Azusa precinct. In 1868 Dalton called a meeting of the settlers, and stated to them that there was really water enough in the river for all concerned, and that he was tired of litigating over it, and that if they would enlarge the ditch to carry all that was needed, he would withdraw his objections to their using enough for their lands; provided, that should he gain the pending suits as to title to the lands, he was to have all the water without adverse claim on their part; and should they succeed in the land cases, he would acknowledge their right to an equitable share of the water. The settlers then enlarged the ditch to carry about five heads, or five hundred miner's inches of water.

In May, 1873, the Azusa township was formed out of the northern part of San José township and the eastern part of San Gabriel township, and embracing the lands now in both the Azusa and the Duarte irrigation settlements, so that these both came under one board of water commissioners. Matters went on in this way (the questions of the limits of the Azusa grant and title to the land held by settlers, still undetermined) until 1874, when Dalton commenced suit, claiming all the water, and seeking to enjoin all others from using it. In 1875 the land cases were decided in favor of the settlers, but litigation over the water continued, pending the result of which, by stipulation between the attorneys, three fourths was run to the district irrigators and one fourth to the Dalton; and in 1879 all parties agreed to leave the distribution entirely to the commissioners of the district. In the meantime, in May, 1877, an election was held to establish the Azusa water district under the law of 1874, known as the Bush Act; but this appears to have failed, for only nineteen votes were cast. In 1878 the boundaries of the township were changed so that it no

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longer embraced the Duarte irrigation neighborhood, and the Azusa people, continuing to elect their water commissioners under the law of 1854, had a board entirely to themselves.

Between 1880 and 1883, by foreclosure of mortgages and otherwise, the Azusa rancho came into the ownership of J. S. Slauson of Los Angeles, and — Martz of Michigan; and in the latter year these commenced suit in the superior court of Los Angeles county against the settlers for a division of the waters, claiming one half of the full flow of the Azusa ditch. The complaints in this suit were, on demurrer, several times set aside. The Slauson interest was then transferred to Martz, who, being a citizen of Michigan, brought a suit of similar nature in the United States circuit court. Pending a decision in this case, a compromise was arrived at between Martz and a majority of the settlers, and entered as a decree of the court, whereby the rancho was accorded seven twenty-fourths of the use of the water, and seventeen twenty-fourths were allowed to the district or the settlers in the district; with this stipulation, namely, that all waters of the rancho's apportionment not needed on the rancho lands were to flow unobstructed to the settlers. This adjustment was finally arrived at in 1884.

Up to 1863 the Azusa people claim there had been no diversion of water from the river on the west side, except as there was a surplus over and above the diversion by the Azusa ditch on the east side. In the fall of that year and the following, the supply being very short, by courtesy from Dalton's agent (Dalton himself being in Mexico), water was turned down the stream past the Azusa ditch two days in each week to supply the Duarte ditch for purposes of watering cattle, there being very little if any cultivation under the Duarte ditch and dependent on it at that time of year. Upon the strength of this precedent Duarte afterwards claimed one third of the flow of the San Gabriel at all times, and afterwards, when the irrigated lands on both sides of the river were put into one irrigation district under the law of 1854, the commissioners recognized the claim, and so it has stood to this day—the Azusa ditch taking two thirds of the flow up to its capacity, and the Duarte, or west side ditches, taking the other third. This statement does not accord with the version of the matter adhered to by the Duarte irrigators, as will be seen in the account of the west-side works.

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The Azusa Irrigating Company:—The Azusa Old Settlement irrigators continued to elect their water commissioners and to keep up the organization of a district under the law of 1854, notwithstanding the fact that it had long ago been repealed, until in August, 1886, a number of them, realizing the necessity for some other organization, formed the Azusa Irrigating Company, and a majority of the commissioners, together with their water overseer, turned the affairs of the district over to the officers of this new company.

The Azusa Irrigating Company was incorporated as above said, with a capital stock of $60,000, divided into four thousand shares at a par value of $15 each, and it was intended that all owners of lands in the old district should be eligible to subscribe to its stock. It was first arranged, by the force of a by-law, that each subscriber should be allowed to take one and a half shares of stock for each acre of land up to twenty acres, and those owning more than twenty acres might take stock for additional acres up to sixty in all, by a sort of sliding rule so arranged that while the subscribers for twenty acres might take thirty shares, the subscriber for sixty acres could only take sixty shares. But this has now been changed, so that each subscriber may take one and a half shares per acre up to the limit of sixty acres. There are now about two thousand two hundred and fifty shares taken, on which $4 95 per share has been paid in.

The Azusa Land and Water Company:—The Azusa Land and Water Company was formed in 1887, and succeeded to a portion of the water and ditch rights of Slauson and Martz of the Dalton rancho ownership. Under the same management is the Azusa Agricultural Water Company. These are recent organizations whose works or acts as yet have not been notable in the line of irrigation. The former company supplies the town of Azusa with water.

SECTION II.

The Azusa New District Irrigations.

Azusa Water Development and Irrigation Company's Canal.

District and Work:—As has been said the Azusa Water Development and Irrigation Company's canal serves some lands of Azusa Old Settlement, other lands lying above it to the east, and

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still other lands lying south of it. It commands the entire eastern end of San Gabriel valley beyond the river, except the extreme eastern points where are situated the neighborhoods of Glendora and San Dimas. This is a magnificent plain reaching down to the Coast Range and embracing twenty thousand to twenty-one thousand acres of the richest soils in Los Angeles county, and lying most favorably for irrigation.

CANAL AND STRUCTURES:—The canal takes water at the point of mountain, through which, as already described, a new heading has recently been made by a long tunnel for the Azusa and Duarte old canals. The original heading of the old Azusa ditch was in the river channel immediately at or opposite to the point of cliff, and the old ditch was situated one hundred feet or more away from its base.

The new work now being described was constructed close along the base of the cliff and carried through its extreme point by a short tunnel, thus tapping the channel above the head of the old ditch. But the managers of the old work drove the long tunnel through, several hundred feet farther back in the point, tapped the river above, and carried their waters over the line of the new canal below.

Headworks:—As now seen, the Development company's canal takes water by a tunnel one hundred and seventy-five feet in length through a second small point of rock about three hundred feet below the head of the Azusa and Duarte companies' new tunnel, conducts it several hundred feet, in a walled-up channel along the base of the cliff and between it and the river bed, thence passes by another tunnel sixty feet long through the extreme point of cliff, and turns south along the base of the cliff, passing under the flume at the lower end of the Azusa and Duarte tunnel, as already mentioned. There is a sliding wooden head-gate at the upper end of each of the tunnels in the line of the new ditch, and the whole work is quite well arranged both to command the low-water supply and control the attack of floods.

Canal:—The ruling gradients of the work for the first seven miles from the head are between five and twenty feet per mile, so that while the old Azusa ditch drops down with the slope of the wash at the foot of the mountain's point, at the rate of about sixty feet per mile, this new canal is located along the steep face of the

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mountain and edge of mesa or foothills south of the mountain—passing through several tunnels, and by flumes or trestles across gulches—for a length of about two miles, until it rounds the point of foothills back of Old Azusa and swings eastward for about two miles farther out upon the plain. Then it turns south to an excavated and cement-lined reservoir having capacity to hold eleven million gallons, located at the edge of a drop in the plain, about seven and fifteen one hundredths miles on the canal line, from the head of the work, where it is considered that the main ditch ends. In section the water-way, where on normal grade and in earth construction, is twelve feet wide on top, four and a half feet deep, with sides sloping at about one on one to one and a quarter, and with the bottom rounded between these two sloping planes. It is lined with a cement plaster about two inches thick, and laid immediately on the earth as cut out to a form. The soil is for the most part a heavy, brown, sandy loam, much firmer in the cuttings than would be supposed possible from its appearance on the surface.

This cementing work was done in 1885, and thus far has stood remarkably well, although where poor quality of cement was used, it has scaled up, and in some such places has worn nearly through on the bottom, and in other places has cracked on the sides. Taken all in all, though, the construction may be considered a success, and the method applied with good materials and due care seems to promise excellent results in localities where frosts do not occur. Where along the mountain face and elsewhere in harder material, the canal section has steeper sides, wider bottom, and narrower top than those above given, and where on heavier gradients, as down some drops in the plain, the section is diminished in area to about one half that already described. Its capacity may be placed at four thousand five hundred to five thousand miner's inches, as determined by its sections, grades, and character of water-way, but it remains to be seen whether its construction would stand the greater destroying power of this volume of water. The point could only be determined by a close investigation and a series of experimental trials.

DISTRIBUTION WORKS:—Distribution is effected by a series of lateral ditches, all cement-lined, in the same manner as the main canal. One of these, having a capacity equal to the main work,

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extends south from the reservoir about a mile to Walnut Grove creek or wash, which is at the northern base of San José hills bounding the valley at this point on the south. This canal is used as a waste-water way. Other distributaries lead down the slope of the plain, due west from the main work, on section and quarter section lines. There are about fourteen miles of these little works placed on the grade of the county which varies between twenty and sixty feet per mile. They are from eighteen to thirty inches wide on top, eight to eighteen inches wide on the bottom, from eighteen to twenty-four inches deep, and vary in forms of cross-section. Their capacities range between one hundred and four hundred miner's inches.

Outlets:—Water is taken out of the main canal into these laterals by means of eighteen to twenty-four-inch wrought iron riveted pipes, about twenty feet in length, laid through the side of the canal, and opening into the water-way, with ends cut to fit to the slope of its side, at about half its depth. The lower or outer end of each of these pipe-culverts (as they may be called) is received and held in a rubble-stone masonry wall at the head of the branch it is intended to supply, and a heavy wooden gate or valve is held against it by means of two thumb screws whose buts are anchored in the masonry. These gates are under light pressure from above, which, of course, tends to open them when the screws are turned off. To turn out a full head when the supply is low in the main canal, its water-way is partially closed by sliding flash boards down into grooves made for the purpose in its sides just below the outlet, thus checking the current and causing a ponding of water over the mouth of the outlet pipe. This has been a very cheap and convenient arrangement in construction, but it is objectionable in use, for the valves or gates clog up, are difficult to manage when a good head is in the canal, and cannot be utilized for purposes of measuring or partitioning the water in any manner.

WATER DEVELOPMENT TUNNEL:—At a locality commencing about a mile above its opening the San Gabriel cañon, in going up stream, is found to make two decided short turns, so that its alignment on a map looks like a very much pronounced letter S. The length of this part of the channel around the two points is over a mile and a half, while the distance straight across from

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upper to lower end, and cutting the points of mountain around which the cañon winds, is only about two thousand two hundred feet. The grade of the river in the cañon is here eighty-five to ninety-five feet per mile. It was pointed out in a report of the state engineer, made in 1879, that this was a rare opportunity for underdraining the channel of this river, that a tunnel should be driven under these points and into the bedrock above, so as to completely underdrain the river and take in all the waters of percolation which were finding escape through its gravels.

The primary object of the Azusa Water Development and Irrigation Company, as the name would seem to imply, and as was the fact announced at its inception, was to develop a greater supply of water than the river afforded for summer use in the Azusa. It does not seem to have occurred to the users of water there that they already had full twice as much water as they were actually applying in irrigation—that their works for conducting and distribution were wasting full half of it. So the development tunnel was the first work projected while yet the control of the company was in the hands of Azusa Old Settlement people. It was begun in 1882, has been carried forward each year since, and is now about one thousand two hundred feet in length. Commencing at an elevation of six to eight feet above the river bed, it has pierced through one point of mountain a length of about six hundred feet. has passed the bed of the river, through the gravels and bowlders. about forty feet below the surface thereof, a length of over two hundred feet, and is now about four hundred feet into the rock of the second point.

Where in the river bed this tunnel is timbered with eight by eight-inch bents placed close together, where in rock it requires no timbering. It is three to three and a half feet wide, five and a half to seven feet high, and has a grade slope of about fifteen feet per mile. This tunnel is now yielding about one hundred and forty miner's inches of water, which nearly all comes into it during its passage through the gravels of the river bed, and more particularly just at its first entrance into these gravels. Whether these are intercepted percolating waters of the gravels independent of the surface-flowing stream at this point, or whether they are derived by direct or appreciable draft on the surface waters down through the gravel, is a question as yet undetermined, and which constitutes a point of contention in pending litigation. It is not

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known what experiments, if any, have been made to determine this point, but there are many theories and arguments advanced on both sides, seemingly with very little foundation of fact, and based on opinion possibly marshalled by partisan feeling.

It is certain the Azusa Old Settlement people commenced this work of development to get more water for their lands. There was a difference of opinion, to be sure, as to how the subterranean-flowing waters of the cañon were to be caused to flow on the surface—some of the settlers favoring this tunnel enterprise, and some favoring a bedrock dam. But all agreed that there was a large volume of water to be rescued some way from its percolative channels in the gravels. Now this tunnel has brought one hundred and thirty to one hundred and forty inches to the surface. So far as is known this water has not been traced to the surface-flowing stream, and from a reasonable standpoint the work now only fulfills the expectations of the original projectors, most of whom having disposed of their interest in it to outside parties, now claim that it has not developed any new waters, but is robbing the river of its flow. This case presents an interesting question, one in which the welfare of Southern California is in no small degree concerned, and no pains should be spared to fully develop the true facts. Indeed, the interests at stake would seem to warrant every reasonable effort to that end. Mere opinion, scientific or practical, unguided by experiment, would hardly seem just ground for conclusion in such a matter.

COST OF THE WORK:—The following statement presents nearly an accurate account of the cost of these works:

Canal excavation made in 1882	$5,000
Canal lining (cement plaster), 37,000 feet, put in in 1885	35,000
Reservoir—excavation and lining	3,200
Canal extension (wasteway), 5,000 feet, excavation and lining	5,000
Lateral ditches—excavation and lining—about 14 miles	18,000
Gates, bridges, etc.	2,000
Total: canal	$68,200
Development tunnel	20,000
Total: works	$88,200

The company reports that it has expended on all accounts about $120,000. Its legal expenses have been very great. The water development tunnel is now costing at the rate of about $10 per linear foot.

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Operation and Maintenance:—The Azusa Water Development and Irrigation Company is organized as a general water-supply corporation, furnishing water, to the extent of its supply, to all who call for it within the spread of its distributaries. There are no water-rights issued, but stockholders always have preference in receiving supply, and none is sold to others if the supply is short. There is no limitation as to the holding of stock, either as to amount held or location of lands for which held. It is not made an appurtenance to lands at all, neither does its holding necessarily accompany land ownership, although it has become recognized, by custom, as about the thing to hold a share of stock for each acre for which irrigation is demanded.

Water-rates; Cost of Irrigation:—Water is sold at the rate of $1 50 per head of one hundred miner's inches for each run of twelve hours; and water bills must be paid in advance on demands being made for the water. The cost of water for irrigation at this rate ranges between 50 cents and 95 cents per acre per year. Maintenance and operation of works cost about $1,800 per year, including pay of *zanjero* during the irrigation season, secretary, and labor of clearances and repairs.

DISTRIBUTION:—Water is distributed on order, by "heads" and without measurement other than the judgment of the *zanjero* in charge. The demand has to be made on the secretary several days in advance, and payment made for a head for the desired length of time. Then the *zanjero* is notified, and the ticket or receipt exhibited, and he delivers the water in rotation and as best suits economical use of the works. In this way the round is made of all customers every ten days to two weeks.

Water-supply and Use:—Water-supply to this work has been regulated more by the question of water-right than by the volumes available in the stream. It is said that even when there was an abundance of supply in the river for all the ditches, those in control of the situation have refused to allow water to be taken into the new canal because they might thereby recognize some right it claimed to have against the older diverters. Just how much it has been allowed to take, from time to time in the past, is not worthy of inquiry for purposes of this report. At times when water has been most needed there has been a row each season over its division. In 1887 there was a small war in the mouth of the

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San Gabriel cañon, on this point. In 1888 the waters are being apportioned, under a temporary order of court, in the following manner: All of the water is taken into and through the Azusa and Duarte tunnel and received at its mouth in a flume. One hundred and thirty-seven inches (that being the amount flowing out of the tunnel of the new company, into the river above) is first dropped into the new ditch, and then this ditch also gets seventeen one hundred and eighths of the balance—that being the share of the old irrigators who want to receive their supply through it.

IRRIGATION:—In 1888, there are about five hundred acres of land regularly and fully irrigated under this ditch and about two thousand acres which have received partial irrigations, as the water-supply would permit. Grapes and deciduous fruits grow without summer waterings in this district, so that these crops are not counted as irrigated, although extensively cultivated. The chief irrigated crops are oranges, vegetables, summer crops, and alfalfa, but of this latter, owing to short water-supply, there is only a very small acreage. The new ditch supplies a much wider area of country with water for domestic purposes, however, and for this use it has proven a great boon to the district generally. It has conducted in a pure and palatable state, a little stream of only twenty to twenty-five inches, and distributed it for domestic purposes and use through several branches throughout a wide expanse of country, with scarcely perceptible loss. There are about seventy users of the water, of whom thirty-eight are of the Old Settlement irrigators.

History and Water-right:—The Azusa old ditch has always been a very wasteful work, and its location is not economical of grade any more than its character and construction is economical of water. Some of the irrigators under it have for a long time recognized these facts. They have contended that full two thirds of water diverted was lost uselessly into the ground and gravels along the course of the ditch and its branches, and never reached the cultivated soil for which it was intended. They have urged that by constructing a work of better character a very much lighter gradient could be adopted from the head, and thus by locating on higher ground other and most desirable lands could be brought under irrigation with part of the waters saved by the

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better canal: That not only could all be better supplied, but the area of cultivation could be increased. Until within the past few years, however, a majority of the Azusa irrigators have opposed any improvement or any change from the old order of things, and it is not too much to say that this apathy and failure to recognize the fact that the water-supply of the San Gabriel river was not being diverted and conducted out upon the plain and utilized to due advantage and with reasonable economy according to the standard of the times, has brought upon them and the irrigation interests of the whole region another installment of trouble and batch of law suits.

The original water commissioner law of 1854 was virtually repealed by the "Bush Act" of 1874, nevertheless the Azusa district, as well as some others, continued to be operated according to its provisions up to a very recent date. While this organization served a good purpose for the administration of an old ditch system in a district of primitive irrigations, it provided no adequate means for raising money to construct a new work of better order.

Formation of the A. W. D. and I. Company:—To provide a proper organization and construct a better work, a number of the Azusa Settlement irrigators formed the Azusa Water Development and Irrigation Company, in 1882. The intention and understanding was that the corporation was organized solely for the Azusa Settlement irrigators, and there was an agreement or resolution that the works of the company were to serve only Old Settlement lands, or rather the lands of the holders of rights in the original settlement ditch.

Only a portion of these settlers came into the organization, however, so in a short while it was found that the company was embarrassed. About this time claimants to whatever surplus water there might be in the river, appeared in the persons of owners of lands west of the river and beyond the Duarte, and it seemed that if the new Azusa company failed to go on and make good its claims, the Azusa neighborhood would become involved in a water-right dispute with an altogether outside interest. In this dilemma the directors of the new company determined to sell a portion of their stock to a large land-owner located just south of the district, and so he took a fifth of the whole. Then, through other internal troubles and lack of enterprise, another fifth of the stock soon found its way into the same hands, and by 1885 nearly the entire

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stock was held by persons outside of the old district, among whom J. S. Phillips was the controlling owner, so that the work became known as the Phillips ditch.

During the season of 1884, there being an attempt, under a verbal agreement between the water commissioners for the Azusa ditch, and those in control of the Duarte and of the Azusa Development company's ditches, to divide the waters then available, between the several works, the board of water commissioners took possession of the waters and turned all to waste down the stream, except so much as was wanted for the old ditches—leaving the new work—the Azusa Development company's ditch—without any.

The Brunson Decision:—This company then sued to have their rights determined, and the superior court of Los Angeles county decided that the old Azusa ditch was entitled to one thousand inches—the extent of its capacity and use—that the west side ditch was entitled to five hundred inches—the extent of its capacity and utilization—and that the new ditch company was entitled to the waters developed by its tunnel, and to the surplus waters of the river up to the extent of its capacity. This is called the "Brunson" decision from the name of the judge who rendered it.

By stipulation of attorneys, a new trial was granted and the complaint was amended. This case finally fell to the ground on a decision in another case that there was no legal organization of irrigation districts under the law of 1854, and consequently no properly constituted board of water commissioners. Previous to the Brunson decision the new ditch had been taking water in a common headwork with the old Azusa ditch, and dividing it over a weir; but now a separate headwork was ordered under the decision, and constructed for the "Covina" ditch as the new ditch was sometimes called, from the name of the lower neighborhood served by it.

The Duarte-Azusa War:—In November, 1884, the Duarte Mutual and the Beardslee canal owners west of the river, served a notice on the Covina, or Phillips, ditch managers, that they claimed and owned a right to full one third of all the waters in the river, up to the extent of the capacity of their works (which, by the way, they had rebuilt within the year or two then just passed), and notified them that any act depriving their ditch of its full supply would be regarded as a trespass.

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Matters stood in this way—the Covina ditch taking at time of low flow only such waters as were coming from its development tunnel, and such share of the Azusa ditch waters as properly belonged to those Azusa Old Settlement irrigators who, owning stock in the new company, wanted their supply delivered to them through the new ditch—until the early summer of 1887, when a conflict arose between the Duarte and Azusa settlers, on the one side, and the managers of the Covina ditch. The settlers turned all the water out of the new ditch, and under arms held possession of the headworks. This led to a suit for an injunction, brought by the Azusa Water Development and Irrigation Company against all other water claimants, which is termed the "Omnibus" case.

During the irrigating season of 1887 the greatest confusion and discord prevailed. The old settlers held possession of the waters by force of arms; numberless legal processes were invoked, and repeated arrests and trials were had. Finally, at the opening of the present season the superior court, to prevent a recurrence of the scenes of the former year, rendered an interlocutory decree in the "Omnibus" case, and placed the waters in charge of a receiver, as it were, to apportion them amongst the several claimants, temporarily, as follows:—

Present Status:—One hundred and thirty-seven miner's inches—the amount coming out of the Azusa Water Development and Irrigation Company's tunnel—to their ditch; thirty-six one hundred and eighths ($\frac{36}{108}$) (or one third) of the balance, to the Duarte and Beardslee ditch; seventy-two one hundred and eighths ($\frac{72}{108}$) (or two thirds) to the old irrigators under the Azusa ditch. Of the last amount, seventeen one hundred and eighths ($\frac{17}{108}$) goes to the new ditch, because the irrigators to whom it is due want delivery made to them through it; fifty-five one hundred and eighths ($\frac{55}{108}$) goes to the old Azusa ditch, and of this last amount the Azusa rancho owners get seventeen twenty-fourths ($\frac{17}{24}$), under the compromise of 1884.

Water Development Plans:—A chief cause of disagreement which prevented many of the Azusa irrigators from entering the Azusa Water Development and Irrigation Company, when it was controlled by their cotemporaries of the old district, was a difference of opinion as to the plan to be followed in conducting the work of

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development. Some were in favor of a bedrock tunnel to underdrain the river bed, and others were in favor of a submerged dam to intercept and force the flow to the surface of the gravels. When it first transpired that those in control favored the tunnel plan, those who were in favor of the dam plan either refused to join, or having joined, soon backed out. All this was based on individual opinions, and without engineering advice whatever.

About one half of the irrigators originally subscribed, but after it was decided to run the tunnel, not more than a fourth paid up and took stock. It was at this juncture—when only about one fourth of the stock had been paid for—that the outside parties were taken into the company as already narrated. The tunnel was driven two hundred and forty-six feet under the original management; and the primary intention was to do for all the lands of the old districts what has since been done in this way for some of them and for other lands outside of it.

SECTION III.

Duarte District Irrigations.

The Duarte Mutual Irrigation and Canal Company, and Beardslee Water Ditch Company.

District and Work:—The gravelly and bowlder-strewn plain that now indicates the former extent of the San Gabriel's spreading from the cañon's mouth, holds between its northwest boundary and the mountain's base a gore of sloping bench-land and alluvial plain, which, comprising an area of about two thousand five hundred acres, embraces the irrigation neighborhood of Duarte. Commencing about two miles from the cañon proper, this gore is only a quarter of a mile wide, from thence it extends west three miles on its northern line, and near four miles at its southern limit, and is two miles wide on the western side. At its upper end, and along its northern side, the lands are steeply sloping bench-lands—the irrigated tracts not infrequently sloping as much as six or seven feet in the hundred. These slopes gradually flatten out as the district grows wider towards the west, so that the plats of its southwest quarter have slopes varying between fifty and seventy feet per mile.

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Taking water from the San Gabriel river at the opening of the cañon, where described in a previous article relating to the Azusa ditch, the works of the Duarte Mutual Irrigation and Canal Company and of the Beardslee Water Ditch Company have for their object the irrigation and domestic supply to the lands of and the dwellers in the Duarte district as above described. The diversion and main conduit for about two miles is a work in common by the two companies; but thence the systems separate—the main conduit of the Duarte Mutual keeping next the mountain, and covering and supplying the bench-lands and upper part of the plain, and that of the Beardslee extending diagonally across the country to supply the lower plain towards the southwest corner of the district.

THE MAIN CANAL AND PIPE; JOINT WORK:—From the dividing flume at the point of the crossing of the Azusa old ditch, as described in a former article, the Duarte joint work extends westerly across the old east-side gravel wash to the river channel, as a cobble and bowlder paved ditch about two thousand five hundred feet in length—from one and a half to two feet wide on the bottom, two to two and a half feet deep, four and a half to six and a half feet wide on top, and with varying gradients. This canal is cemented on the bottom and for about one third the way up the sides—a sufficient finish of this class to carry the available supply without loss, only at times of low flow when the supply is short and all waste constitutes serious deprivation.

Across the present river channel the waters are led in a rude flume of one-inch boards, on light, temporary trestle bents not over ten feet high, a length of three hundred and eighty feet. This flume is twenty by fifteen inches. Two pipe-lines have in past years been laid across the river, and deeply covered in the debris of its bed, but both have failed. The first, of cement, burst from the pressure immediately the water was turned in; and the second, of iron, was washed away during the first winter's experience. It must be confessed, however, that the flood which took it away was much above the ordinary in volume and violence. The general idea of making this crossing by a pipe suspended above the reach of high waters by means of cables passing over towers on either bank is being canvassed by members of the directory and may lead to a good work.

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From the river crossing, the Duarte joint work leads out westerly, across the old gravel wash—gradually getting away from the stream and approaching the mountainous base. For two thousand seven hundred feet, it is a well constructed, rock-paved, and cemented ditch, two and a half feet wide on bottom, six feet on top, and two and three quarters feet deep, laid in a direct line to the crossing of Fish Creek wash. Here for four hundred feet is a twenty-six-inch cement pipe laid in a concrete casing four to six inches thick and covered in. This section of the work was at first constructed as an open, paved ditch, but Fish creek floods filled it and caused so much trouble that the change was made after the first season. At the end of this piece of pipe is found a wasteway structure of wood, and here also the waters of Fish creek are at ordinary stage during the winter brought into the system by the means of a cement pipe branch. The river being subject to frequent freshets during the rainy season and always coming down very muddy after each heavy rain towards its source, the waters of Fish creek, which remain quite clear after the first storm, are preferred and taken, for at that season the use is confined for the most part to domestic service.

From the wasteway at Fish creek, the conduit continues as a brick, cement-lined culvert for one thousand two hundred feet to a brick walled sand box, sluice way, and regulator. The culvert is twenty-four inches wide, twenty-two inches high on sides, and with an arched top is twenty-eight inches high in the center. The floors, walls, and arch are eight inches thick, laid in cement, and lined with a quarter to half-inch coating of cement plaster. This portion of the line is for the most part along the base and in the slope of the rough mountain side, and brings the waters out upon the commencement of the first bench-land. Thence extends a twenty-six-inch cement pipe, gradually leaving the base of the mountain on a short cut across the bench, for one thousand three hundred feet to the point of division between the two companies.

The structure here located is a simple box partitioner, in which the waters are led for sixty feet of run in a flat-bottomed rectangular channel, and there are separated by a thin-edged vertical sheet iron partition placed at one third the width from one side, thus dividing the flow by proportion of its width—one third to the Beardslee company and two thirds to the Duarte Mutual. The entire structure is seventy-six feet long; the approach and divid-

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ing run three feet wide, and with walls twenty-six inches high; all built of concrete.

Duarte Mutual Separate Works:—From this partitioner the Duarte Mutual company's main extends as a twenty-two inch cement pipe a length of eight thousand seven hundred feet, and there are yet about five thousand five hundred feet to lay to complete the work. Along this part of the work waters are distributed in irrigation, and there are a number of ten-inch turn-outs arranged in brick-work boxes with iron slide gates, and also with corresponding iron gates on cast slides to check the flow in the main conduit. There is as yet no lateral piping or branch work done by the company, and it is a question whether any will be put in, or whether permanent distribution works will be left to the irrigators for construction.

The twenty-two-inch pipe-line follows the general location of the old upper ditch, which skirted the upper limit of the steeply sloping irrigable bench-land, and there is something over a mile of the old work yet in use which, as above recited, is to be replaced by a pipe. In addition to the comparatively new work, the Duarte Mutual company maintains in good condition its old ditch at the head, for diversion in early spring and whenever the supply in the river is sufficient to make it unnecessary, for economy's sake, to bring the Duarte waters from the upper diverting point. This old point of diversion is a few hundred feet above the flume crossing, and the waters are taken directly into the head of the long line of paved ditch. Then, below the line of the paved ditch the old "middle ditch," so called, is maintained and used through the district, a length of about two and a half miles, as a distributary at all times and an additional supply channel when waters are plentiful.

Beardslee Company's Separate Work:—The waters of the Beardslee company are conducted from the partition described, by a twelve and fourteen-inch cement pipe, a distance of about three and three quarters miles, on grades between fifty and seventy-five feet per mile, and following close along the western limit of the San Gabriel wash and the lower limit of the Duarte district, to the lower Duarte. Here they are distributed by means of small flumes and pipes. The cement pipe acts merely as an open conduit. The total length of this separate work is between five and six miles.

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COST OF THE WORK:—The following is a reasonably close statement of the cost of the Duarte Mutual works inclusive of the Beardslee share of the main work:

Headworks, tunnels—Duarte share, one third	$2,400	
Cement ditch, torn up	100	
Dividing flumes, etc.	400	
Dam—Duarte share, one third	100	
		$3,000
Paved ditch beyond river, 2,500 feet—excavating and paving at $1 25	$3,125	
River crossing, 400 feet—cement pipe at $1 75	700	
Iron pipe at $4	1,600	
Paved ditch, 2,700 feet—excavating and paving at $1 50	4,050	
Paved ditch across Fish creek, 400 feet—excavating, paving, etc., at $1 50	600	
Cement pipe across Fish creek at $1 30	520	
Brick culvert conduit, 1,200 feet, at $2	2,400	
Sand box	100	
Cement pipe, 26-inch, 1,300 feet	1,700	
Dividing box	300	
		15,095
Cement pipe below divide, 22-inch, 8,800 feet	$8,800	
Outlet gates	850	
		9,650
		$27,745
Work not yet done:		
Cement pipe, 22-inch, 5,500 feet at $1 30	$7,150	
Outlets, etc.	250	
Incidentals	100	
		7,500
Total probable cost		$35,245

Operation and Maintenance:—DUARTE MUTUAL COMPANY:—The Duarte Mutual company and the Beardslee company are each organized for the supplying of waters for irrigation and domestic purposes to stockholders, only. No water is sold or at all disposed of to any one not a stockholder; and no charge for water, as such, is made to the stockholders. The costs of operation and maintenance are met by special assessments on the stock, levied as occasion requires. With this similarity in general principal, each company's operations are entirely independent of the other in the distribution of its waters.

DISTRIBUTION:—The Duarte Mutual distribution is in charge of a *zanjero*, and the principle is the measurement of time in proportion to interest, with a stated irrigating "head" of water, which is considered to be about one hundred miner's inches in volume. Distribution is commenced some years at the foot of the system,

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and some years at the head, as the directors decide. There is no stated period of rotation or predetermined schedule for delivery of supply to the irrigators. The *zanjero* has a list of the irrigators arranged in order as they are situated along the lines of delivery, with a memorandum of the number of shares of stock owned by each. Twenty shares of stock entitles the holder to a "run" of a "head"—that is a stream of one hundred inches for twenty-four hours. Upon this basis, from the stock list, the *zanjero* makes up a schedule for guidance in dividing the waters—calculating the number of hours and minutes each irrigator is entitled to a head. He notifies the irrigators in succession, each twenty-four hours in advance, as to the time he will turn the water to them, and they must take it and use it then or else wait until their turn comes again in the regular succession. This is the practice for the irrigation season in years of ordinary amount of water-supply.

Heads; Runs; Periods:—During months of the year when water-supply is plentiful and in years of great abundance throughout the season, the irrigator, by giving several days' notice, can get water as much as he wants and whenever he wants it. On the contrary, during seasons of exceptionally low flow in the streams, when the water-supply is short, the division is made on "half-times"—the twenty shares entitles the holder to a "head" of water for twelve hours only, instead of a full day, and he is given it for six hours of day time and six hours of night time—and in one season, before the works were improved to economize in delivery of water, the "runs" were made on "quarter-time." Not only is the time of a run thus affected by the measure of supply, but in years of drought the heads of flow are not so large as in years of plenty; but this, after all, affects all irrigators alike, and the apportionment of the supply is made to each by time. An exception to this rule, however, is caused by loss in delivery, for the heads are much reduced in volume by a long course down an earthen ditch.

The irrigator may, by an arrangement, dispose of his water on his time to a neighbor, but not so as materially to change the order in, or place of delivery. Or he may dispose of his water to any one in the district by giving sufficient notice so that arrangements be made to deliver it in that irrigator's turn. Thus, within restricted limits, the irrigator may sell his water without selling

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his stock, and this is the only sale of water known to the system. The irrigator may, in his turn, by previous arrangement with the *zanjero*, take a "half-head" for a "double-time," or a "quarter-head" for a "quadruple-time;" and the one or the other is generally done by those whose places are on the steeper bench-lands where a full head of one hundred inches could not be handled in irrigation without much washing out of the trenches and furrows of sub-distribution.

Under this system the period of rotation varies greatly with the water-supply, and with the demands of the irrigators. When the supply is about three hundred inches, or a little more, the irrigators' turns come around in about two weeks, for then some irrigators do not take water every time. When the available waters fall to about one hundred and fifty to one hundred and seventy-five inches, the irrigations are run on "half time;" the turns come around only about every three weeks, for then everybody wants water.

Cost of Administration, etc.:—The cost of operation, and maintenance of the Duarte Mutual since the works have been improved, for the present season for instance, is about $1,200 to $1,300, or say $1 per share on the one thousand two hundred and sixty shares. This includes a *zanjero* for six months at $50 per month; service of secretary, $200 per year; incidentals, inclusive of fees to directors for meetings, $200; and the balance for clearances and repairs. When the works were all simple open ditches, the expense of repairs and clearances were two to four times as great, and sometimes still greater costs had to be met at the headworks. As the works are in time still further perfected, the annual expense will to some extent further decrease. The cost of water per year for these items is at the rate of about 75 cents per acre irrigated during the summer. The cost of new works is of course a heavy charge on the present irrigators, as also the expenses of litigation elsewhere referred to, but these are held separate from the foregoing account, being temporary burdens.

THE BEARDSLEE COMPANY:—Under the Beardslee company's works the division of water among the stockholders is effected by measurement of time in proportion to the amount of stock held by each individual. The full head of flow, varying between seventy-five and two hundred and fifty inches, is delivered to each irrigator in turn throughout the irrigating season according to

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schedules fixed at the beginning of the season. The main schedule is fixed for a six-day recurring period, and that is applied for the six weekdays of each week, and there is a separate schedule arranged for Sundays. So that each irrigator is served each week and every fourth Sunday in proportion to his stock holding. The arrangement insures an equitable apportionment of the daylight and nighttime water and of Sunday and weekday service. The gentle slopes and absorptive character of the soil in the district served by the Beardslee company make it possible for irrigators to handle the large heads thus delivered, whereas such volumes in the upper Duarte would be uncontrollable by men of ordinary means, on the steep slopes and soils there and which so readily wash away. Under the Beardslee management, however, irrigators are permitted to "lump" their "runs" and divide the water—taking the flow between them for the full time of the two or three, and dividing the stream to suit themselves.

The water coming through the Duarte canal, and thence by pipe to the irrigated lands, there is no necessity for a *zanjero* to take care of the main work. The Beardslee company pays one third of the cost of maintenance of the joint work above the divide, and the Duarte Mutual *zanjero* looks after it. The Beardslee irrigators, each having a printed schedule of distribution for the season, all know exactly who is entitled to the water at all times, and each turns on the flow of his own ditch at the appointed time for him to take it. Distribution is yet effected in open ditches, but these are none of them over half a mile in length from the piped supply.

Before incorporation the water-rights and ownership of the work was held in two hundred and twenty-five shares, which corresponded with two hundred and twenty-five acres in the Beardslee tract for which the water was originally appropriated, and the first incorporation was put on that basis. But now the six hundred and thirty shares in the company bear no stated relation to land ownership, and the stock-holding is not supposed in any way to go with it.

Cost of Administration, etc.:—The cost of operation and keeping has, in years before the canals were paved and the pipe laid, run up as high as $1,200, or $3 to $4 per acre of land irrigated during summer. With the improved works such costs do not exceed $200 per year, or half a dollar per acre of summer irrigation effected.

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Water-supply and Use:—With respect to reliability and sufficiency of water-supply for these irrigations, very much the same remarks apply for the Duarte and Beardslee works as were made under this heading with reference to the Azusa Old Settlement ditch: At the times when the supply has been short the fault was largely with the works—there was enough water in the river, but the works lost it in transit to the lands. True, the river was very low, as elsewhere shown, but with the works of to-day such low-water years should not be seriously felt on an area of irrigation similar in extent to that of 1883, when the greatest reported drought was sustained.

IRRIGATION:—The extent of irrigation in 1879, reported for the state engineer, was about one thousand two hundred and sixty-five acres, but this was certainly an over statement for that period. The figures probably included lands served in early spring and winter, and planted to grain, and did not relate to summer irrigation, only, as do the estimates generally in this report. In 1880 a careful examination of the Duarte irrigations, exclusive of those of the Beardslee association, showed a total irrigated area of three hundred and twenty-three acres; of which two hundred and fifteen were in orchard; ninety-five in vineyard; eighty-seven in summer crops; and the balance not segregated as to cultivation. In the same year there were about two hundred acres of summer irrigations in the Beardslee sub-district—making, in all, for the Duarte, about five hundred and thirty-three acres. In 1886 the extent of irrigation was reported to be about one thousand six hundred acres for the two companies. In 1888 it is at near the same figure; the lands being cultivated about as follows: Citrus fruits, four hundred and twenty acres; deciduous fruits, seven hundred and eighty acres; vines, one hundred and ninety acres; summer crops, one hundred and sixty acres; and alfalfa, fifty acres.

The irrigation of vines and deciduous fruits is generally confined to early spring months—the water-supply not being considered sufficient to serve them through the summer; so that the effective summer irrigation ordinarily does not exceed seven hundred acres, and in dry years it would be less. Of the one thousand six hundred acres found to be irrigated for this year, about five hundred are served by the Beardslee company; and this includes

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about two hundred acres not ordinarily served in the driest months of summer.

History and Water-right:—It has been said that water was diverted from the San Gabriel river on the west side at about the location of the Duarte diversions, by the *Padres* about 1821, and carried in a ditch to a neighborhood of the Mission San Gabriel for irrigation of extensive fields there cultivated by Indian labor under direction of the priests. But the rights of present irrigators are not in this case, as in that of the Mill creek irrigators in San Bernardino county, clearly traceable to so early an origin. Andres Duarte, the owner of the Duarte rancho, in 1854, constructed a ditch and took out the water, the rights to which, it is claimed, have been transmitted to the present irrigators. This old ditch, it is now claimed by the Duarte people, in early years divided the waters equally with the Azusa ditch. This latter ditch had been taken out, as we have seen, more than ten years earlier, and its head was always at the same place—about half to three fourths of a mile above the point of diversion by the Duarte ditch. According to the verbal claims of the Azusa people, and recorded evidence, however, in 1854 and up to 1868, the Azusa ditch only carried two irrigating heads—about two hundred inches, miner's measurement—so there was probably a surplus in the river for the Duarte ditch from 1854 to 1868, in most years, at least, as great as the measure of diversion by the upper work.

In 1859 or 1860, N. Beardslee acquired by purchase a portion of the Duarte ranch and with it the right to take water from the river for irrigation. The old Duarte ditch having in part washed away, Beardslee and Duarte in the last named year, reconstructed it out from the river, and Beardslee dug his ditch, as a branch of the old one, down to the lower Duarte neighborhood.

In 1872, Alexander Weil, who succeeded in ownership to Duarte, subdivided some two thousand five hundred acres of the ranch, and sold out numerous small parcels with rights to water from the Duarte ditch. These tracts were chiefly along the upper part of the ranch and next to the base of the mountain, in what is now known as the upper Duarte. In 1875, other persons bought lands in the lower Duarte with rights to water in the Beardslee ditch, and acquired right of way through the Beardslee ditch. In September, 1881, the Beardslee Water Ditch Company was

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formed and incorporated. This at first included only the rights originally acquired by Beardslee for water for two hundred and twenty-five acres. This ditch claimed one ninth of the waters of the river up to five hundred inches. There is a claim of record for six hundred inches.

Duarte Mutual Irrigation and Canal Company:—The capital stock of the Duarte Mutual company is $12,590, divided into one thousand two hundred and fifty-nine shares of $10 par value each. The Duarte Mutual Irrigation and Canal Company was incorporated in February, 1882, and the water-right and ditch interests of Weil and those who had bought from him in the upper Duarte were transferred to the company in April of that year in exchange for its stock. The company claims two ninths of the water of the river up to one thousand inches. The improvement of the works were commenced in 1882, when the rock-lined and cemented ditch was built across the wash, east of the river, to connect with the Azusa ditch. This was the first year that the waters were divided in the Azusa ditch. Formerly the division was made at the Azusa head gate, and the Duarte share was allowed to run on down the stream to the head of the Duarte ditch some distance below. In the succeeding year the work of improvement was continued—the brick culvert pipe was built, and some cement pipe has been laid each season since. In the meantime—1884 to 1888—the Beardslee company has completely piped their waters from the Duarte divide to and through the district they serve.

The rights now merged into, and water and canal properties now held by the Duarte Mutual Irrigation and Canal Company were before incorporation of that company owned by members of a voluntary association of irrigators in sixty shares—one share going with twenty acres of land, and the whole representing one thousand two hundred acres, for which it was supposed the water was held. At the time of incorporation, it was intended to form the company on the basis of a share to each of one thousand two hundred and sixty acres, but through some clerical error the number named was only one thousand two hundred and fifty-nine, and the incorporation was formed with one thousand two hundred and fifty-nine shares.

Before the construction of the new joint work, the Duarte association irrigators and the Beardslee irrigators each held one half of the west side water-right. But by arrangement the work was

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built and paid for in proportion of one thousand two hundred and sixty parts by the Duarte, and two hundred and twenty-five parts by the Beardslee, and the latter released to the former one third of its half interest in the water; so the water-right and work is now owned two thirds by the Duarte Mutual, and one third by the Beardslee company, and each bears the cost of maintenance in proportion to ownership.

Beardslee Water Ditch Company:—The Beardslee Water Ditch Company was incorporated in September, 1881, with a capital stock of $2,250, divided into two hundred and twenty-five shares, to correspond with each acre of the original Beardslee tract; but in 1884 this was increased to $20,000, divided into six hundred and thirty shares.

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CHAPTER XVIII.—LOS ANGELES[5]; WORKS AND PROJECTS[10].

SAN GABRIEL VALLEY IRRIGATIONS.

SIERRA MADRE CAÑONS GROUP[2]; SANTA ANITA SUB-GROUP[6].

SECTION I.—*Sawpit Cañon Works:*
Santa Anita Water Company;
Bradbury System;
Glendora Water Company.

SECTION II.—*Big Santa Anita Works:*
Santa Anita Water Company;
Baldwin Rancho System.

SECTION III.—*Little Santa Anita Works:*
Baldwin Rancho Works;
Sierra Madre Water Company.

SECTION IV.—*Sundry Small Intermediate Works.*

SECTION I.

SAWPIT CAÑON WORKS.

Monrovia and Santa Anita Colony Irrigations.

District:—Coming from the mountains, Sawpit cañon swings east and then follows south against the base of a high mesa for about a mile. Its wash thence down the plain, borders the upper Duarte district on the west. Lying next west of the Sawpit and between it and the wash of the Santa Anita, on a sloping point of bench-land embracing one thousand five hundred to one thousand six hundred acres of fine soil, is the town and neighborhood of Monrovia. It extends from the mountain's base down the plain

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about two and a quarter miles, to the lower Duarte settlement, which as we have seen, receives its irrigations from the Beardslee company's system. Still farther west, adjoining the Monrovia neighborhood, and in most part beyond the Santa Anita wash, is the town site of Arcadia and the Santa Anita colony lands, embracing about one thousand one hundred acres. These two neighborhoods constitute the district served or to be served with water by the Sawpit cañon works, and in part also by those deriving supply from the Santa Anita cañon, as will presently be explained. The water-rights of Sawpit cañon are owned by W. L. Bradbury and by the Santa Anita Water Company, in equal parts, and the work of diversion and main line out of the cañon has been built at joint cost.

Bradbury-Monrovia Works.

Works:—JOINT MAIN LINE:—The extreme head of the Monrovia bench stands as a bluff about one hundred and twenty-five feet in height above the bed of the cañon at its opening from the mountains. The cañon is very steep in grade and has excessively precipitous and rocky sides. The waters have been concentrated by a tunnel two hundred and forty feet long, driven in the gravel of the stream bed. From this point in its bottom, about two thousand two hundred feet within the gorge, a twenty-inch cement pipe is laid on grade in a trench cut along the mountain's side, out on to the head of the bench-land west of the cañon.

Partitioner:—Here is a dividing box or partitioner, designed to apportion the waters in equal parts to the pipes of the two parties at interest, which lead out of it. Without entering into an exact noting of its details: it consists of a rectangular concrete-walled main chamber eight and a half feet long, seven and a half feet wide, and four feet deep, with two secondary chambers adjoining, two and three quarters by three and a half feet each, side by side, on end, at the lower end of the main chamber. The water enters the main chamber by the twenty-inch pipe about the center of one end and near the bottom, passes out at the other end over two metallic sharp-edged weirs of equal length and even elevation—falling from these two weirs into the two secondary chambers, respectively—and thence escapes at a low level into the two independent pipe systems. About midway of the main chamber is a diagonally-placed-shutter grating, intended to evenly

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break and distribute the current films in their approach towards the weirs; and the whole structure is covered with a heavy wire netting serving to protect the waters from animals, but at the same time admit of aeration and sunning of the chamber.

PIPE LINES: BRADBURY SYSTEM:—The Bradbury main line—a twelve-inch cement pipe—leads thence southeasterly about three quarters of a mile to the Azusa Rancho lands, where is a sand box, and thence the distribution commences southward—serving the extreme southeastern and eastern part of the Monrovia neighborhood. These works comprise about three quarters of a mile of twelve-inch cement pipe, one mile ten-inch wrought-iron pipe, and three miles of six, four, and two-inch iron pipe.

Operation and Maintenance:—Distribution is effected under pressure from this sand box. Water-rights are sold with lands and town lots, in the form of shares in the ownership in the water, but no determined measure of supply is in any way guaranteed. There is no annual charge for water, nor any charge for water as used; and the cost of operation and maintenance is borne by those who hold water interests, in proportion to their holdings. Water is not disposed of or furnished to any one except those who buy lands in the Bradbury-Azusa tract. There are as yet no determined rules as to distribution, seeing that thus far the supply has exceeded the demand, and no necessity has arisen for regulation.

Water-supply and Use:—The total flow of Sawpit cañon, as thus developed and brought out, during the test months ranges between sixty-five and eighty-five inches in ordinarily dry years, half of which is due to the Bradbury system. It is only within the last two years that this half has come into use, and in the present year the irrigation effected has been ten acres of citrus orchard, ten of deciduous fruit tree orchard, twenty of vines, and an unknown small area of summer crops.

Domestic water is also furnished to several hundred people in the east part of Monrovia, but it would seem that a considerable part of the supply must have run to waste.

History and Water-right:—Sawpit cañon is on the dividing line between the Santa Anita and the Duarte ranchos, and its waters have been adjudged to those properties as riparian lands, in equal parts. The Santa Anita Water Company holds the one

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right, and Bradbury holds that due the Duarte, the unsold residue of which rancho he owns and is selling off with shares in the water, as already described.

[The Santa Anita company's Sawpit cañon system will be described in connection with their Santa Anita cañon works, in the next section.]

SECTION II.

SANTA ANITA CAÑON WORKS.

Colony and Rancho Irrigations.

District:—The Santa Anita cañon waters command and serve, or are designed to serve, the lands of the Santa Anita colony, as heretofore described, a bench of about two hundred and fifty acres between the two Santa Anita washes, and lands in private ownership and use on the Santa Anita rancho, and lying next west and south of the colony tract. The cañon water-right is owned in equal parts by the Santa Anita Water Company and E. J. Baldwin, the proprietor of the Santa Anita ranch, and the diversion and main work out to the point of division has been accomplished at joint cost.

Santa Anita Water Company's Works.

Works:—JOINT MAIN LINE:—This is one of the boldest works of its class yet attempted in the southern part of the state. Where the diversion is made the stream is held in a perpendicular-walled gorge near half a mile in the cañon from the first bench-land at its mouth.

Headworks:—Here, just above a sharp, solid point of the cliff, a masonry dam, about three feet thick on top and four to six feet high, has been built, resting against the point and curving up stream and across from it. From above this dam a tunnel was driven forty to fifty feet through the rock point, and within this a twenty-inch cement pipe was laid and then walled in with concrete. A gate at the upper end of the pipe and a waste gate next it in the dam, serve to control and regulate the water-supply to the main conduit; while a grating and lower over-fall, above, protect these from drift.

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Main Conduit:—The main line thence out to the head of the mesa, a length of one thousand eight hundred feet, is a twenty-inch cement pipe laid on grade upon a bench cut into the mountain side. For about half of the distance this is located, forty to fifty feet above the arroyo bed, in the face of an almost perpendicular cliff, and for the remainder of the way, on an excessively steep and rocky mountain slope, where it is at several points carried over side ravines on timber-truss bridge supports.

Partitioner:—The partitioning structure is of brick, oval in plan, sixteen feet long, ten feet wide, and four feet deep. The water enters from the twenty-inch supply main at one end, near the bottom, is divided by passing over two twenty-seven-inch weir openings in a transverse partition wall, located about two thirds the length of the structure from its head, into two small chambers formed by this wall and a longitudinal partition wall at the other end, and passes from these chambers, respectively, into the heads of the two pipe systems. In this case the weirs are not perfect—being mere beveled edges of masonry, and while they may serve well enough the purpose of dividing the water they are not suited for its measurement.

MAIN PIPE-LINES; *Santa Anita System:*—From the partitioner, the main pipes of both parties at interest are laid side by side, westward around the base of the mountain, passing over a number of ravines on truss bridge-flumes a further distance of about four thousand eight hundred feet, and then they turn due south on Santa Anita avenue, which is on the line between the colony tract and rancho lands. The company's work here consists of a twelve-inch concrete pipe, four thousand eight hundred feet, to head of Santa Anita avenue; twelve-inch concrete pipe thence nine thousand seven hundred feet down the avenue; six-inch concrete distribution pipe about ten thousand feet; four-inch iron distribution pipe about four thousand feet.

Sawpit Pipe System:—The Santa Anita company's Sawpit cañon pipe system embraces: a half-interest in the two thousand two hundred feet of main line out to the partitioner; thirteen thousand two hundred feet of twelve-inch concrete main pipe thence, and about twenty-five thousand feet of six-inch concrete distribution pipe. This is supplemented by the lines of the Monrovia Water Company, which serve in distribution for domestic supply through-

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out the town of Monrovia, but are supplied by the Santa Anita company's mains.

[The Santa Anita Rancho works from this source will be spoken of in connection with the irrigations from the *cienega* sources on that property.]

SECTION III.

Little Santa Anita Cañon Works.

Sierra Madre and Santa Anita Rancho Systems.

Districts:—Lying immediately west of the Little Santa Anita cañon wash, and against the mountain's base, is a high piece of sharply-sloping bench-land of about nine hundred acres. This, with a portion of the wash of the stream, and a small tract east thereof, the whole being nearly two miles in length, east and west, and a mile in width, out from the mountain southward, contains one thousand one hundred acres, and is known as the Sierra Madre tract. South of this lies the Santa Anita rancho lands, and about a mile and a half away are the irrigated portions thereof. The waters of the Little Santa Anita are owned in equal parts by the Sierra Madre Water Company and by the owner of the Santa Anita rancho, and are held for the irrigation of these two tracts; and these two owners have constructed works of diversion and delivery out to the head of the distribution district, in common.

The Sierra Madre Water Company's System.

Works:—Development Works, and Joint Main Line:—Diversion from the Little Santa Anita cañon was much more easily accomplished than from the two cañons last spoken of—the mountain sides being less precipitous and rocky, and the cañon more open. The heading is at a point about a third of a mile within the opening of the cañon, and about one thousand five hundred feet above the sea. Here, where a side ravine comes in from the west, there has always been a strong spring of water flowing out of the gravels close to the mountain base, and an area of wet hill-side farther up the cañon indicated other waters siping there. A tunnel has been driven through the bedrock point immediately below, a length of two hundred and thirty feet, in behind

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the spring, and the waters are all thus concentrated to flow out of it. From here they are led on grade, in a ten-inch cement pipe, around the cañon's side and out on to the head of the bench, a quarter of a mile west, to a partitioner—a total distance of about four thousand feet.

Partitioner:—This partitioning work is a concrete chamber, ten feet long, four feet wide, and about three feet deep. At one end the waters enter from the ten-inch main; three feet thence they fall over a level-topped masonry wall extending across the width of the chamber; two feet thence they are divided, as they flow forward over the level bottom of the chamber, by the edge of a partition wall placed longitudinally in the chamber, and from the spaces on either side of this wall they are taken into the heads of the respective pipe system. A grating serves the better to distribute the flow, between the over-fall and the partitioning edge.

MAIN AND DISTRIBUTION PIPE-LINES:—The Sierra Madre Water Company has a half interest in the above described work. Thence its main pipe leads westward, near the top of the sloping bench, about three thousand eight hundred feet, to a paved and cemented distribution reservoir of about one million gallons capacity; and there is another smaller reservoir on the way. From these, distribution in pipes under pressure is effected down the slope. Of such pipe about thirty-five thousand feet in all, varying in sizes from two-inch (screw pipe) to eight-inch (wrought-iron riveted), has been laid.

COST OF WORK:—The joint work out to the partition cost somewhat over $3,000, the reservoirs about $4,500, and the company's work entire about $12,000.

Operation and Maintenance:—The Sierra Madre Water Company is incorporated on a general water-supplying basis, but is operated for the sole benefit of the Sierra Madre tract of land. The company was organized with as many shares of stock as there were acres in the tract; and in sales of land by the owner, a share of water company stock has been transferred with each acre sold—he owning, practically, all of such stock at the beginning. The deeds seek to make the stock an appurtenance to the land, but it is said that stock has been transferred from second hands

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without selling lands. Distribution for irrigation is effected by measure of time, and is regulated by schedule fixed at the beginning of the irrigating season—each irrigator knowing the days and hours that his turns will commence and end, and the operation being in care of a *zanjero*. A charge of 40 cents per month is made to each householder and each irrigator to pay *zanjero's* fees. The expense of repairs, clearances, etc., is met by special assessments on the stock.

Water-supply and Use:—The ordinary low-water flow of the Little Santa Anita stream is twenty-five to thirty-five miner's inches, of which half is due to this system. During the present season (1888), about three hundred acres have been irrigated, of which about one hundred acres are in citrus orchard, one hundred in other fruits, and one hundred in various summer crops. Vines are not irrigated on this bench-land during the summer, the grapes maturing perfectly without it.

History of Water-right:—The Little Santa Anita stream, naturally, flows out upon the Santa Anita rancho, whose upper line crosses the wash just below the mouth of the cañon. The former owner of the rancho, Wolfskill, appropriated its waters and took them down to the plain, in an open ditch for spring irrigation, in very early times. About 1872 there was a wooden V flume which carried the waters down in conjunction with those of the Santa Anita. Richardson, a preëmptor of government lands on the bench above the rancho line, once appropriated some of the waters. A suit at law followed, and it was decided that the waters had become appurtenant to parts of the Santa Anita ranch. This was in April, 1874. The Sierra Madre tract and Water company's rights were acquired by N. C. Carter from the owner of the Santa Anita rancho; and he organized the company, and has been the head and front of the enterprise.

[The pipe-line from this source to the Santa Anita rancho will be described in connection with works of irrigation from the *cienegas* on the ranch lands.]

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CHAPTER XIX.—LOS ANGELES[c]; WORKS AND PROJECTS[16].

SAN GABRIEL VALLEY IRRIGATIONS.

SIERRA MADRE CAÑONS GROUP[2].

SAN PASQUAL SUB-GROUP[d].

SECTION I.—*Davis Cañon and Other Works:*
Sierra Madre Villa Works;
Vosburg Water Company;
Kinneloa Irrigations.

SECTION II.—*Eaton Cañon Works:*
Precipice Cañon Water Company;
Tunnels Under the Cañon;
High Pressure Pipes;
A Jet Pump and Other Works.

SECTION III.—*Rubio and Los Flores Cañons and Other Works:*
Rubio Cañon Water Company;
Los Flores Water Company;
Small Developments; San Antonio to Arroyo Seco.

SECTION I.

DAVIS CAÑON AND OTHER IRRIGATIONS.

The Sierra Madre Villa and Vosburg Systems.

District and Work:—Next the deep wash of Davis cañon, on the west, lies a point of the old mesa formation, which, extending three fourths of a mile to, and overlooking the wash of Eaton cañon, embraces about four hundred acres of land. Upon this point is the Sierra Madre Villa and the Vosburg tracts, and the waters of Davis cañon are devoted to irrigation and domestic supply thereon.

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MAIN LINE; JOINT WORK:—These waters are brought from a point about six hundred feet within the cañon, by an eight-inch vitrified pipe, a distance of one thousand three hundred and fifty feet, out and around on the mesa's face to a reservoir, and there are partitioned to the two ownerships, and delivered thence in separate pipes. The headwork is in a tunnel driven seventy feet through a vertical point of rock, so as to undercut the cañon to bedrock, just at the foot of a perpendicular fall of twelve to twenty feet, in its water-way. After this tunnel was made, the pipe was laid through into the bowlders of the cañon channel, and there covered in with masses of rock, and then the tunnel was in part refilled behind the end and around the pipe, so that it receives its waters under the protection of the rock masses, and thus they are at all times freed from drift before being taken into the conduit. The pipe is laid with cement joints, on a regular slope along an old flume grade in the cañon wall and the face of the mesa bluff, for about one thousand one hundred feet, and then turns out on to the bench. The partitioner is a wooden structure, and division is made by means of two small weirs of equal length and in the same level plane—each drawing half of the water to the conduit of the respective systems of the Villa and the Vosburg tracts.

DISTRIBUTION :—*The Villa System:*—The Sierra Madre Villa works from the partitioner consist of nine hundred feet four-inch cement pipe, one thousand six hundred feet three-inch iron screw-pipe, a reservoir paved and cemented holding about ninety thousand gallons, and about five thousand feet of one and a half and one-inch iron screw pipe.

The Vosburg System:—The Vosburg reservoir is nearly circular, eleven feet deep, and with capacity for seven hundred and fifty thousand gallons. From it the distribution is made in iron screw-joint pipe, of which there are several thousand feet ranging in size from three down to one inch.

COST OF WORK :—The cost of the original flume out from the cañon is not known, but probably exceeded $800. The newly driven tunnel and ironstone pipe-line cost about $700. The Vosburg reservoir cost $1,500. The Vosburg pipe system, about $2,000. The Villa reservoir and pipe system (constructed some years ago when material and labor were higher) cost about $3,500. This makes a total for the entire system, from the begin-

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ning, of $8,500. The whole system could probably now be put in for $6,500.

Operation and Maintenance:—Although a portion of the Vosburg interest is incorporated, as hereinafter explained, the works are thus far managed altogether as private property, and hence nothing of moment can be said under this heading.

Water-supply and Use:—The low-water flow of Davis cañon comes altogether from one spring or group of springs about half a mile above the point where the diversion is made. The cañon bed is exceedingly steep—there being a number of vertical falls, and the channel-way being over solid rock for no inconsiderable part of the distance. The supply for the crucial months of July to September, inclusive, has been found to range between ten and fifteen miner's inches, according to the year and the time of the year, state of weather, and time of day when gauged—for this is a stream, which in hot weather loses no inconsiderable part of its volume in flowing half a mile over bare rocks exposed to the sun's full effects, and, consequently, it has a large diurnal variation.

IRRIGATION:—There are in all about one hundred and five acres irrigated by these waters, of which sixty are cultivated in citrus fruits, and forty-five in deciduous fruits. Vines thrive on this mesa without artificial watering.

History; Organization, etc.:—The water was brought out by means of a little flume laid on the route of the present pipe nearly thirteen years ago. This work lasted until 1886, when it was replaced by the pipe, and the tunnel was driven. The Villa tract is within the Santa Anita rancho, and the Vosburg tract was government land. The claim of the rancho to the waters of the cañon was secured with the tract bought, and the water-right was shared equally with the owners of the Vosburg tract. The Villa tract is still held in private hands.

Vosburg Water Company:—The Vosburg tract consists of one hundred and eighty acres, of which forty have been divided into half-acre villa lots. To supply this part of the tract and sell rights to water with the lots, the Vosburg Water company was incorporated. It has a capital stock of $80,000, divided into four hundred shares. The company acquired one third of the Vosburg half interest in the water, or one sixth of the whole. Two shares

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of stock are sold with each half-acre lot; there being no guarantee of quantity of water furnished, nor restriction as to the area of land to which the company may distribute its stock, on the basis of present water-ownership. About one hundred and forty acres of the tract are on the mesa, and it is stated that the full half-interest in the waters—or, say, seven to eight miner's inches for three months in the year—is to be devoted to this tract. The Water company's stock is not made appurtenant to the lands, but is simply transferred with the lot ownership as a personal property.

Kinneloa Irrigations.

District; Works; Water-supply and Use:—Immediately west of the Vosburg irrigations, and occupying the western corner of the Sierra Madre Villa mesa, is a tract known as Kinneloa, the property of Mr. Abbott Kinney. In this locality the mesa is cut through by three ravines made by washings from small cañons in the mountain's face behind. In these ravines four tunnels have been driven to a total length of about eight hundred feet, and a water-flow of about nineteen miner's inches, in the aggregate, has been thus developed. This is piped to a small reservoir, and thence distributed in iron pipes throughout the tract. There are about three miles of pipe laid, and sixty acres of the mesa irrigated, which is chiefly cultivated in oranges.

SECTION II.

Eaton Cañon and Other Works.

Precipice Cañon Water Company.

District and Works:—In coming from its cañon the wash of Eaton creek turns southeasterly, and skirts the base of the mountain for nearly a mile, leaving a high mesa standing outside of it, and then turns south. The waters of the cañon are devoted to irrigation on this bench and the plain sloping therefrom, for about three miles from the mountain's base, and are distributed at points about a mile and a half apart in an east and west direction. The water-right is held by the Precipice Cañon Water Company, whose works will now be described.

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DEVELOPMENT AND DELIVERY WORKS:—The diversion of water from this cañon was until quite recently made from a point about five hundred feet within the cañon mouth, by means of a timber dam put down through the gravels (it was intended) to bedrock, and the water was carried thence by a small box flume along the western side of the gorge and bluff of mesa to the bench. Now the diversion is combined with a development work, and is effected by two tunnels driven through bedrock points to undercut the cañon bed beneath its gravels. The first tunnel passes from a location, about one thousand two hundred feet in elevation above the sea-level, on the east side of the cañon opening, five hundred and fifty-four feet, through a spur around which the cañon comes to its *debouchement*, and then cuts under its bed at a depth of forty feet below the surface gravels, and just at the level of bedrock, thus securing the underflow there. The second tunnel, at a location about one thousand nine hundred feet up the cañon, passes, about two hundred and fifty feet, through a narrow point in a spur around which the cañon winds in a course nearly a mile in length, and in like manner, again undercuts the channel beneath the gravels where they are at an elevation of about one thousand five hundred and eighty feet above the sea.

The waters derived from the upper tunnel are taken in a six-inch iron pipe around the wall of the cañon, dropped, in their pipe, by an incline into the lower tunnel near its upper end, and carried by it through the lower spur. This pipe, together with a similar one conveying the waters derived from the lower tunnel, is thence carried across the cañon wash by suspension cable supports, at a level about fourteen feet below that of the old line of conduit, on the west side, out to the mesa. The lower tunnel waters being too low to reach this conduit, a three-eighth-inch jet from the upper tunnel pipe, under about three hundred and thirty feet of pressure, is utilized to raise them by means of a "jet pump," the fourteen feet they are deficient in elevation, and pour them into the flume. But the main body of the water from the high-pressure source is carried on, westward, to a reservoir on the mesa about three hundred feet higher and one thousand three hundred feet distant.

Pipe-lines:—The works consist of: main conduit, eleven by fourteen-inch box flume, on grade of seventeen and one half feet per mile, out from cañon opening to edge of the mesa, three thousand

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feet; thence nine-inch ironstone pipe, three thousand two hundred feet down the mesa to the Crank reservoir; thence eight-inch ironstone pipe, three thousand feet, still down the mesa to the Brigden reservoir; and thence by pipe similar to the last, about five thousand feet, to the Craig reservoir—a total distance of fourteen thousand two hundred feet. The three reservoirs mentioned are each about six hundred thousand gallons capacity, and there are a number of covered cisterns of thirty-five thousand to forty thousand gallons capacity, all walled, paved, cemented, and covered in.

The pipe-line from the higher tunnel is three thousand feet six-inch screw-joint iron pipe, and one thousand five hundred feet four-inch to the Allen reservoir, which is masonry-lined and cemented and of three hundred and seventy-five thousand gallons capacity. From here the distribution system consists of wrought iron screw-joint pipe, five, four, three, and two inches in diameter, to an aggregate length of about ten thousand feet.

Water is all held under pressure except in the main ironstone pipe and flume leading out from the cañon at the lower level. Irrigation distribution is largely effected by means of small V flumes. Besides the two tunnels already described, there are two short water-development tunnels at points well up in the cañon, and a third on the west side just above the low-grade diversion flume. This last is one hundred and twenty feet in length and yields about five inches of water.

Operation and Maintenance:—The Precipice Cañon Water Company was incorporated for the purpose of "acquiring by purchase, location, or otherwise, any water-bearing lands, water-rights, waterworks, and water in Los Angeles county, that may be deemed necessary or proper for the uses and purposes hereinafter stated; and to develop water and construct and purchase water-works for the purpose of appropriating and using all waters acquired or obtained; and distributing the same among or to its stockholders for domestic, irrigation, and other uses upon the Santa Anita and San Pasqual ranchos, in proportion to their respective shares and in accordance with such rules and by-laws as may hereafter be prescribed or adopted by this corporation; and also to acquire and own stock in other corporations." In the by-laws the directors are given power "to declare dividends out of the surplus profits;" "to divide and pay over, among, and to the stockholders, in

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accordance with their respective holdings of stock, the proceeds of sales of water, water-rights, or water-bearing lands, etc."

It would appear from the foregoing that the company was incorporated to acquire any waters in Los Angeles county, and furnish them to its stockholders anywhere on the two ranches named. It is not limited to one specific operation; but is confined, in distribution, to its stockholders: It is not, under its articles of incorporation, a general water-supply company, formed for the distribution and sale of water to the public; but under its by-laws it is organized for the sale, rental, and distribution of waters as a general supply company. There are four principal shareholders, who each have a reservoir into which the waters are delivered, and from which distribution is made under the supervision of the owner, in each case. One of these has assigned a portion of his stock and waters to the Lamanda Park Water Company, and this company issues its own stock and distributes the water to purchasers of lots in that tract. But the Precipice Cañon company distributes direct only to its stockholders, of whom four individuals control nearly the entire interest.

Water-supply and Use:—Eaton or Precipice cañon has ordinarily yielded by natural flow at the old point of diversion, just above the cañon opening, during the dry months of ordinarily dry seasons, from fifteen to twenty miner's inches. The company appear by their works to have increased the supply to thirty-five to forty miner's inches.

IRRIGATION:—The utilization of waters in irrigation from this source commenced in 1866. Although the first irrigator under it applied his supply only to orchard service, others who came in afterwards irrigated their vineyards as well. In 1881 it was reported for the state engineering department that there were four hundred and forty-seven acres cultivated by the use of these waters; of which eighty-three were in citrus fruits, one hundred and forty-three in deciduous fruits, and two hundred and twenty-one in vines. There were four users only, who irrigated from ninety to one hundred and ninety acres each. Now the watering of vines has been done away with, and in the present year (1888) there are about two hundred and fifty acres irrigated, which are cultivated about one hundred and fifty in deciduous fruits and one hundred in oranges. The demand for domestic supply now

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constitutes a very considerable draft on this work. The greatest extent to which this water has been used was reported for 1885, when the area was six hundred and fifty acres, held and farmed by the same four owners, and this included some vineyards as well as the orchards.

History and Water-right:—Eaton cañon flows out upon the San Pasqual ranch, and its waters have always been claimed and held for a portion of these lands. The first diversion was commenced in 1865, by members of the family of General Joseph E. Johnston, who acquired a piece of the rancho property. It was finally accomplished by Hon. Benjamin S. Eaton, who succeeded to the Johnston ownership in 1866, and water was first used in irrigation in the following year. The use was for orchard irrigation only—this being the pioneer attempt in the county to cultivate vines without irrigation. The present company has succeeded to this water-right. For a number of years it and the low-grade works were owned by four individual cultivators, who used the supply all for their own irrigations. But the demand for water and land on the part of others, led to the incorporation of the Precipice Cañon Water Company, in 1887. The capital stock is $625,000, divided into twelve thousand five hundred shares of a par value of $50 each.

SECTION III.

Rubio and Los Flores Cañons Works.

District:—Rubio and Los Flores cañons come out of the mountain close together at the head of and at the highest point of the Pasadena mesa. They have formed an immense "dump" of gravelly bench-land soils (elsewhere described), over the old mesa formation, which is known as the Mesa de Los Flores, from its brilliant covering of wild flowers and conspicuous appearance in spring and early summer. The waters of these cañons are used in irrigation and domestic service on this highest part of the mesa, and along a strip of territory about a mile wide, extending about two and a half miles down the middle of the mesa, between the district commanded by the Precipice Cañon company's works on the east, and those of the North Pasadena Water Company, yet to be spoken of, on the west—the more conspicuous tracts of the dis-

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trict being known as Altadena, Highland Park, and the Pasadena Improvement Company's, and the Jewett tracts.

Rubio Cañon Land and Water Association.

Works:—DEVELOPMENT TUNNELS; PIPE-LINES:—Water is developed and concentrated by means of tunnels driven into the mountain sides of the cañon at two points where some show of springs was found. These tunnels have an aggregate length of something less than two hundred feet. Their waters are brought by means of a five-inch and three-inch iron pipe, respectively, to a sand-box located several hundred feet within the cañon's mouth. They are thence taken out by a seven-inch wrought-iron riveted pipe, whose length is about two miles, and which, with distributary pipe, comprises about five miles of conduit for the system.

One of the tunnels, extra large in section (about five by seven feet) and in bedrock, cost at the rate of $6 50 per linear foot.

Operation and Maintenance:—The Rubio Cañon Land and Water Association was incorporated for the purpose of acquiring, etc., waters and water-works, and distributing waters among its stockholders, in proportion to the extent of their ownership of the full amount of the stock. Its stockholders have, chiefly, been several other corporations—viz., the Iowa Improvement company, and more recently the Pasadena Improvement company, holding thirty thirty-sevenths of the stock, and controlling the distribution of the water. In disposing of its lands this latter company attaches two shares of the Rubio Water stock with each acre, and waters are distributed to none but stock owners.

Water-supply and Use:—The Rubio cañon water-supply is very small, naturally, indeed, during the dry months it almost, if not quite, dries up. Certainly in all ordinarily dry seasons the normal flow during August to October has not exceeded three to five inches. The company, by its tunneling, appears to have developed and concentrated a volume of thirteen to fifteen miner's inches, as observed in the driest part of the present year.

IRRIGATION:—About two hundred acres are served in irrigation, but domestic supply constitutes a very material demand. The cultivation is altogether of citrus and deciduous fruits. Vines flourish without irrigation.

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History; Organization:—The Rubio Cañon Land and Water Association was incorporated in March, 1886, with a capital stock of $185,000, divided into three thousand seven hundred shares.

NOTE.—It is observed after the above was written, and too late to make further inquiry, that a Rubio Cañon Water company was incorporated in June, 1886, and it is possible that there may be some confusion of names herein.

Los Flores Water Company.

Works:—DEVELOPMENT TUNNELS; PIPE:—This company has four water-development tunnels, at points within the cañon, whose aggregate length is about four hundred feet. The water is collected by means of small pipes and carried out to a reservoir, of about thirty-five thousand gallons capacity, on the mesa about half a mile from the cañon opening. Thence it is distributed through three and two-inch pipes whose total length is about five miles.

Operation and Maintenance:—The company was incorporated to furnish water to its own stockholders only, and does not sell it to others. There were eighty-seven stockholders in July of the present year, of whom eighteen were actual residents and users of water.

Water-supply and Use:—The Los Flores or Forsythe cañon naturally almost goes dry during the hot months of ordinarily dry years. The company's tunneling work has apparently yielded them a supply of about ten miner's inches. The extent of irrigation does not exceed one hundred and fifty acres, for a large part of the water is now devoted to domestic use.

History; Organization:—The Los Flores Water Company was incorporated in June, 1885, with a capital stock of $96,000, divided into nine hundred and sixty shares.

SMALL IRRIGATIONS.

San Antonio Cañon to Arroyo Seco.

There are a large number of small water developments and utilizations made by private enterprise, between San Antonio cañon on the east and the Arroyo Seco on the west, along the upper edge of San Gabriel valley. Some data of these will be presented in summarizing this subject in a closing chapter of the report.

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CHAPTER XX.—LOS ANGELES[7]; WORKS AND PROJECTS[17].

SAN GABRIEL VALLEY IRRIGATIONS.

BASIN GROUP[3].

SECTION I.—*San Gabriel and Santa Anita Cienega Works:*
Baldwin-Santa Anita Cienegas and Wells;
Rose-Sunny Slope Cienegas and Wells;
Shorb-San Marino Springs;
Wilson-Mission San Gabriel Springs;
Kewen-Molino Springs;
Stoneman-Los Robles Springs;
Bacon-Marengo Springs and Tunnels.

SECTION II.—*San José Cienega and Creek Works:*
The Phillips and Rubottom Ditches;
The Wright and Currier Ditches;
The Foster and Ybarra Ditches;
The Quintana and Rowland Ditches;
The Puente Mill and Peco Ditches.

SECTION III.—*Middle San Gabriel Works:*
Pecks Ditch;
Winter and Spring Irrigation.

SECTION I.

SAN GABRIEL AND SANTA ANITA CIENEGA IRRIGATIONS.

Springs and Artesian Well Supplies.

District and Water Sources:—As explained in Chapter XIV. of this report, along the southern edge of the Pasadena mesa, and thence in line easterly to the Santa Anita wash, a series of springs break out, forming *cienegas*, and artesian waters are obtained by boring. The irrigations from these sources, some of which are among the oldest and best known in Southern California—extending

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through the Santa Anita rancho and into the neighborhood formerly so often spoken of as the San Gabriel Orange belt, are herein classed as the San Gabriel-Santa Anita Cienega irrigations. Severally named, according to the ownership of property or local nomenclature, in order of location from east to west, the sources of supply (*cienegas* or groups of springs) are as follows: The Baldwin-Santa Anita, the Chapman, Rose-Sunny Slope, Titus, Foord, Winston, Shorb-San Marino, Wilson-San Gabriel, Wilson-Mission Cañon, Kewen-Molino, Oak Knoll, Stoneman-Los Robles, and Bacon-Marengo. From each of these sources a group of irrigations is supplied. The principal ones of which, in extent, are those from the Santa Anita, the Wilson, Stoneman, and Rose Cienegas.

Santa Anita Rancho Irrigations.

Tract and Works:—The eastern end of this artesian belt, for two miles and a quarter of length, is within the undivided remainder of Santa Anita ranch, owned by E. J. Baldwin. There is here an area of four hundred and fifty to five hundred acres of decidedly wet or marshy land, lying in a strip near two miles long, east and west, with a maximum width of three fourths of a mile; and within, or on the margins of which are three more or less distinct groups of artesian springs of the character described in the chapter above named, and also a number of artesian wells.

The *cienegas* and well waters are collected by little open ditches, and in some cases by pipes, into sixteen or eighteen small earth-embanked reservoirs, and are drawn thence and distributed, chiefly through cement pipes, together with waters brought from Santa Anita and Little Santa Anita cañons (see Chapter XVIII. *ante*), in irrigation over a body of land about three miles in length, east and west, and a mile to a mile and a half wide, lying immediately south of the *cienega* or artesian belt, and west of the Santa Anita colony tract heretofore described. These are the Baldwin-Santa Anita sources and irrigations.

Main and Distribution Pipe-lines:—There are for the service of these irrigations: (1) the pipe-line from the partitioner out of Santa Anita cañon, which is a twelve-inch concrete pipe and near four miles in length; (2) the line from the partitioner out of Little Santa Anita cañon, which is a six-inch concrete pipe about two miles in length; (3) the collecting pipe system from the *cienegas*, and the distributing system for the whole supply, which is also of

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concrete, ranging from six to ten-inch, and in the aggregate making a length of twelve to thirteen miles. Distribution is effected by "turnouts" the same as already described for the Ontario and Etiwanda works, and the pipes, of course, serve only as open channels—not being under pressure.

Water-supply and Use:—The following is a statement of the supply of water at command for these irrigations during the driest months of the present year:—

Santa Anita cañon—one half the flow	27
Little Santa Anita—one half the flow	15
Cienega streams	28
Artesian wells (nine)	34
Total: miner's inches	104

The volumes of the *cienega* streams have been heretofore reported as much greater than that above shown, but this is a fairly liberal estimate for them for the present season.

IRRIGATION:—There are about one thousand four hundred acres of cultivation under these works, of which about half is orchard, regularly irrigated, and the balance vineyard, not irrigated through the summer.

Marengo Water Company's Works.

District and Work:—The westernmost out-cropping of this artesian basin is found in the two ravines which flank the Raymond Hotel hill on either side, immediately south of Pasadena, and their waters are utilized on or are due to a tract of land about nine hundred acres in extent, which reaches away from the foot of the hill southerly for about a mile and a half. This tract has long been known as the Bacon ranch; the unsold portions of it now belong to the Raymond Improvement Company, and the water interests have been merged into the Marengo Water Company.

WATER DEVELOPMENT TUNNELS:—The waters naturally burst forth in the two ravines cut by the wash of surface drainage down into the water-bearing gravels, where these crop out along the slope of the mesa bluff, described in a former chapter. To further develop and concentrate the supply, a tunnel has been driven from each ravine under the mesa edge into the gravel. The west tunnel is about seven hundred feet in length, and that from the east ravine is about three hundred. They are both timbered, and were

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driven several years ago, at a cost of between $3 50 and $4 per linear foot. The waters are led thence by a six-inch wrought iron riveted pipe on light gradients around the hill slope, and dropped into a reservoir situated at the head of and about the middle of the tract. The fall in dropping the supply from the eastern source into the reservoir is to be utilized in raising, by means of a hydraulic ram, a portion of the waters to a smaller reservoir on the hill above, for the service of some of the lands not commanded by gravity flow from the sources.

DISTRIBUTION; RESERVOIR; PIPE-LINES:—The main reservoir is about three hundred and thirty-three feet long and ninety feet wide on the bottom, with sides sloping at about one on one and a half. It is intended to hold water at about seven feet of depth, and has capacity for about one million eight hundred thousand gallons. The bottom is covered with good concrete, three inches thick, with an inch of strong cement plaster as a coating; the sloping sides, with similar concrete and cement coating, to a thickness of nine inches at the bottom and four inches at the top. The water is received through and taken out by heavy pipes with water gates in a concrete gate house—the whole being well arranged and substantially constructed. The work is set on the sloping plain, so that its upper side is all in cut, and the lower side half in embankment. There was an old earthen reservoir at the site when the new work was undertaken in 1887, so that the excavation was about half done.

COST OF THE WORKS:—The cost of the reservoir work was as follows:—

Excavation; heavy earth and gravel	$1,955 82
Concrete	7,448 20
Pipe and fittings in reservoir gate house	225 00
Superintendence and engineering	244 00
Sundries—dressing bank, fence, etc.	1,218 00
Total	$11,091 02

The waters are distributed from this reservoir by means of six, four, and two-inch iron pipe, of which, including the mains from the springs, about ten miles have been laid. The total cost of the water-works thus far has been about as follows:—

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Water development	$4,000
Reservoir, etc.	12,000
Pipe system	16,000
Total	$32,000

The estimated cost for full completion of the system is $45,500.

Water-supply and Use:—The two springs as developed and concentrated by the tunnels, have ordinarily yielded about thirty-six miner's inches of water almost unvaryingly throughout the year. Very recent work in making a heavy railroad cut in the east ravine is reported to have developed twenty to twenty-five inches additional. The irrigation from this source is of early date; but its spread has been checked by the demand for the property commanded, for suburban home grounds, so that now the waters are in part being devoted to domestic use. There are about one hundred acres in oranges, walnuts, and vines irrigated.

Operation and Maintenance; ORGANIZATION:—The Marengo Water Company was incorporated in December, 1884, with a capital stock of $250,000, divided into five hundred shares, as a general water-supply company, but more especially to acquire and manage the water properties on the Marengo tract.

Distribution is in charge of a superintendent. The property is losing the character of an irrigation neighborhood, and assuming that of residence lands, so there is nothing of special interest in matters of operation, from the irrigation standpoint.

Water-rights:—The by-laws say: "All waters belonging to the company and used by the stockholders, shall be distributed to each in the proportion that the number of shares held by such stockholder bears to the whole number of shares of stock in the corporation; but to each and every acre of land within the limits of the Marengo tract lying below the heads of springs or water sources on said tract embraced in the sale to this company, not less than four shares shall appertain and permanently attach; and they shall pass to purchasers of said land from time to time as sales are made, and must be transferred to them at time of such sale. Any excess of shares over and above the four shares per acre, which may be held in the treasury of the company or otherwise, shall be entitled to a pro rata use and distribution of water wherever the holder thereof may wish to make use of it.

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Stockholders shall be responsible for the amounts charged for all water used under and by virtue of any stock held by them."

Alhambra and Addition to Alhambra.

District; Works; Water-rights:—Lying south and east of the Marengo are the irrigation colony, or neighborhood tracts, known as Alhambra and Addition to Alhambra. The Alhambra tract containing two hundred and seventy-five acres, subdivided and sold out in quite small parcels, is served with water for irrigation from the Wilson springs of Mission cañon in the mesa's edge. The supply is taken about half a mile in an open ditch, and there the Alhambra waters are partitioned off and carried in a five-inch iron pipe for one and a half miles to the reservoirs, which have capacity for seven hundred and fifty thousand and five hundred thousand gallons, respectively. From here they are distributed throughout the tract, under pressure, by means of four-inch iron pipes, of which there are about seventeen thousand feet laid. The charge for water is $2 50 per day for twenty-five "surface," or "weir" inches—measured as described for the Pasadena works. This irrigation was one of the enterprises of the original Lake Vineyard Land and Water Association, whose origin and history is traced in the next chapter. The right to purchase water, or a "water-right," was sold with the lands in small parcels, and these rights were afterwards merged into a water company in exchange for its stock.

Alhambra Addition Water Company.

District; Water-source:—The Alhambra Addition Water Company was organized to serve the Alhambra Addition tract with water for domestic and irrigation purposes, and about one thousand eight hundred and fifty acres are covered by the works. The supply is obtained from El Molino cañon—one of the natural cuts in the mesa edge, in which springs burst forth, as elsewhere explained—where eight development tunnels have been driven. These little works range from twenty to two hundred and seventy-five feet in length each, have an aggregate length of a little less than eight hundred feet, an average of ninety-six feet, and are driven into the gravels along the ravine's sides and under the mesa edge.

DELIVERY AND DISTRIBUTION:—The delivery and distribution works consist of eleven thousand one hundred feet of thirteen-

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inch, seven thousand six hundred and thirty-five feet of ten-inch, six thousand three hundred and fifty feet of seven-inch, twenty-eight thousand six hundred and ninety-nine feet of four-inch wrought iron riveted pipe, and five thousand one hundred feet of two and one and a half-inch gas pipe. There are three reservoirs holding two million, one million five hundred thousand, and three million gallons, respectively, all rock-lined and cemented, as described for others elsewhere.

COST OF THE WORKS:—The pipe system cost $24,500; the reservoirs, $10,600; the entire pipe and reservoir system, including outlets, etc., about $37,000; and the whole works, including water development tunnels and other things necessary, very nearly $50,350.

Old San Gabriel Irrigations.

District; Works; Water-rights:—The San Gabriel Mission neighborhood is the scene of cultivations dating from the very earliest times in the development of agriculture in this southern country; and here are yet found some irrigations of the primitive class, bearing the stamp of a past civilization, as attested by the remains of the Old Mission canal yet to be traced through the country. The Old Mission irrigators of to-day have rights, acquired seemingly by use, to the employment of waters from the principal Wilson *cienega* stream. The rights are personal—representing the full run of the stream for so many days or nights, or parts of days or nights, per month or per week, to the several individuals. The system is much mixed, and there is a *zanjero* who looks after the collective and individual interests of the irrigators in the matter of supply and distribution. They have to pay for water, however, and the charge is $1 50 per day, and 75 cents per night for a head.

Synopsis: San Gabriel-Santa Anita Cienega Irrigations.

Works; Operation; History:—To enumerate in this chapter and describe in detail the many water sources, works, and irrigations of the San Gabriel-Santa Anita Cienega group would swell the volume of this report far beyond its enforced limits.

The immediate sources are all on lands long in private ownership, so that the waters, since California was a state, have been looked upon as private property. There have been no notable

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conflicts over water-rights, no specially instructive experiences in organization development; there are no works from which any lessons may be learned other than those abundantly taught by types of which examples are herein repeatedly presented—except in the matter of water development, and this subject is dealt with, as a whole, in a special chapter elsewhere in this report. Except as heretofore spoken of, these works have nearly all been carried out, and are owned and operated by private parties, and for the most part for individual use, and there is nothing to be said as to operation and maintenance worth the saying, after the much which has already been written of similar irrigations. Other data concerning these will be presented in appendices at the close of this publication; moreover, there will be much to say of these irrigations, and particularly of those on the Wilson-Shorb, Stoneman, Rose, and Chapman estates, in the chapters on the Practice of Irrigation, and so it is necessary to forbear speaking at length of each of the works here.

Water-supply and Use:—The data of flow of these *cienega* streams, so far as at hand, will be found in the summary on the subject of Water-supply, hereinafter presented.

IRRIGATION:—As to extent, etc., of irrigation, an examination made for the state engineering department in 1879, showed that there were then about one thousand five hundred and eighty-five acres receiving water from the *cienega* sources west of the Santa Anita rancho tract. In 1881, a careful collection of statistics, over the same ground, showed fifty-nine individual irrigations—several large tracts, each owned by several persons, being under one management. There were two thousand one hundred and eighty-nine acres irrigated, of which eight hundred and thirty were in orchard and one thousand three hundred and fifty-nine in vineyard. The largest individual irrigation was four hundred and forty-five acres in extent; the smallest, one acre; and the average thirty and nine tenths acres. In the current year it is estimated that there are about six thousand acres, west of the Santa Anita rancho tract, which are directly dependent on these waters, and which are for the most part irrigated by them. The number of irrigators is somewhere between two hundred and seventy-five and three hundred, and the average actual irrigation is from fifteen to twenty acres. The irrigated cultivation is for the most part of citrus

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fruits, and deciduous fruits come next in order. Vines are not regularly irrigated, and by some cultivators not at all. The era of extended vineyard irrigation in this region, once so prevalent, has now past. The young and particularly the larger vineyards are not watered, as a general thing, and so the average irrigated holding is much reduced in area.

SECTION II.

San José Creek Irrigations.

District:—The valley or pass of San José creek, extending through from Pomona to the lower part of San Gabriel valley, is about thirteen miles in length and contains about ten thousand acres of fine arable land, in long narrow tracts adjoining the creek channel, which, winding through the pass is about ten to twelve feet in depth below the general level of the plain. The stream is but a small rivulet, comparatively speaking, and, having no independent mountain drainage, never runs in very high flood. Its water-supply rises at intervals along its course, from sources believed to be as explained elsewhere in this report, and is diverted by little ditches for the irrigation of lands lying immediately adjacent to or within a mile of its banks. These ditches are here mentioned and described in the order of their location going down stream.

Phillips Ditch:—Diverts water on the north side; is one mile long; irrigates about twenty acres, all in summer crops, and for the most part vegetables.

Fryer Ditch:—Diverts on north side, one quarter mile below the Phillips ditch. This is the oldest of the five upper ditches, having been built about 1867. It is one and a half miles long; irrigates about one hundred acres, cultivated, five in deciduous fruits, twenty-five in vineyard, sixty-five in alfalfa, and five in summer crops.

Rubottom Ditch:—Diverts on north side immediately below the one preceding; is about one mile long, and irrigates about forty acres, cultivated, five in vineyard, twenty-five in alfalfa, and five in summer crops.

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Wright Ditch:—Diverts on north side a mile below the Rubottom ditch; is about a mile long, and irrigates about sixty acres of land, cultivated, fifty in alfalfa, and ten in summer crops.

Currier Ditch:—Diverts on south side, one and a half miles below the Wright ditch. This ditch is about two miles long, and irrigates about one hundred and fifty acres, which is planted three acres in citrus fruits, seven in deciduous fruits, sixty-four in alfalfa, and seventy-six in summer crops.

Each of the foregoing five ditches is an individual farm-work, and diverts all of the water of the stream which comes to it.

Rowland and Foster Ditch:—Diverts on north side, half a mile below the Currier ditch. The ditch diverts one half of the water which comes to it, amounting to about sixty-eight miner's inches, and allows the other half to pass on down to the next two ditches named. This ditch is about four miles long, and irrigates about two hundred acres of land, all planted to summer crops, principally corn.

Ybarra Ditch:—Diverts on the north side below the Rowland and Foster ditch. This is a community ditch, and supplies eleven different families; the owners divide the water in proportion to acreage, and distribute by a full head, in a twenty-day rotation period. There is no organization and no administrative officers; the ditch is maintained by the contribution of labor in equal parts. This ditch takes two thirds of the water which comes to it, allowing one third to pass on for the next ditch. This ditch was formerly known as the Chavez ditch, and is a very old ditch, having been constructed about 1850, and at one time served a much larger area than at present. The lands were in litigation in 1880, and the extent of cultivation under it ran down to forty or fifty acres. In the current year (1888) it is about six miles long, and irrigates about three hundred and fifty acres, cultivated, thirty in deciduous fruits, thirty in vineyard, fifty in alfalfa, and two hundred and forty in summer crops.

Quintana Ditch:—Diverts on north side a few miles below the Ybarra. This is quite a small ditch, serving a part of the territory commanded by the two last named ditches. It is about one and a half miles in length, and irrigates about one hundred acres,

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of which twenty are in vineyard, twenty in alfalfa, and sixty in summer crops.

Monroe Ditch:—Diverts on south side three fourths mile below the Quintana; is one mile long, and irrigates forty acres, planted, three in vineyard and thirty-seven in summer crops.

T. Rowland Ditch:—Diverts on the south side a mile below the Monroe. This ditch diverts all the water which comes to it, and has a supply of about one hundred miner's inches. Its water-rights (and those of the Rowland ditch next below) are owned and its waters divided among six persons equally. One of them has carried a ten-inch iron pipe across the creek for a ditch to Puente for the purpose of giving a supply to the town. A general development of this water-supply by a system of cement pipes is being agitated among the owners, but they are as yet unable to agree upon it. The land requires so little water that if the supply were carried in pipes throughout, it is thought to be sufficient for more than two thousand acres.

J. Rowland Ditch:—Used to divert on south side one and a half miles below the T. Rowland ditch; for several years has taken its waters from the T. Rowland ditch. This was one of the earliest diversions in the valley, having been made in 1851–1852. These two Rowland ditches, taken together, are seven miles in length, and irrigate about two hundred and fifty acres, five being in citrus orchard, twenty in vineyard, one hundred and twenty-five in alfalfa, and one hundred in summer crops.

Workman Ditch:—Diverts on north side three and a half miles below the J. Rowland ditch. This is the old farm ditch of the Workman or Puente ranch; and its irrigations immediately at the homestead are: Vineyard twenty-five acres, citrus fruits two acres, and deciduous fruits three acres. It is about a mile in length.

Puente Mill Ditch:—Diverts on north side three and a half miles below the Workman ditch, where the creek is close in against the point of hills at the opening of the outlet of San Gabriel valley. Its waters were formerly used for power purposes at a grist mill, but are now devoted to irrigation, serving about

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sixty acres, of which twenty are in vineyard, ten in alfalfa, and thirty in summer crops.

Pio Pico Ditch:—This diversion, made about a mile below the Mill ditch, is the lowest from Puente creek, and is devoted to irrigation on the sandy loam bottom-lands, south of the creek, and in the Paso de Bartolo, where one hundred and sixty acres, all cultivated in summer crops, and for the most part corn, are served. This cultivation is in the midst of the upper irrigations of the lower San Gabriel group, described in chapter XXV, and might with some propriety be grouped with them.

San José Creek Irrigation; Synopsis.

Water-supply and Use:—The total flow of the creek to all these ditches amounts to about 800 inches—of which three hundred inches rises in the first two and a half miles from the uppermost springs, and furnishes the supply to the eight upper ditches. Taken together, these irrigations cover one thousand five hundred and sixty acres, of which ten are in citrus fruits, fifty in deciduous fruits, one hundred and forty-eight in vineyard, four hundred and nine in alfalfa, and nine hundred and forty-three in summer crops.

The following is a comparative statement of irrigation under twelve of the fourteen ditches, made from the state engineering department statistics, and shows the character of cultivation to which this district is adapted by the outcome of practice:

	Area of Irrigation in Acres.				
	Orchard.	Vineyard.	Summer C.	Alfalfa.	Total.
Statistics of 1880	73	129	437	42	681
Statistics of 1888	60	128	753	399	1,340

In 1880 the ditches had an aggregate length of twenty miles, as compared to thirty-one in 1888.

History:—In the early days of the settlement of the country when the Spanish priests, who established the San Gabriel mission conducted extensive farming operations in the San Gabriel valley, they were attracted to this stream by the permanence of its flow, and the fertility of the lands bordering upon it, and the lines of

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the old irrigating ditches with which they diverted its waters may still be traced. One of them left the creek near the "Old Switch" on the railroad, passed through the present town site of Puente, and extended a long distance out into the San Gabriel valley, northward to where the ruins of the old adobe buildings of the *padres* may be seen. Another embraced a large area of land on the opposite side of the creek, and it is believed from the size of the ditches, and the territory commanded by them, that at least one thousand acres must have been irrigated by these two ditches in this section. At the same time they carried the waters of the River San Gabriel to the Old Mission by a canal, of which there are still traces to be found. Of the existing ditches the J. Rowland and the Workman are the oldest, having been dug in 1846 to 1850. A portion of the stream rising below the lowest ditch can only be diverted by the ditches that head in the San Gabriel River, a little way below the mouth of the creek.

SECTION III.

MIDDLE SAN GABRIEL WORKS.

Peck Ditch.

On the west side of San Gabriel River, about five and a half miles southwest from the cañon mouth, the Peck ditch takes its head, and with a length of three to four miles serves in irrigation a small body of fine sandy alluvial lands lying next west of the wash, and about two and a quarter miles south of the Beardslee district in the lower Duarte. This ditch was reported in 1879 to be an insignificant work, because of the fact of its heading below where the river waters sink, or are all diverted by the Azusa and Duarte ditches in the irrigation months of all ordinary years, and above where waters commence to rise again, there was no possibility of summer irrigation, and no special importance to the work. It has been used, however, as an early spring and winter irrigating ditch to good advantage by its owner, and in that capacity bids fair to teach a lesson to the irrigators of the valley. During the two summers of 1884 and 1885, the water-supply for it kept up throughout the ordinary irrigation season, and it began to assume an importance in a new role.

Its utilization and experiences will be spoken of in future chapters on the Practice of Irrigation.

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CHAPTER XXI.—LOS ANGELES[3]; WORKS AND PROJECTS[66].

SAN GABRIEL VALLEY IRRIGATIONS.

SAN GABRIEL AND SAN FERNANDO GROUP[4]. CAÑON AND SPRINGS SUPPLIES.

SECTION I.—*Arroyo Seco and Millard Cañon Works:*
Millard Cañon Water Company;
North Pasadena Land and Water Company;
Small Individual Works and Irrigations.

SECTION II.—*Arroyo Seco Springs Works:*
Pasadena Land and Water Company;
Pasadena-Lake Vineyard Land and Water Company.

SECTION III.—*Highland Park Water Company:*
Crystal Springs Water Company.

SECTION I.

ARROYO SECO CAÑON AND OTHER WORKS.

District; The Pasadena Mesa:—In the extreme northwestern corner of San Gabriel valley lies a tract of the old red mesa formation, extending southerly from the base of the Sierra Madre, resting against the San Rafael hills on the west, and sloping south and east to a break-off, or rolling bluff, which extends diagonally across the end of the valley, as elsewhere more fully explained. The eastern part of this mesa has been, in large part, cut through and swept away by torrents from Eaton cañon and others east of it; but west of Eaton cañon wash it is more nearly intact. Along its margin at the mountain's base, and for some distance down, its original mesa soil surface is heavily covered with lighter alluvial washings from the slopes above. Along its western border it

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is cut away from the San Rafael hills by the deep wash of the Arroyo Seco. The part of this mesa lying west of Eaton cañon, and comprising much the greater portion, is herein called the Pasadena mesa. It is four miles in width, east and west, six miles in length on its western border, and three miles on its eastern border. It slopes about eighty feet to the mile near its southern end or edge, and two hundred feet per mile near the mountain base.

The works heretofore described as deriving supply from Santa Anita, on the east, and other streams to Davis cañon, are, in great measure, designed to serve the parts of the old mesa, left between the cañon washes, there located. The Eaton, Rubio, and Los Flores cañons works, also already spoken of, command the northeastern and eastern portion of the part of the mesa west of Eaton cañon wash. The Millard Cañon Water Company, North Pasadena Land and Water Company, Pasadena-Lake Vineyard Land and Water Company, and Pasadena Land and Water Company, have works deriving waters from the Arroyo Seco cañon and tributaries, and its lower springs, which are designed to serve the main body of the mesa, whereon are found the neighborhoods known as Altadena, North Pasadena, Pasadena, and South Pasadena, and various tracts with special names not necessary to enumerate here.

The Millard Cañon Scheme.

District and Project:—The Millard Cañon Water Company has a project for piping the waters of Millard cañon out upon the highest part of the Pasadena mesa, in the extreme northwest corner thereof, for irrigation and domestic service there, but no company works have as yet been constructed. The water-right is secured, and the waters are, in part at least, utilized by some members of the company in private irrigations, which are served by a small flume and pipe-line. The Pasadena Improvement Company, heretofore written of, is reported as owning half the stock of the Millard Cañon company; the other half being owned by the individuals now using the supply, as above. The present works embrace about two miles of eight-inch main pipe, and near a mile of five-inch distributary. The water-supply at period of low flow is about seven miner's inches, and the irrigation thus far served something less than fifty acres.

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North Pasadena Irrigation Works.

District and Works:—The North Pasadena Land and Water Company, controlling all water-rights of the Arroyo Seco cañon, except those of Millard cañon, its lower tributary, as next above referred to, seeks to furnish a supply for domestic and irrigation purposes to a body of one thousand eight hundred acres of land lying below Altadena and above Pasadena, known as the Painter and Ball tract, or more recently as North Pasadena. This district occupies the middle portion in the Pasadena mesa, lapping diagonally, in a southeasterly direction, over those of the two companies below, and extending, at its extreme point, somewhat more than half way down the mesa from the mountain's base.

MAIN PIPE-LINES:—The water is led out from a point just within the mouth of the cañon by a cement pipe conduit a little over two miles in length, of which about three fourths of a mile is twelve-inch, and the balance ten-inch—the total fall being fifteen feet in the length of the work. At times of low flow—for several months of almost every year—the supply is very short, so that to collect waters found in little springs and flowings over bedrock in the cañon and its tributaries above, and bring it down to the head of the main conduit, about six miles of iron pipe have been laid, of which three miles are six-inch, one mile is four-inch wrought iron riveted, and two miles are one and a half and two-inch gas pipe.

DISTRIBUTION SYSTEM:—The main pipe delivers water into a paved and cemented reservoir of seven hundred and forty-eight thousand gallons capacity, whence it is distributed down the slope, over the tract in four and five-inch wrought iron pipes, of which over eleven miles have been laid. There is another reservoir of about four hundred and forty thousand gallons capacity in the system, located about half way down the tract, and it serves to break the head in the pipe system, which otherwise would be excessive. This reservoir is paved and walled in masonry of bowlders, and cemented.

DEVELOPMENT WORKS:—Within the cañon the company has three water-development tunnels driven to an aggregate length of three hundred and fifteen feet; one being in bedrock, one in bowlders and gravel, and one in a sort of cemented conglomerate.

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There is also a cutting through bowlders to bedrock in the cañon bed, with a dam therein to force the water to the surface. At the mouth of the cañon, below the main point of diversion, and just below the entrance of Millard cañon, a force is engaged in sinking several large shafts into the gravels to bedrock, with the view of pumping supplies therefrom should the demand make such a course necessary.

Cost of Works:—The works, as now described, exclusive of the old Darque ditch, have cost about $50,000, of which about $6,500 was expended for the two reservoirs, about $3,000 for water development works, and the balance principally for piping.

Operation and Maintenance:—The company is incorporated to acquire by purchase, or otherwise, waters, etc., which can be conducted upon the lands of its incorporators, as described in its by-laws; to develop and collect such waters, and conduct, deliver, and distribute them on the lands, for irrigation and domestic purposes "among its stockholders, in proportion to the number of shares owned by each." It is clearly, therefore, not a general water-supplying company. Its by-laws authorize its directors to make rules for distribution of waters to its stockholders only; and further say that "all waters belonging to the company and used by the stockholders shall be distributed to each in the proportion that the number of shares held by such stockholder bears to the whole number of shares of the stock of the corporation; and said waters to be used only upon the lands described on the map known as 'Painter and Ball's Addition to Pasadena,' as recorded," etc. It would appear, therefore, that these waters are intended to be used on these lands only, and none are delivered off the tracts described. The supply is so small, moreover, that it is all taken for domestic purposes during summer and fall, and irrigation waters are delivered only during spring and up to about the last part of June. At these times irrigation streams are furnished on orders at the rate of twenty cents an hour for twenty "Pasadena" inches, measured as hereafter explained.

Water-supply and Use:—The Arroyo Seco is a dry cañon, as its name implies. The stream fails almost entirely at the cañon opening for several months in ordinarily dry years. By its works of developing, collecting, and piping waters from above, the com-

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pany seems to have secured a supply of about ten miner's inches as a minimum. No water is distributed for irrigation after June, so that there is practically no use of water for irrigation such as this report is specially considering. About ten to thirty inches for ten hours per day is used in irrigation during spring, but the area of lands thus served is not known.

History and Water-right:—The first diversion of water from Arroyo Seco cañon was made in 1869, by one Darque, a tenant of Wilson and Griffin, owners of the San Pasqual ranch, with their consent, and for the irrigation of some of their lands on the mesa where now is North Pasadena. About 1871 or 1872, this water-right, which embraced all the low-water flow at the cañon mouth, was sold with the one thousand eight hundred acres of land lying next to the Arroyo Seco and below the grade-line out from the cañon mouth, and above the grade of the old ditch out from Devil's Gate, hereafter described.

From the name of its owner this body of land then became known as the Monk tract, but the old ditch that commanded it was called the Darque ditch. The property was afterward acquired by Messrs. J. H. Painter and B. F. Ball, and was known by their names. The main pipe-line was laid in place of the ditch, following it closely, in 1881. The owners of the tract, with several other persons, organized and incorporated the North Pasadena Land and Water Company in January, 1885, for the purpose of managing the water property and selling interests therein with the lands of their tract. The company has a capital stock of $90,000, divided into one thousand eight hundred shares, to correspond with the one thousand eight hundred acres in the tract; and in sales of land one share has been transferred with each acre sold. The water-rights of the Painter and Ball tract with the works at that time constructed were transferred to this company, their former owners taking stock of the company in payment therefor. Very much more than half the lands have now been sold, so that the control of the company has really passed into the hands of the land purchasers.

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SUNDRY SMALL IRRIGATIONS.

There are along the mountain's base between the county line and this point, a number of quite small water-developments and utilizations which have not found mention herein. A description of each one would swell this report beyond its prescribed limits. Some data of them will be presented in closing chapters.

SECTION II.

ARROYO SECO SPRINGS WORKS.

PASADENA WATER COMPANIES.

San Gabriel Orange Grove Irrigations.

District and Works:—Lying in a body somewhat less than a mile in width, and four miles in length in a north and south direction, on the western border of the Pasadena mesa, extending down to its southwest corner, and for the entire length overlooking, westerly, the Arroyo Seco wash, is a tract of one thousand five hundred acres, known as the San Gabriel Orange Grove Association's tract. This district is served with water for domestic and irrigation purposes, by the works of the Pasadena Land and Water Company, an organization which has of late years succeeded to the ownership and control of waters and works formerly held by the San Gabriel Orange Grove Association and those who held water-rights under it. The water-supply comes in part from the upper groups of springs, located just above and below Devil's Gate in the Arroyo Seco, known as Thibbets, Ivey, and Flutter-wheel springs; and in part from Sheep Corral springs, located at the lower gorge of the Arroyo Seco, as elsewhere fully described. The upper sources of supply command the entire tract by gravity flow. The lower group of springs command only about four hundred and fifty acres, located at the extreme southern end of the tract; but at periods of least supply waters from this lower source are pumped, to add to those from the upper sources for service on the higher portion of the lands.

UPPER SERVICE SYSTEM; *Gravity*:—As explained in the next article in this chapter, the Pasadena Land and Water Company has recently joined with the Lake Vineyard company in the con-

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struction of a new main conduit, etc., out from the upper group of springs, but their old work is yet in use. The water is diverted by a simple box conduit, located under the protection of a bedrock point on the east side and at the extreme upper limit of the Devil's Gate gorge. It is then carried in a wooden flume along the base of the eastern wall of the gorge about six hundred feet, crossed over the gorge in a suspended iron pipe, and delivered into the head of a wrought iron riveted main line. Commencing with eleven inches of diameter, and being reduced by successive sizes to seven inches, this main is located along the lower bench-lands of the Arroyo middle basin, crossing the stream channel, and mounting the slope of the eastern mesa, to a reservoir situated on a point of the mesa immediately overlooking the second narrows or gorge in the Arroyo, wherein the Sheep Corral springs are located. Its total length is less than three miles and its fall from head to reservoir about sixty-three feet.

Pumping Station:—Water is pumped from the Sheep Corral springs, distant a quarter mile, up to this same reservoir with a lift of one hundred and sixty-five feet, by means of a Worthington old style pump of thirty thousand gallons per hour capacity, which is a little more than the springs yield in dry years at period of lowest supply. The reservoir is a simple earth excavated and embankment work, oval in shape, with a partition bank across the middle, forming two compartments; and with a total capacity of about three million gallons.

Main and Distribution Pipe-lines:—From this reservoir distribution is made under pressure by iron pipes throughout about one thousand acres of the tract. The main distributing pipe—thirteen, ten, and eight inches in diameter—is nearly two miles in length. This, together with a mile of thirteen-inch iron pipe from the new joint work, elsewhere explained, and about four miles of branch pipes, make up a total of about seven miles for the distribution system, and ten miles, including the main, from the cañon to the reservoir. There is a hydrant to serve each separate tract in private ownership, with waters for irrigation, and the pipes are tapped for small house-service connections.

LOWER SERVICE SYSTEM; *Gravity:*—From Sheep Corral springs a gravitation pipe leads along the bluff, and comes gradually out to a little reservoir commanding the lower part of the mesa in South

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Pasadena. This second main comprises about eleven thousand five hundred feet of thirteen and twelve-inch wrought iron riveted pipe, recently laid to replace twelve and ten-inch cement pipe laid six or seven years ago, and which had become thoroughly choked with roots. From the reservoir, which has capacity for about one million gallons, and is paved and cemented, the waters are distributed under pressure in iron pipes of four to eight inches diameter, and delivered in irrigation by hydrants, as in the upper system already described.

COST OF THE WORKS:—The main pipe, from Devil's Gate, the reservoir excavation, and some distributing pipe for the upper supply, as constructed in 1873–74, cost about $22,500. Distribution pipe-lines and additional expenses on reservoirs brought the expenditure on works to about $40,000 at the commencement of 1883. The mile or more of twelve-inch cement pipe put in for the main from Sheep Corral springs has been replaced by wrought iron riveted pipe, and much of the original wrought iron riveted distributing pipe is now abandoned for cast iron. The total cost of works is put at about $65,000, up to the time of the recent commencement of the present joint pipe-line work with the Pasadena-Lake Vineyard Land and Water Company. Taking that into account, and other very recent independent works, the cost has not been less than $75,000, of which $65,000 is for the gravitation systems, and about $10,000 for the pumping plant.

Operation and Maintenance:—IRRIGATORS' WATER-RIGHTS:—The Pasadena Land and Water Company is incorporated as a general water-supply company; or, as its articles of incorporation say, "to do all acts and things that may be necessary for the development, management, sale, rental, and distribution of all waters and water-rights held by this corporation." But the by-laws empower the directors to make "regulations for the division and distribution of water for irrigation and domestic purposes among the stockholders of the company," and not for distribution to others; and they further say, "all waters belonging to the company and used by the stockholders, shall be distributed to each in the proportion that the number of shares held by such stockholder bears to the whole amount of stock of the corporation." Finally, the "water rules" of the company say, "the lands to which the waters of this company apply, and to which they shall be distributed, are hereby declared to be the lands of

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the San Gabriel Orange Grove Association," as per map, etc. "and the reservations included within the geographical limits of said recorded plat, and the Raab tract of sixty acres, more or less, lying on the west side of South Fair Oaks avenue." All lots or parcels of land in order to receive their full apportionment of waters must, under these rules, have attached to and held for them two shares of the water company's stock to each acre, and proportionately for fractional parts. Lots fifty by one hundred and forty-five are to have one third of a share, and lots fifty by one hundred and twenty-five feet, two sevenths of a share. Thus it would seem that not only for agricultural or horticultural use, but also for domestic use, the water is intended to go with the lands, or, at least, cannot be distributed on any land for which the stock of the water company is not held in due proportion.

DISTRIBUTION AND MEASUREMENT:—The water being apportioned to stockholders in proportion to their holdings of stock, there is a *zanjero* in charge of distribution, who delivers to each irrigator in turn his part of the available supply, in the form of an "irrigating head" for a proportionate part of an irrigating period, one would suppose, but since irrigation is now being largely abandoned to give place for this city, this distribution is made on orders or demands for water, in rotation according to the demand and as is most convenient and economical in the service. Water for domestic and general household purposes is supplied through three fourths-inch service pipe under pressure, as usual in city supply works. This domestic service used to be on an intermittent plan through one-inch pipes, at a charge of $1 per month for two hours run per day—the time being roughly graduated according to distance from head of supply and pressure, on account of the varying discharge produced by differences in these elements.

Module:—Notwithstanding the fact that, to quote the "water rules," "the distribution of water for irrigation shall be made to the stockholders *pro rata* in proportion to the number of shares of stock held by them;" and notwithstanding the fact that water may be distributed for irrigation only to certain specified lands whose owners must hold water stock in order to be served, Rule 11 says, "that the water shall be measured out in heads by the *zanjero*, and charged for by the hour per head." The "irrigating head" is defined as "so much as will flow over a gauge ten inches wide and two inches deep without pressure." And it is declared

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that "all gauges for measuring water shall be two inches deep." This, then, is the Pasadena module, and it is intended to measure out an inch—a Pasadena inch—to each square inch of opening, or twenty inches to the module. An inch board having such a notch is placed across the irrigating ditch below the hydrant, and then water is turned on into a pool around the hydrant, and flows thence by the ditch through the module—the quantity just sufficient to fill the notch being regulated by means of the hydrant. All irrigators are obliged to put in these modules, as required by the *zanjero*, and to keep them in good condition.

Water-rates:—The charge for irrigating water for a number of years in this settlement was 25 cents per head for three hours. This has been advanced from time to time, until now it is 20 cents per head per hour, or 60 cents for the three hours. Domestic water is charged for at the rate of $1 50 per month for each head of family, and 10 cents additional for each other person, besides extras for cattle, horses, etc. The meter rate for house service is 25 cents per one thousand gallons.

Cost of Irrigation:—During the years when the water was used principally for irrigation, and when it was not necessary to pump, the cost of operation and maintenance used to run from $1,200 to $1,500 per annum, or $1 to $1 20 per acre irrigated per year, but other expenses brought the cost to materially higher figures. The annual expenses now run much higher, owing to change in character of service, from irrigation to municipal supplying.

Water-supply and Use:—The Ivey, Thibbets, and Flutterwheel springs together naturally yield, during the months of greatest demand, from eighty to one hundred and ten miner's inches—extraordinarily dry seasons being followed by the lower output, and winters of full rainfall being succeeded by summers in which the larger flow is presented as nearly the season's minimum. During the present year some work has been done with the view of increasing the low-water flow, but it is of a nature which, though it may have succeeded for the time being, cannot be regarded as having permanently added to the available supply.

Wilson's spring, about half a mile below Devil's Gate, yields, as developed by a tunnel, about five miner's inches; so we say that

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the ordinary flow from these sources in the average year is about one hundred miner's inches, and in dry years, say eighty-five inches. Of these amounts three tenths, or twenty-five and one half inches in dry and thirty-three inches in average seasons, are due the Pasadena Land and Water Company. In addition to this, it has the entire flow of Sheep Corral springs, which ranges from fifty inches in the hot months of very dry seasons to one hundred and thirty or more inches in corresponding months of years of largest supply. It may be said that the flow in average years from these springs is about ninety inches, so that in such season the full supply at the disposal of the Pasadena Land and Water Company for the three driest months will be about one hundred and twenty-three inches. The pumping works were used during the dry seasons of 1882 and 1883, were not used in 1884, 1885, and 1886, and were used in 1887 and the present year.

IRRIGATION:—Irrigation commenced on the Orange Grove Association tract in 1874. In 1879 it was reported to the state engineer that "the whole of the one thousand five hundred-acre tract is occupied, planted to fruit trees and vines, and under a high state of cultivation, although but one third of it is actually irrigated." In 1880, according to statistics fully and carefully collected by the state engineering department, there were fifty irrigators whose places represented in all one thousand one hundred and ninety-five acres; the largest individual ownership being of sixty; the smallest, five; and the average, twenty-three and eight tenths acres. These places were carefully cultivated and irrigated, but owing to the fact that the areas included adjacent streets and roads, and to the existence of uncultivated plats in house and barn sites, walks, private roads, etc., the aggregate area of actual irrigation was only about nine hundred and fifty acres, of which four hundred and ninety were in citrus fruits, three hundred in deciduous fruits, one hundred and forty in vines, and the balance in garden plats. In 1884, after the lower system from Sheep Corral springs had been constructed, the area of actual irrigation probably reached one thousand three hundred, possibly one thousand four hundred, acres. Since that date it has steadily diminished. The "boom" has swept over this fair colony. A large part of its orchards and vineyards have been divided into town lots, and streets have been cut out to afford them frontage. The

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city of Pasadena claims some of the best orange lands to pave under with rock or build over with brick. The town of South Pasadena occupies other good lands at the other extremity of the tract. In 1886 the area of irrigation had diminished to less than one thousand acres. In 1888 it does not exceed five hundred acres. Residences are multiplying, orchards and vineyards are giving place to ornamental gardens and lawns, and a material portion of the whole has passed into the hands of non-residents, and is neglected and not irrigated.

History of Enterprise and Water-rights:—The San Pasqual rancho was granted to Manuel Garfias in 1843, and sold to John S. Griffin and B. D. Wilson in 1858 for $6,000, and these two individuals thence owned it in undivided equal parts. The grant had consisted of three and a half Mexican leagues of land of which part had been sold to Grogan and part to Monk, as before narrated in connection with the Eaton cañon and North Pasadena works. In 1866 the waters of the springs at and just below Devil's Gate were brought out in a small earth ditch for irrigation on the low bench-land, in the Arroyo Seco basin, a mile or so away; but little was done with them there, however. In 1873 a partition was made of the unsold lands and waters, and Griffin received four thousand acres in two pieces, two thousand five hundred acres lying above the Monk tract, where now is Altadena and the Mesa de Los Flores, and one thousand five hundred acres in the southwest quarter of the grant, lying next to the Arroyo Seco—together with a half interest in the Thibbet springs, and the entire ownership of Sheep Corral springs. Wilson took the other half interest in Thibbet springs, the whole of Flutterwheel springs, and a body of land lying above and east of the lower piece taken by Griffin, and another including the upper springs.

The Indiana Colony:—During the summer of 1873 in Indianapolis, Indiana, an association of about fifty individuals was formed under the title of the Indiana Colony, for the purpose of settlement in Southern California. D. M. Berry and General Kimball were sent out to select a site for settlement, and they contracted, through B. S. Eaton, acting as Griffin's agent, for the Griffin interest—lands and waters—in the San Pasqual ranch, provided that these should be partitioned off to suit them. The partition between Griffin and Wilson was then effected as already

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described, substantially in accordance with the desires of the colony agents. The purchase price was to be $25,000, of which half was to be paid in cash and the balance on time. A general financial crash or depression coming at the period when the colonists were arranging to come west, but a small portion of them, about twelve, ever managed to pay up their first installment for the purchase, and the promoters of the enterprise succeeded in having the uncalled-for shares taken in Los Angeles—there being in all about thirty individual subscribers. But a small part of these were farmers, and only two or three were horticulturists. A majority were merchants, mechanics, and professional men. They then organized and incorporated the San Gabriel Orange Grove Association, in November, 1873, and the sale was made to this corporation, with one quarter cash payment.

San Gabriel Orange Grove Association:—There were one hundred shares in the organization. Each share was to entitle its holder to a fifteen-acre subdivision of the one thousand five hundred-acre tract. The two thousand five hundred-acre tract and the ownership of the springs were to be held by the association for the benefit of its stockholders. The one thousand five hundred-acre tract was then subdivided, the lots or plats distributed to the shareholders, and the original pipe-line, reservoir, and distribution system from Thibbet springs was constructed in 1874. The water-rights were to be apportioned to the subscribers in the same measure as the one thousand five hundred acres of land, and certificates of stock were issued representing the proportion of water the subscriber was entitled to. By tacit agreement it was understood that any one might sell land without water, or water without land. Contracts of sale were given for the land parcels, which were to be exchanged for deeds from the association on final payment being made to Griffin, and the title being transferred by him. The two thousand five hundred-acre tract was afterwards disposed of by the association for the benefit of its stockholders, and the proceeds were put into improvements of the water works, etc. In this case, be it observed, there was no separate water company. The individuals dealt with themselves. organized as a land and water company for their own benefit. The lands were apportioned to the individuals with proportionate water-rights. The water—the springs—remained the common property of all in the association.

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The Water Ownership Conflict:—It was supposed by the Orange Grove association founders and the purchasers of its shares, that the Griffin lands carried with them half of all the waters rising above Devil's Gate—that the name of Thibbet springs applied to the whole group of springs there located. At the time of purchase they allege there was no such name as "Ivey" springs known. The Wilson estate owners claimed otherwise—that the name Thibbet springs applied only to those rising waters lying east of the upper opening of Devil's Gate gorge, and that those rising west were the Ivey springs, to the ownership of which, in their entirety, they had succeeded. This difference brought about a grave conflict between the two water companies which had succeeded to these two interests. The matter was carried before the courts, and in October, 1879, a decree was rendered in the lower court, in compliance with the claims of the Lake Vineyard (Wilson interest) company.

In July, 1883, the Orange Grove association bought from the Lake Vineyard association, for $10,000, an undivided one tenth interest of their water-rights, a three tenths interest in the water-bearing lands, including the sites of the upper springs, a three tenths interest in about one thousand acres, remaining unsold, of the two thousand five hundred acre-tract of the Lake Vineyard association, and a three tenths interest in the cement ditch. This purchase gave the Orange Grove company a tenth each of Flutterwheel and Ivey springs waters, and six tenths of Thibbets springs, with right to use three tenths of the capacity of the cement ditch in which to bring out its waters.

Pasadena Land and Water Company:—The Pasadena Land and Water Company was incorporated in March, 1882, with a capital stock of $50,000, divided into two hundred shares of $250 par value each. This capital was in December, 1885, increased to $75,000, and the number of shares to three thousand of $25 par value each. The corporation was made with general powers and purposes, to purchase or otherwise acquire lands and waters and water-rights, and to manage, improve, and dispose of the same as a general land and water company.

In November, 1883, ten years after its formation, the charter of the Orange Grove association being about to expire, its rights and properties were, by order of its stockholders, turned over to the Pasadena Land and Water Company, and the stock of this new

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company was issued in place of that of the old. The name "Pasadena," meaning in some Indian dialect "Crown of the valley," was adopted for the settlement, at a meeting of the Orange Grove association in April, 1875, to take the place of "Indiana Colony," which had become affixed to the place.

In 1885 a suit was brought by the Pasadena Lake Vineyard Land and Water Company against the old Lake Vineyard association and those who had purchased the residue of its property, the Pasadena Land and Water Company amongst the number, to annul the sale above referred to, but this was subsequently compromised on the basis that the Pasadena Land and Water Company should have, in lieu of its fractional interests held under the original partition and the purchase of July, 1883, three tenths of all the waters of all the upper springs. This closed the controversy as to measure of claims and rights of waters there.

The Orange Grove association's original works, planned and carried out under the supervison of Hon. B. S. Eaton, were the first constructed in Southern California wherein water was conducted and distributed for general horticultural irrigation, by means of iron pipes, and under pressure. The plan was such a change from the old system of distribution through earthen ditches and little wooden flumes that it elicited much comment and criticism. It has proven a fair success and has been extensively imitated.

Pasadena Lake Vineyard Irrigations.

District and Works:—Lying next east of the Orange Grove tract and south of the Ball and Painter or North Pasadena tract, heretofore described, with a narrow arm extending between the two, northwesterly, to the Arroyo Seco at Devil's Gate, is the old Lake Vineyard Association tract of two thousand five hundred acres. It is in a compact form, and embraces nearly all the balance of the mesa, not in the tracts heretofore written of, and down to the individual properties which include its edge, where lie the lower springs and *cienegas* elsewhere described. The waters of the Pasadena Lake Vineyard Land and Water Company derived from the three groups of springs—Thibbets, Ivey, and Flutterwheel, at Devil's Gate—are devoted to the irrigations and domestic and municipal service throughout this tract, and are used also to some extent on lands lying east and northeast thereof.

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MAIN LINE; JOINT WORK:—*Cement Ditch; Steel Pipe:*—The main work has until quite recently consisted of a concrete-lined ditch, about thirteen thousand feet in length, leading from the lower end of the gorge, six hundred feet below the upper springs, and coming out to a reservoir upon the mesa at the head of the main part of the tract, about twelve thousand five hundred feet below. This canal has now been replaced to within about one thousand feet of its head, by a twenty-two-inch steel, lapped and riveted pipe. This, with a fall of eleven feet in its length of eleven thousand four hundred and twenty-eight feet, delivers the water into reservoir No. 1, whence it is distributed through iron pipes under pressure. The new pipe is a joint work of the Pasadena Lake Vineyard company and of the Pasadena Land and Water Company, and is designed not only to take the place of the concreted ditch of the former, but to bring all the water of the springs, and thereby take the place also of the old pipe-line now used by the latter company.

Partitioner:—With this view, delivery is to be made from the twenty-two-inch main into the chambers of a structure, as the waters depart from which a partition of them will be made in proportion to the respective interests of the companies in the total supply. This partitioner consists of a brick-walled chamber, built in the outer slope of the reservoir embankment, about six by eight feet exterior dimensions in plan and six feet deep. Its walls are twelve inches thick, and it is divided into three compartments by two cross walls, twelve and eight inches thick, respectively. The compartments are all forty-eight inches long—the width of the structure inside—and twenty-six inches, sixteen inches, and thirty inches wide, respectively. The water from the supply pipe enters the twenty-six-inch compartment on end and near its bottom; rises and flows over the partition into the sixteen-inch compartment; passes with a downward current through this compartment and under the next dividing wall into the third compartment; and, having there risen to a plane sufficient to produce the requisite pressure, it escapes by way of circular apertures four inches in diameter through thin metal plates. Of these apertures there are three in a plate set vertically at the end of the compartment, and seven in a similar plate set in the side next the reservoir space. They are all in the same horizontal plane, and presuming that the water in the compartment will be undis-

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turbed as to currents, and with a surface plane uninfluenced by boiling action (which, of course, depends on the volume presented to be partitioned), each aperture will discharge one tenth of the supply, and thus three tenths will be poured into a side chamber, and be taken thence by a cross-main to the Pasadena company's reservoir, and seven tenths will be poured into a conduit and dumped immediately into the Lake Vineyard company's reservoir.

Distributing Reservoirs:—This reservoir is an oval, with a cross embankment forming two compartments, one of which, as recently deepened, paved, and cemented, holds at ten feet of depth about one million seven hundred thousand gallons. There are two other similar reservoirs in the system, but their use has recently been discontinued until they can be purified and lined as above described..

DISTRIBUTION PIPE-LINES:—The Lake Vineyard company's distribution from the completed reservoir is made under pressure through wrought iron riveted pipes; and waters are turned out to irrigators by means of hydrants, as in the case of the Orange Grove tract. The main pipe—ten, seven, and six inches in diameter—extends easterly across the head of the tract, a distance of about two and a half miles, and five-inch pipes lead thence due south, at quarter-mile intervals, to total distances of one and a half to two miles. The total length of main and distributary pipe in this system, below the reservoir, is probably sixteen miles.

COST OF THE WORKS:—The original construction of the concrete ditch, two of the earth-excavated reservoirs, and distribution pipe, etc., to serve about one thousand acres, cost at first about $30,000. The expenditures on construction from that time to the commencement of the recent joint work with the Pasadena Land and Water Company are not known—the books containing the accounting not being in the hands of the present company. The new twenty-two-inch steel pipe-line cost about $19,500, of which about $5,800 is chargeable to the Pasadena Land and Water Company. The reëxcavation and lining of the reservoir, heretofore described, cost about $6,000.

Operation and Maintenance:—The Pasadena Lake Vineyard Land and Water Company was incorporated for the avowed purpose of acquiring the water, works, etc., theretofore owned and

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"operated by the Lake Vineyard Land and Water Association, in the distribution of water to the purchasers of land and water-rights from said association;" to purchase other water-rights; to develop other waters; "and to carry said water so purchased and developed upon the lands of such purchasers" (that is, the lands of those, presumably, who had bought from the old Lake Vineyard association); and to "take and hold all said rights absolutely or in trust for its stockholders, who are to be limited to purchasers of lands, or land and water and water-rights from said Lake Vineyard Land and Water Association." The by-laws direct the board of directors "to make rules and regulations for the distribution of water for irrigation and domestic purposes, and the rates to be charged for the use of the same to the stockholders." There is no authority given to distribute water to any but stockholders.

The rules and regulations, recently adopted, declare that the company designs furnishing water (1) to all parts of the Lake Vineyard Land and Water Association's tract, lying below company's works; (2) to all consumers outside the limits of the tract who have hitherto received water from the company; (3) to consumers desiring the water on any part of the San Pasqual rancho lying east of Fair Oaks avenue and not above the level of the works, "but this class of applicants can only be furnished so far as the supply permits."

It would appear from these documents that although the stock of the company may be held only by those who have purchased lands from the old Lake Vineyard association, the company does furnish and proposes to continue furnishing water to lands outside of the tract, so far as its supply will admit of. As a matter of fact, its stock has been placed outside of the two thousand five hundred-acre tract, so that, although a large part of that tract was too high to be reached by its waters, all of the stock has been placed on lands which can be reached.

DISTRIBUTION AND MEASUREMENT:—Under a former organization and management, the waters for the Lake Vineyard irrigations were distributed in proportion to interests owned in the supply, by regular turns, in a period of rotation, according to a prefixed schedule; and a module was used for the purpose of regulating the heads of delivery, to a uniform volume—time being the

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element varied to measure the varying interests of the irrigators. Now, however, distribution for irrigation is made wholly on orders for water, filed at the company's office and filled in succession as most convenient in operation. Irrigation works are under control of a *zanjero*. The rules of the company say: "Persons desiring to irrigate with hydrant streams must notify the company at least three days before such intended use, and must accept their turn to irrigate, subject to the previous engagements of the company with other irrigators on the same main." "The *hydrant must be opened only by the inspector of the company*, who shall take note of the time of turning on the water, and shall report at the office the duration of the irrigation."

Module:—The module is precisely similar in size and principle to that described for the Pasadena Land and Water company's irrigation, and the "irrigating head" is defined in the same way: as the quantity of water that will flow through a rectangular opening in the top of a board, ten inches wide and two inches deep, without pressure. In this case, however, a module structure is built up in the form of a box around the hydrants, and thus the conditions of measurements are made better than in the case of the Pasadena Land and Water company's apparatus. The Lake Vineyard module notch was originally three by ten inches, affording thirty inches (Pasadena measurement), but scarcity of water, and a desire for uniformity in the neighborhood, led to the adoption of smaller dimensions. The first change made was to a notch twelve and a half by two inches, affording twenty-five "weir inches" discharge. Then within the past year, the change has been made to the two by ten-inch notch, which is the same as that of the other Pasadena supply company.

Water-rates:—By the old module in 1880, the charge for irrigation water was 25 cents per head of thirty inches for three hours, flow. The original Lake Vineyard association, however, reserved the right, in making its deeds of water interests, to charge as high as 10 cents per one thousand gallons, if necessary to do so in securing sufficient revenue for purposes of operation and maintenance. The present charge for irrigation water is 20 cents per hour for the twenty-inch (Pasadena inch) head, and provided that no head will be furnished for less than a charge of 50 cents, or for two and a half hours' run. Domestic service rates are $4 per

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quarter for each family, including minor children, with 30 cents additional for each extra adult, each horse or cow, and with other extra charges for bath tubs, etc. Domestic meter rates are 40 cents per thousand gallons.

Water-supply and Use:—As explained in the preceding article under this sub-heading, the Pasadena Lake Vineyard company has seven tenths of the flow of all the Arroyo Seco upper springs, which volume amounts to about seventy miner's inches during the driest months of ordinary seasons, and about sixty inches during the corresponding months following very dry winters; and to these amounts about five inches are to be added for Wilsons springs.

IRRIGATION:—The Lake Vineyard colony enterprise was inaugurated in 1874, and irrigation commenced in the following year. In 1879, it was reported to the state engineer that irrigation had extended over five hundred and ninety-five acres. In 1880, however, there were but six hundred and five and a half acres in the tracts under irrigation, and probably not over five hundred and fifty acres actually irrigated. Of these about four hundred and twenty acres were in citrus fruits, one hundred in deciduous fruits, and thirty in vines. There were thirty-nine owners of these tracts, of whom thirty-eight were individual irrigators, and one was a coöperative association holding about two hundred and ten acres, in citrus orchard. Among the individuals, twenty-five acres was the largest holding, three acres the smallest, and with an average of ten and two fifths acres. The average, over all, was fifteen and a half acres per holding. In 1884 irrigation had spread to full two thousand acres. Then, owing to causes already explained in writing of the Orange Grove irrigations, the area commenced to decrease. By 1886 there were only one thousand seven hundred to one thousand eight hundred acres; and in the present year (1888) the area does not exceed one thousand acres.

History of Enterprise and Water-right:—In 1874, with the view of establishing another settlement similar to the Indiana colony, the Lake Vineyard Land and Water Association was incorporated. It acquired from those controlling the Wilson interest in the San Pasqual rancho two thousand five hundred acres of land adjoining the Orange Grove association's tract on the east, a body of land, including the springs at Devil's Gate, together

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with the water-right and part ownership of the springs accorded the Wilson interest in the partition already adverted to. And it also acquired a tract on the plain below the mesa, where the Alhambra and Alhambra Addition colonies are now found, as elsewhere written of.

Lake Vineyard Land and Water Association:—The new company's water-right was divided into five hundred shares, the waters were made appurtenant to the two thousand five hundred-acre tract, a concrete lined canal was constructed out from the springs to the head of the tract, several distributing reservoirs were made, iron distribution pipes laid, and the lands put on the market. A large part of the tract was soon sold in small parcels; one share of (or a five-hundredth interest in) the water being conveyed with each five acres of land. The deeds of conveyance also granted to the purchasers the right to receive the waters so conveyed to them, by means of the pipes and reservoirs of the association, but subject to the regulations, and upon paying a proportionate part of the expenses of administration and maintenance of the system.

The Concrete Canal:—The canal was thirteen thousand feet long, four feet wide, and three feet deep—the bottom being a half-circle, in cross-section. The concrete lining, four to five inches thick, was made with lime taken from a quarry opened, it is said, by the Mission Fathers a century ago, and utilized in masonry works about the San Gabriel Mission, among which works was a walled-up irrigation canal whose masonry still stands in fair condition. The Lake Vineyard canal cost about $1 50 per foot, and has been in use until within the past few months. It has never had any efficient head-gate, and so at times has been injured by flood-waters of the Arroyo Seco bringing in bowlders to be bumped along on its bottom by the current. This was the first work of its class in Southern California since the days of the *padres*, but it has been extensively imitated since. It was carried out, with the other works then built, under the supervision of Hon. J. De Barth Shorb, of San Gabriel, who was the leading spirit of the original Lake Vineyard enterprise.

The Syndicate:—In July, 1883, after about one thousand five hundred of the two thousand five hundred acres had been sold, the Lake Vineyard Land and Water Association, for $10,000,

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conveyed an undivided tenth interest of its waters, and an undivided three tenths interest in its water-bearing lands, in the yet unsold one thousand acres of colony lands, and in its main conduit (the concreted ditch), from the springs down to the reservoir, to the San Gabriel Orange Grove Association. It then conveyed, for $40,000, to a syndicate composed of twelve individuals, residents of Pasadena, the remaining seven tenths of the water-bearing lands, and all of its rights of way, reservoirs, and other property not sold as above to the Orange Grove association; and from that time forward the Lake Vineyard works and affairs were managed by the syndicate, until taken in hands by the present company.

The Lake Vineyard colonists, having bought with their lands only undivided interests in the water-supply and the right of use of the works for delivery of their water, could make no valid objection to these sales of the balance of the water interests, lands, and works. But still it placed them in an awkward predicament as compared to their neighbors of the Orange Grove association who owned their works as a common property. The part of the two thousand five hundred acres which had not been sold off to colonists was for the most part rough, and at that time, undesirable land, or was located above the line of the ditch.

Pasadena Lake Vineyard Land and Water Company:—The Pasadena Lake Vineyard Land and Water Company was then formed by those holding water interests under the original Lake Vineyard Association, in January, 1884, for purposes set forth in its articles of incorporation, as follows:

"1. To acquire all the waters, water-rights, ditches, canals, flumes, pipes, reservoirs, and water works, springs, *cienegas*, and water-bearing lands, heretofore owned and operated upon by the Lake Vineyard Land and Water Association, in the distribution of water to the purchasers of land and vineyard water-rights from said association, in the San Pasqual rancho, etc.

"2. To purchase other water-rights.

"3. To develop water by digging, boring, etc., and to carry said water so purchased and developed upon the lands of said purchasers.

"4. To take and hold all said rights absolutely or in trust for its stockholders, who are to be limited to purchasers of land and water and water-rights from said Lake Vineyard Land and Water

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Association, in said San Pasqual rancho, or to hold the same as appurtenant to said lands."

The object of this move was the consolidation of the water-rights acquired from the Lake Vineyard association, with the property rights reserved by the association, and the placing them in a new corporation for management in the interest of those who had held the individual rights. Ten shares of the new company's stock were issued in exchange for each of the old five-acre water-rights, thus placing the stock at two shares per acre.

Water-right Adjustments:—In the meantime the Pasadena Land and Water Company had been formed with a similar object with respect to the water-rights acquired under and works and properties of the Orange Grove association. After the formation of the new Pasadena Lake Vineyard company, nearly all those who had purchased lands and acquired water-rights (or part ownerships) under the old Lake Vineyard association, in two separate deeds, one of which was signed by about one hundred and fifty and the other by about sixty-two individuals, conveyed to the new company all of their water-rights and interests—both deeds being absolute in form and containing no declaration of trust. The new company then acquired from some members of the syndicate an undivided seven sixteenths ($\frac{7}{16}$) part of the water-works and other property, and seven sixteenths ($\frac{7}{16}$) of their seven tenths ($\frac{7}{10}$) of the water-bearing land. C. T. Hopkins acquired the remaining nine sixteenths ($\frac{9}{16}$) of the seven tenths ($\frac{7}{10}$) of the water-bearing lands, and nine sixteenths ($\frac{9}{16}$) of the water-works, rights of way, and other property. The Pasadena Land and Water Company, be it remembered, had acquired from the old Lake Vineyard association, one tenth ($\frac{1}{10}$) of the waters and three tenths ($\frac{3}{10}$) of the water-bearing lands originally owned by it.

The Pasadena Lake Vineyard Company's Troubles:—The Lake Vineyard water interests were now scattered and confused, and there was much dissension and discord among the interested parties. Besides the complications consequent upon part ownership in the waters and works going into the rival company, and another part ownership being held by an individual outside of the colony organization, the colonists were not agreed among themselves as to the course best to pursue for their own interests as irrigators. In the first place, there were those who still held on to their indi-

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vidual rights, acquired under the old Lake Vineyard association—refusing to merge them into the new company and take its stock in exchange; and then, of those who had entered the new Lake Vineyard company, there was an active minority who opposed going forward and effecting the very objects for which that company was formed—the improvement of the works and the development of waters. About this time, it was feared too, that the new organization was itself not on a sufficiently broad basis to enable it to handle the property as it should be handled: namely as a general water-supply property, furnishing water to all customers, the city of Pasadena included. And so there was a deplorable state of affairs in the internal economy of the colony with respect to water interests.

These internal complications and outside conflicts culminated in 1885. A large part of the Lake Vineyard association people who had gone into the Lake Vineyard company desired to come to some settlement with the Pasadena-Orange-Grove people whereby a more exact definition of water-rights would be had, and they thought it best also that all the Lake Vineyard and the Orange Grove rights and works should be consolidated and brought under one management. In 1885, however, a majority of the board of directors of the (new) Lake Vineyard company were opposed to any such compromise on any basis that would recognize the validity of the sales (of July, 1883) made by the (old) Lake Vineyard association to the Orange Grove association and to the syndicate.

The opposition of this board of directors to these interests brought about a conflict between them on one side and some of the syndicate interests and the Pasadena Land and Water Company (representing the Orange Grove interests) on the other, as to the division of the waters from the upper springs. The Pasadena Land and Water Company proposed to compromise on the basis of three tenths of the whole supply from these upper springs for their share, and seven tenths for the Lake Vineyard share. It is alleged that a very large proportion of the Lake Vineyard people were in favor of accepting the proposition. The majority of the directors of the Lake Vineyard company, however, rejected it, and suit was commenced by them, representing the Pasadena Lake Vineyard Land and Water Company, against the (old) Lake Vineyard association, the members of the "Syndicate," and others,

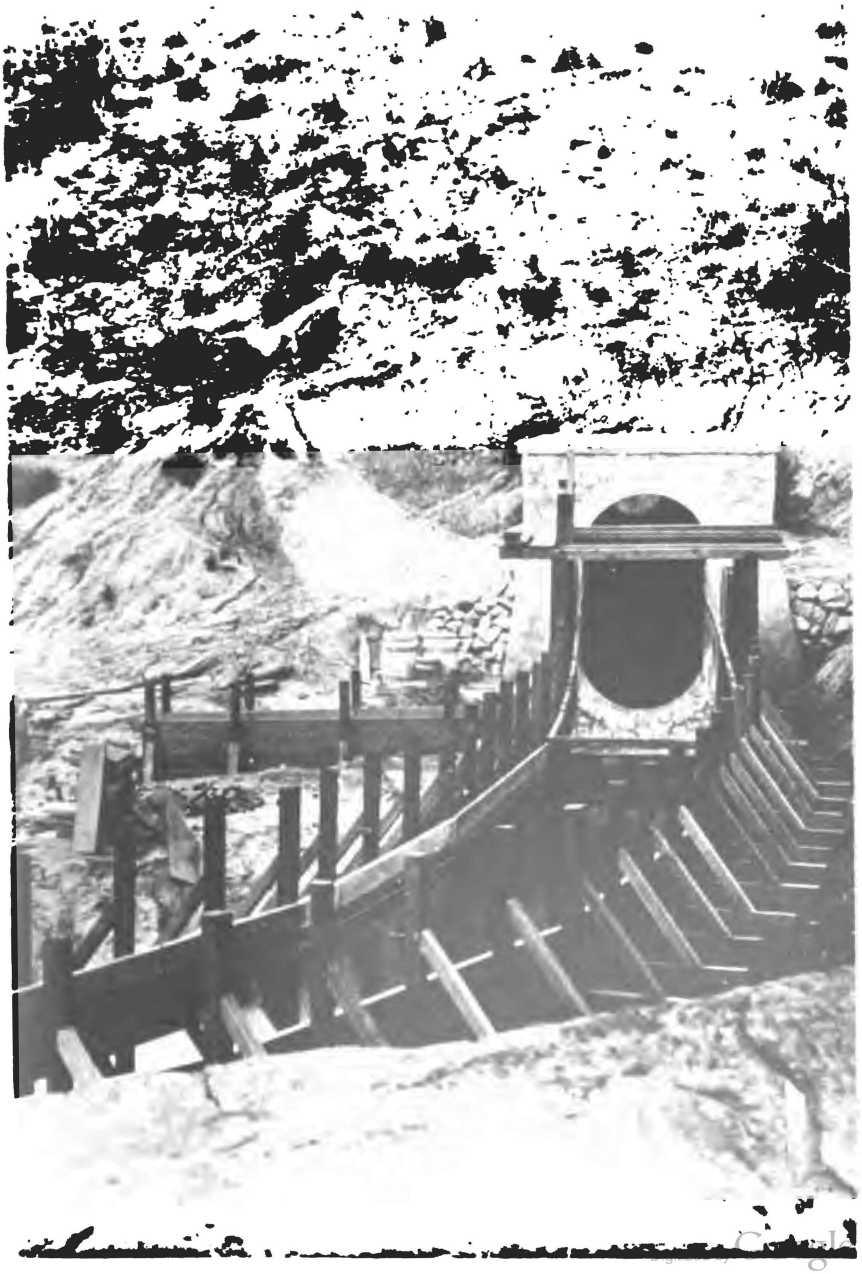
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for the settlement of the controversy. Public sentiment was so strong, however, in favor of some immediate adjustment of the conflict, and the necessity therefor was so great, that the issue was forced to a termination out of court, on the basis proposed by the Pasadena Land and Water Company, and an agreement was entered into on that basis, and the suit was dismissed.

Compromise with the Pasadena Land and Water Company:—Under this agreement the Pasadena Land and Water Company (Orange Grove people) are to take three tenths of the waters and water lands at the upper springs, and the Pasadena Lake Vineyard Land and Water Company are to take the other seven tenths interests in these properties. The Orange Grove people ratified the agreement, but a very few of the owners of Lake Vineyard company stock refused to concur in it. The Lake Vineyard company was not able, either, to take and pay for its share of the rights still held by members of the syndicate. So these interests were consolidated in the ownership of C. T. Hopkins, who agreed to hold them for the company for one year for cost price with interest. This compromise seemingly settled the differences as to water-rights between the companies representing the Orange Grove and the majority of the Lake Vineyard interests, and it put the Pasadena Land and Water Company (Orange Grove) in a position to act with the other company in improving the joint works and endeavoring to secure additional waters; but the Lake Vineyard interests were still unconsolidated, and the Lake Vineyard company organization was thought to be insufficient for the purpose desired.

Reorganization Attempted—The Arroyo Seco Company:—Following closely the story as told in an answer filed in the suit last above referred to, the situation may be described as follows: At the time the Pasadena Lake Vineyard Land and Water (new) Company was formed, the waters were owned and held by comparatively few people, not more than two hundred and fifty altogether, and these were settled upon the lands they had purchased from or through the Lake Vineyard Land and Water (old) Association, and were engaged in raising different kinds of fruits, and in farming their lands, and it was then expected and believed that the rights of the purchasers from the Lake Vineyard Land and Water Association could be combined and united in one com-

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pany, and a system of water-works be kept and maintained in repair, and a good supply of water furnished to the parties entitled to it under the deeds from the Lake Vineyard (old) association. After the formation of the new company, however, the number of people owning and residing upon these lands rapidly increased to more than three thousand, and the city of Pasadena was incorporated, embracing within its corporate limits the greater part of the Lake Vineyard two thousand five hundred-acre tract, besides the original townsite of Pasadena. Moreover, a large part of these lands were cut up into small subdivisions, and even into town lots, and sold off with fractional interests in the old water-rights, or new water company stock; so that by the early part of 1887 the company stockholders numbered more than five hundred, and contracts of sale had been made which, when consummated, would make the number over one thousand. The company had been formed chiefly as an irrigation organization for supplying its own stockholders; the demand for water was rapidly changing to that for domestic and municipal purposes, and on the part of people who could not conveniently become stockholders, and, moreover, of people holding lands not within the old association boundaries. The water-works were much out of repair; the main conduit leaky and in part destroyed; the reservoirs foul; and the pipes leaky and insufficient in capacity. Furthermore, at times the water-supply was barely enough to meet current demands, and the necessity for acquiring more water was plainly apparent.

A very large part of the Lake Vineyard people now realized that something must be done to better the situation in water matters. The election of officers of the Pasadena Lake Vineyard Land and Water Company in January, 1887, resulted in the almost unanimous choosing of directors pledged to immediate settlement of all water difficulties, and improvement of the water system. The sentiment was in favor of perfecting and merging all the interests into another organization whereby the subject could be properly handled. With this view some of the leading stockholders of the Pasadena Lake Vineyard Land and Water Company, among whom were the newly elected directors of the company, organized in February, 1887, the Arroyo Seco Water Company, and issued an address to the stockholders of the Pasadena Lake Vineyard Land and Water Company inviting them to

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subscribe to its stock—merging their Lake Vineyard company interests therein. In March of 1887, at a public meeting of these stockholders, a resolution was unanimously adopted requesting the board of directors "to go forward with diligence in the improvement and development of the water-supply, in the way and manner pointed out in the address of the directors"—that above referred to.

A large number—more than one hundred and sixty—of the stockholders of the Pasadena Lake Vineyard Land and Water Company, representing, it is claimed, and as near as can be ascertained, a majority of the company stock as at that time held, assigned and transferred all their rights and interests in the waters and water-bearing lands, acquired by them from the old Lake Vineyard association, to the Arroyo Seco (new) water company, and at the same time authorized and directed the board of directors of the Pasadena Lake Vineyard Land and Water Company to transfer to the Arroyo Seco company all water-rights and other property acquired by it from them or their grantors. In obedience to this instruction the directors of the Pasadena Lake Vineyard Company passed a resolution to turn over its works, water-rights, and properties, etc., to the new company.

Injunction and Present Status:—At this juncture, in April, 1887, a suit was entered by four owners of Pasadena Lake Vineyard Land and Water Company stock against that company and its board of directors, seeking to restrain them from transferring the company property to the new company, and declaring that the company held the property only in trust and for specific purposes, for the benefit of those who had deeded their individual Lake Vineyard interests to it (among whom were the plaintiffs) and could not legally transfer them to any one else. It appears that the deeds were absolute in form; but that in January, 1886, while a majority of the board of directors of the Pasadena Lake Vineyard Land and Water Company were of those in opposition to compromise with the syndicate and the Orange Grove people, a resolution had been passed, declaring that the company property had been deeded to the company in trust, only; and in accordance with this resolution, the majority of the Board made out, signed, and had recorded a declaration of acceptance of the trust, asserting that the company "holds said waters so conveyed to it by said parties, for the purposes and upon the trusts of man-

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aging and controlling said waters, and to furnish the same to and distribute it among the said parties, grantors in said conveyance, for irrigation and domestic uses, according to their respective interests in said waters." The leading spirit of those who had brought this last action was a member of the directory of the company at the time of the making the declaration of trust.

The present managers of the company claim that the conveyances to the Pasadena Lake Vineyard Land and Water company were not made in trust; and that the declaration of trust made by the directors in January, 1886, was fraudulent. But the bringing of this suit has had the effect of arresting further immediate action under the proposed new organization, the Arroyo Seco company. In the meantime the syndicate interest held by Hopkins has been taken by the Pasadena Lake Vineyard Land and Water Company, the settlement of water-right conflicts with the Pasadena Land and Water Company has been made final, and the two companies have joined in the construction of a main conduit out from the springs, as elsewhere told. The directors of both of the existing companies desire to go on with works of water development, but as yet no plan has been hit upon whereby the Lake Vineyard interests can be consolidated and the work undertaken.

Other Utilizations of the Arroyo Seco.

The little source half a mile below Sheep Corral springs, and known as Bennet springs, in the bed of the Arroyo Seco, was sold by the Orange Grove Association for the supply of small irrigations and domestic demands on the Highland Park tract several miles below, and this has been piped out for the purpose. There are several other small utilizations of waters obtained from the same arroyo by pumping at lower points, but these all partake of the nature of town or domestic supply rather than irrigation, and hence, need not be described here. The Garvanza Water Company, the Highland Park Water Company, and the Crystal Springs Water Company are organizations having works in this immediate neighborhood and supplying water for domestic use, and, to a limited extent, for irrigation on lots and home orchards or ornamental grounds.

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CHAPTER XXII.—LOS ANGELES[a]; WORKS AND PROJECTS[m].

SAN FERNANDO VALLEY WORKS.

GROUP[g].

SUB-GROUPS[h], [i], [j], AND [k].

SECTION I.—*Cañada and Verdugo Irrigations:*
Crescenta Cañada Colony;
Verdugo and Glendale Works;
Providencia and Other Developments.

SECTION II.—*Tejunga and Pacoima Projects:*
Big Tejunga and Monte Vista;
Pacoima Bedrock Dam;
San Fernando Land and Water Company.

SECTION III.—*San Fernando Cañon and Springs Works:*
Old Mission Cienega and Creek Utilizations;
Recent Water Developments;
Porter Land and Water Company.

SECTION IV.—*Mormon Cañon Works and Projects:*
Diversion Dam and Canal;
Storage Works and Possibilities;
San Fernando Valley Water Company.

SECTION I.

THE CAÑADA AND VERDUGO IRRIGATIONS.

The Upper Verdugo Country.

District:—The pass from the northwest corner of San Gabriel valley between the southern basin of the Sierra Madre and the outstanding Verdugo range, northwesterly, through to the eastern end of San Fernando valley, is about twelve miles in length, and from half a mile to a mile in width. It is a high mesa forma-

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tion; its substrata filled with bowlders, cobbles, and gravel, and its heavier mesa soils much washed away, covered in or mixed with light alluvial washings from the mountain sides. The altitudes range well up to two thousand feet above the sea. The surface pitches sharply, and even steeply, across the pass from the higher mountains on the northwest against the lower range of the San Rafael and Verdugo. Cañon waters coming from the Sierra Madre flow in deep cuts and broad washes down this slope to the main drains which go out lengthwise. The Big Tejunga occupies this pass for about two miles of its western end, going westerly into San Fernando valley. Tributaries of the Arroyo Seco occupy it for an equal length at its eastern end, and escaping in that direction. The intervening space is drained by the tributaries of the Verdugo, which escapes southerly through the open cañon between the San Rafael and Verdugo hills. The principal side cañons, which afford some water-supply to this region, are Cook's, Dunsmoor, Pickens, and Hall's. The notable irrigation is that of the colony enterprise next spoken of.

Crescenta Cañada Colony.

The Crescenta Cañada tract contains one thousand nine hundred acres. Its water-rights are in the flow of Cook's and Dunsmoor cañons and a developed supply known as Pickens spring.

Works:—From Cook's cañon on the west a cement ditch six by eight inches, covered with boards, carries the waters around to Dunsmoor cañon, a distance of three thousand six hundred feet. Thence the waters of the two cañons are taken in a cement pipe, six inches in diameter, four thousand feet, and then in a four-inch wrought iron riveted pipe, six thousand feet farther, to the colony lands; and there distributed in small iron pipes, with the intention of supplying the western one thousand one hundred and fifty acres of the colony tract. The eastern seven hundred and fifty acres of the tract are to be watered from Pickens spring, a supply developed by driving a tunnel one hundred and eighty feet in length, through solid rock in the mountain side, and not under the Pickens cañon. Thence the water is taken by a four-inch iron pipe eight thousand feet into the colony tract.

Water-supply and Use:—The Cook's cañon water-flow, during the crucial months of ordinary years, has ranged between six and

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twelve inches; of which the Crescenta colony has one half, or, say five inches. The Dunsmoor cañon flow at similar periods ranges between eight and fifteen inches, of which the colony portion is ninety one hundred and tenths, or, say ten inches. The Pickens spring flow has been measured at ten inches; the colony owning one half. This makes twenty-five inches for the one thousand nine hundred acres, or an inch to seventy-four acres. The twenty-five shares of Cook's cañon water and ninety shares of Dunsmoor cañon water, making one hundred and fifteen shares in all, are allotted at the rate of a "share" to ten acres for the western one thousand one hundred and fifty acres of the colony tract; and the seventy-five shares of Pickens spring water, in like manner, are apportioned out to the seven hundred and fifty acres of the eastern end. The remaining interests in these three sources are held for private irrigations in the immediate neighborhood, the acreage of which will be included in the summarization at the closing of the report. [Data of Fall of 1886.]

Other Small Irrigations.

Pickens Canon:—Water-supply, ten to twelve miner's inches. Piped easterly three miles in four and six-inch cement pipe to the Lanterman tract and distributed for one thousand two hundred acres—one twelfth of all the water being separately allotted to each one hundred acres. In 1886 there were two hundred acres irrigated.

Hall Canon:—Water-supply, eight to ten miner's inches. Piped about two miles in "Asbestine" continuous cement pipe, irrigated in 1886 about two hundred and thirty acres of land.

Earl Canon:—Two small springs; one piped six thousand feet in one-inch pipe to a tract of one hundred acres lying east of Crescenta. The other spring not utilized in 1886.

Shields Canons:—Three small cañons between Dunsmoor and Pickens cañons each with a perennial flow of a few inches; not utilized in 1886.

Verdugo Cañon–Springs Irrigations.

District and Works:—The Verdugo stream during months of irrigation demand, rises in the form of springs, along the last mile and three quarters of the cañon's course, until arriving at

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the point where it commences to widen out into the lower end of San Fernando valley, or what is locally called Los Angeles valley, its waters, naturally start to sink. Just above here they are diverted and utilized upon lands within a district beginning half a mile below the opening of the cañada and extending southerly about two and a half miles—comprising the settlements distinctly known as Verdugo and Glendale, several fine private estates, and a number of small independent irrigations; the whole lying east of the Los Angeles river, next the footings of the San Rafael and Verdugo hills, and five to eight miles above the city of Los Angeles.

Diverting Dam:—At the point of diversion the stream is flowing in a gravelly bed fifteen to twenty feet wide, with low banks, and within a wide cañada whose bottom is filled with alluvial soil and well overgrown. Here, notwithstanding the fact that bedrock could not easily be reached, a masonry dam or stone wall, fifty feet long, eight feet high, eighteen inches thick at base and twelve inches at top, has been put in. Its base is six feet below the creek bed. Its top is even with the banks and extends back into them, a notch for an overfall weir admits the passage of the stream in time of freshet.

Flume and Pipe-line:—A flume box carries the waters to be diverted, a short distance to a sixteen-inch cement pipe, which thence conducts them about two thousand feet to where they are apportioned between the west and east-side owners—nearly half going, according to time, to the west side, and this is turned out into a reservoir constructed to receive it. The main line goes on down as a sixteen-inch cement pipe five thousand feet farther. Near the end of this main are two other reservoirs for the receiving of two other shares of the total water-supply, and still farther down, one on each of two main branches, are two more reservoirs each to receive the waters of its owners. Thus, the main work delivers to these five reservoirs, and from them independent distribution systems lead. The work comprises about seven thousand feet, sixteen-inch; fourteen thousand feet, ten-inch; and five thousand feet, eight-inch cement pipe, used principally as mains to the reservoirs and not under pressure; and about twenty-four thousand feet of four, six, and eight-inch wrought iron riveted pipe, besides that in the town of Glendale, laid in the distribution

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systems under pressure from the several reservoirs. The reservoirs are circular, and some of them concrete or rock lined, and range from three hundred thousand to two million gallons capacity, each.

Operation and Maintenance:—All of the water interests are merged into the Verdugo Cañon Water Company, which has built the main works described for delivery to the several little reservoirs; but right here its offices terminate, the various reservoirs and distribution systems are each owned by a separate organization or individual, and controlled and operated independently. The waters have been apportioned by decree of court, and are owned in ten thousand parts, nearly half of which in 1886 were held by owners west or north of the creek.

There being very nearly (ten thousand and eighty) ten thousand minutes in seven days, these shares are in practice held to represent a flow of one minute each per week. In 1886 it was reported that these shares were grouped into five associations or organizations, with one outstanding individual owner not included in either. In practice, following closely the proportion of interest owned, about half the water was continuously turned to the north or west side owners, the remaining half being run for thirty-six hours each week to each of the four interests having a reservoir to receive it, and for twenty-four hours the stream was turned to the one irrigator who was not in either of the associations.

In 1888 it is reported to the state engineer that the Cañon Water company divides the waters between four reservoirs and two pipe-line works. Three of the reservoirs each receive a "run" of the full supply for twelve hours per week; the other reservoir is supplied on demand to the extent of five "runs" per week, and the pipe-lines get the remaining six runs.

Water-supply and Use:—As is the case with all streams of its class in Southern California, Verdugo creek is not subject to very great floods in the winter like the ordinary cañon streams, although these sometimes occur; and it generally holds about an even volume throughout the summer and fall, after the spring drainage is run off. The supply ordinarily amounts to one hundred and fifty to one hundred and seventy-five miner's inches; but it has been measured when as low as one hundred and five miner's inches. This is little more than the natural surface

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flow—no work having been done to develop or bring to the surface the waters which may be escaping through the sands and gravels beneath, except the dam or wall heretofore referred to.

IRRIGATION:—There were two hundred and ninety-five acres irrigated from this source in 1881 when first examined in detail by this department, of which two hundred and seventy-five acres were in orchard, and the balance in summer crops. In 1886 there were about one thousand and fifty acres, and in 1888 there are one thousand two hundred to one thousand two hundred and fifty acres irrigated, and cultivated largely in citrus fruits. Deciduous fruits rank next, and vines are not generally watered during the summer months.

History of Water-right:—There has never been any outside conflict about title to this water. It was recognized as being an appurtenance to the San Rafael rancho, within whose bounds it naturally rises and again sinks. The waters were distributed by decree of the district court of Los Angeles, in November, 1870, to those who had come by succession or purchase into the ownership of part interests in the ranch. This decree made the division by ten thousandths, and so the waters are held in ten thousand shares. They are not appurtenant to any lands, however, but are held for service on about four thousand acres, so far as can be told. The following is a memorandum from the record of this original apportionment, and serves as an illustration of the minute and intricate subdivision of water interests made in this country.

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Names: East-side Owners.	Extent of Interest In Waters.	Number of Hours Run Per Week.
Julio Verdugo	.0308	5.1744
O. W. Childs	.1121	18.8328
M. A. V. de Chavoya	.0024	0.4032
Eight Verdugo heirs (8 × .0024)	.0192	3.2256
Ben Dreyfus	.1197	20.1096
Maria Catalina Verdugo	.0108	1.8144
Glassell & Chapman	.1009	16.9512
Difference (?)	.0002	0.0336
Total: East-side	0.3961	66.5448
Names: West-Side Owners.		
Thom and Ross	.2525	42.4200
Sanchez	.2757	46.3176
Keller and Hausen	.0755	12.6840
Difference (?)	.0002	0.0336
Total: West-side	0.6039	101.4552

East-side . . . . . 2 days 18 hours $\frac{4444}{10000}$
West-side . . . . . 4 days 5 hours $\frac{4444}{10000}$

Under this apportionment, in June, 1880, the owners met and resolved that the water-supply was so short for the service to be performed, that the system of dividing the run of the stream by hours would have to be adhered to; and they adopted a time-schedule for the season. The works were then all primitive earthen ditches.

The Verdugo Cañon Water Company was incorporated in June, 1884, with a capital stock of $10,000, divided into ten thousand shares, and all the old interests came into it for the purposes of its corporation, as elsewhere explained. Immediately after the incorporation the new works were built.

The principal subordinate organizations receiving supply from the central company, above named, are the Verdugo Springs Water Company, Verdugo Pipe and Reservoir Company, Glendale Reservoir and Pipe Association, and the Child's Tract Water Company (?). Some data concerning these will be separately presented in closing and summarizing chapters.

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Boulevarde Valley and Providencia Rancho.

There are on the old Glassell & Chapman tract, in what is now known as Boulevarde valley, two miles southeast of the Verdugo district, and, also, in the neighborhood of Burbank, on the Providencia rancho, four miles northwest, several small water flowings, developments, and utilizations, worthy of notice, but that the use is fast tending to municipal or domestic character, and not notable from an irrigation standpoint. However, some data will be offered in summing up the subject hereafter. Other, possible, water development and storage works of the Verdugo and San Rafael hills region, are written of in a special chapter on Water Supply.

SECTION II.

Tejunga and Pacoima Cañon Utilizations.

Monte Vista Colony.

District: Work: Operation:—The Monte Vista Colony tract lies in the cañada east of the outcome of Tejunga cañon, and embraces one thousand three hundred acres of land, of which six hundred acres had been put under a pipe system of irrigation in 1886. The main pipe heads well up in the cañon, and commencing at sixteen inches diameter is diminished in a short distance, and goes on around the mountain base, as a pressure pipe, three miles, to the colony lands. There had been about five and a half miles of pipe laid, the works were in successful operation, and it is reported have since progressed fairly well. The water interest owned by the Colony association was divided into one thousand two hundred shares, and one such share sold with each acre.

Water-supply and Use:—The summer flow of Big Tejunga cañon at its opening to the valley is exceptionally variable in succeeding seasons. In proportion to its drainage area the creek should have a greater supply than it ordinarily has, and considering the high mountain character of its shed, it ought to be more constant. This subject is discussed under the heading of water-supply elsewhere. As matter of fact the low-water flow varies between one hundred inches and several thousand. Even in seasons

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when other streams are running at nearly a normal rate, this one will be erratic. In 1886 there were twenty-three settlers in the Monte Vista colony and about two hundred and fifty acres of land were under irrigation. The state engineer has not had the means to examine the locality since.

History; Water-right:—The entire volume of flow of the Big Tejunga is claimed by the owners of the Tejunga ranch which lies across the opening of its cañon. Owing to the extremely torrential nature of the stream and the rugged and exposed character of its cañon, the permanent diversion of its waters on to lands lying near the mountains has proven a matter of difficulty by the means thus far employed. The original appropriation at the cañon mouth was made for irrigation on the ranch, by a ditch from the right bank, a number of years ago, and this was reported on in 1880, but has since washed away. In 1882 a small flume was built out about two and a half miles, but this had been so badly damaged that it was not in use in 1886. This water-right interest was held in that year by a Los Angeles capitalist who had five eighths of the rancho in ownership, had projected a storage scheme, and was engaged on a tunnel through a long point to tap the torrent so that it would not wash away the works; the object being to divert its waters into a storage reservoir for irrigation out on the plain, and, possibly, supply to Los Angeles. This work has not been completed. In the same year the owners of the three eighths interest started the Monte Vista colony enterprise.

Other Tejunga Small Irrigations.

In 1886 there was a rival appropriation on the north bank, at the cañon mouth, by three settlers claiming that they were on government land. These had diverted waters in a small ditch, and that year irrigated about sixty acres planted to summer crops.

Above the line of the rancho and in the cañon are two settlers on government land, whose little appropriations of water are of many years' standing. Phillippi's ditch, the oldest, is about two miles long, and irrigates about seventeen acres of land, and it is understood that the rancho people acknowledge that this claim is made good as against their claims. Johnson's ditch is another appropriation of very small dimensions in the cañon for the irrigation of a little piece of bench-land there, and is also of long standing.

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Little Tejunga Utilization.

Up to the end of 1886 no specially notable utilization had been made of Little Tejunga creek. Its volume was reported as being quite constant within the cañon, but disappearing entirely before the valley was fairly reached. A small open ditch had recently been constructed, and cultivations of orchard and garden on about twenty-two acres was receiving the benefit of its irrigation. [Locality not examined since, for reasons heretofore given.]

Pacoima Cañon Works.

San Fernando Land and Water Company.

District; Works: Rights:—The low-water flow of Pacoima cañon is all claimed by the San Fernando Land and Water Company, owning the lands through which the stream extends for several miles below the cañon opening; and works for the development and distribution of water-supply from this source have been in construction during the past two years. These have consisted of a submerged dam, the largest work of the kind yet attempted in Southern California, and quite an extended pipe-line system. The definite data of these works are not available for purposes of this report. They have been carried out since the state engineer had any means, officially, to acquire the information, and personal attempts to secure it have failed.

Water Development:—*Submerged Dam:*—The dam construction was personally inspected several times during its progress. At the point of building, the cañon walls are about eight hundred feet apart, and, as it turned out, bedrock (how firm and seamless at all points is not known) was generally twenty to forty-five feet below the gravelly surface of the wash, between. A trench, five to seven feet in width, was excavated across the wash from wall to wall. It had to be timbered and lagged, of course. The material handled was sand, gravel, and bowlders. A wall about three feet thick, of bowlders laid in cement mortar, was built up in this trench, and the excavated debris was back-filled on each side of it. It were useless to go further into details here. The result, it is reported, has been a great disappointment to those who furnished the money for the work. Either there is no underflow of good volume in Pacoima cañon, or else this structure is

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faultily located or defectively built; for, as reported to the state engineer, it does not materially increase the surface flow of the stream, which was but a few inches in driest times. If this work has failed, however, it should in no way militate against the general plan or idea of "bedrock" or submerged dams for the purpose in view.

SECTION III.

San Fernando and Mormon Cañon Works.

Porter Land and Water Company Enterprise.

District and Works:—The sources of water-supply sought to be utilized by the Porter Land and Water Company are the old San Fernando East and West Cienegas and the San Fernando creek. These waters rise on the ex-Mission San Fernando rancho, of which the Porter lands form a part. The company also has a half-interest in Aliso cañon waters, farther west. The lands sought to be served embrace a body of eight thousand to nine thousand acres lying along the foothills west of San Fernando town about three and a half miles, and extending down the plain to about an equal width. The soils are, on the whole, remarkably well adapted for cultivation under irrigation, and to the higher order of horticultural practice. The works projected, and in part carried out, contemplate the development of water in the two *cienegas* and the creek bed, and its distribution through the colony tract and to the town of San Fernando. There being three sources of water-supply, the plans contemplate three systems of works, so arranged that they may be combined or act as reliefs or auxiliaries each to the others.

Water Development:—*San Fernando Creek:*—The visible flow in San Fernando creek during spring, ranges from forty up to one hundred inches, and during summer and autumn sinks to thirty or forty inches; but the gravel and bowlder-filled cañon beneath the visible bed is supposed to carry very much more water in trickling streams between its masses of detritus. To intercept this underflow and bring it to the surface, the plans contemplate a "bedrock" dam of concrete, combined with a cutting and a tunnel to tap it at a low level and lead the water on less grade

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than the creek bed has, out to a main conduit of the system. Borings across the creek show that an apparently impervious foundation will be found at a maximum depth of twenty-one feet, and that the total length of this submerged structure would be about three hundred feet. The tunnel would have to be four hundred to five hundred feet in length, partly through a "cement" point, to tap the gravel above the dam at a plane well below the visible bed of the creek.

WATER DEVELOPMENT:—*East Cienega:*—The east *cienega* was a strip of very marshy land, about one thousand two hundred feet in length, and averaging two hundred and fifty feet in width, lying closely against the base of a low point of hill. The surface of the ground in the one thousand two hundred feet of length has a fall of about twenty-five feet, and the transverse slope of the plain towards the hill is about fifty feet to the mile. There was a natural flow of thirty-eight to forty miner's inches of water from this *cienega*. The development of a greater flow was primarily a problem of drainage—to collect and give free vent to all waters which attain to near the surface—and, beyond that, a matter of boring to tap artesian strata below and admit other waters to gain the surface. An ironstone pipe collecting-main, in size from sixteen down to eight inches, was laid lengthwise through the *cienega*, six to twelve feet below the surface of the marsh, and on grade slopes of one in one hundred to two in one hundred. Frequent side drains were laid of three and four-inch round tiles, and these were usually on grades above two in one hundred, and were brought into manholes loosely constructed of rocks in the line of the main drain.

For the lower four or five hundred feet of the line, quicksand was encountered in the bottom of the cutting. The upper portion was in fine gravel and coarse sand. The surface soil throughout was for the most part a soft, black muck, with an occasional hard point approaching clay in consistency. For the entire trenching the sides had to be lagged and heavily supported with timbers. Throughout the quicksand beds the pipe had to be laid on saddle piles, driven, in some cases, six to eight feet in depth in the bottom of a ditch already eight or ten feet deep. This portion of the main was tightly cemented. There were no side drains laid through the quicksand. Through the gravel and coarse sand,

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the main and side drains were laid with open joints well covered in with small cobbles and gravel, then with a heavy layer of long, coarse marsh grass, and then the earth and gravel were back-filled upon this. The result has been a complete draining of the marsh and an increase in the supply due to this work of about twenty inches of water.

In all, five artesian borings of seven inches diameter were made, varying in depth from one hundred and fifty to three hundred feet, and encountering alternate layers of very stiff clay and coarse sand and gravel, with some variation in the way of rock detritus, cemented rock washings, etc. Rising water in small quantities was found in nearly all the gravel strata. The well tubes were tapped for outlets at as low levels as would admit of the water being piped into the nearest drain. Thus the water flow has been increased to a total of eighty-five to ninety miner's inches.

MAIN AND DISTRIBUTION WORKS:—The water thus collected is brought by the sixteen-inch main to a brick basin, and is therein partitioned, by running over two weirs, to the town and to the irrigation system. The irrigation supply is taken thence in a sixteen-inch cement pipe, laid on grade of about fifteen feet per mile, a distance of four thousand feet, to a reservoir sufficiently large to hold the night-flowing water of the supply, into which it is introduced by a brick gate-house, serving both as an intake and outlet. From here the water is led through pipes, from ten to four inches in diameter, under pressure, the maximum of which is two hundred feet of head, to the lands to be irrigated—there being an outlet so placed that each ten-acre tract is served. The supply is drawn from the pipes by water-gates into wooden boxes, and led thence in ditches and flumes for irrigation.

Operation and Maintenance:—The Porter Land and Water Company, apparently, has not as yet adopted any permanent system of disposing of its waters, or of operating or maintaining its works. Its land sales are accompanied by a contract for a water-right. It is not a general water-supply company.

Water-supply and Use:—The creek supply, without development, may be put at fifty, the west *cienega* at ten, and the east *cienega*, developed, at ninety miner's inches, making in all one hundred and fifty, or three cubic feet per second at period of

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lowest flow in ordinarily dry years. It is understood that some work of development has recently been done in the west *cienega*, but the result is not known to the state engineer.

IRRIGATION:—Previous to the development and construction of new works by the Porter Land and Water Company, these waters had been utilized for a number of years by four irrigators, upon about one hundred and forty-three acres of land, cultivated, forty-five in citrus and thirty in deciduous fruits, fifty-five in vines, and fifteen in summer crops. During the present season there are, by the addition of irrigation on the colony lands—this being their first season—five hundred and forty-three acres, in all, irrigated, the additions being two hundred and forty acres in citrus and one hundred and ninety in deciduous fruits.

History of Neighborhood Irrigations:—The waters of these creeks and *cienegas* have been utilized for irrigation in varying degrees of completeness for many years. Those of the east *cienega*, particularly, having first been applied, soon after the founding of the Mission of San Fernando, in the year 1797. At the lower end of the *cienega* there still exist, as evidences of these early applications, the old dam and head basin, of well preserved masonry in hydraulic lime, whence lead the tracings of a high-level ditch around the upper edge of the plain to the west, and commanding the slope behind the mission; and whence also is readily found the ruins of a conduit of round tiles laid in a concrete casing, leading in a more direct line to the mission buildings, about a mile and a half away. We find also in a ravine of the plain, several hundred yards below the *cienega*, a masonry dam of no insignificant proportions, and of creditable design and construction, which once formed a reservoir in the flat above, to accumulate and save the waters of the *cienega*, during nights and days when not in use, and so afford greater volumes of flow to facilitate irrigation when wanted.

The old mission vineyard, orchard, and garden inclosure, embracing an area of seventy-two acres, whose adobe walls are still in some degree serviceable, and whose palm and olive trees stand as monuments to early tillage, were once in a high state of cultivation, and it is known that a considerable area outside these inclosures was cultivated in cereals, also to a great extent by irrigation. At a later period, after the secularization of the church,

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and the disposal of all the mission properties, except those built upon or inclosed with buildings or walls, the Spanish-American owners of this ex-Mission de San Fernando rancho continued the irrigations in but small measure, so that the waters have not for a number of years been fully utilized, and the old works have gone to decay.

Adverse Claims:—It appears that there are claims to the use of these waters, on about one hundred and fifty acres, in the aggregate, grown up, and which, it is understood, that the Porter Land and Water Company recognize. These are known as the Lopez, Rinaldi, and Pico claims.

SECTION IV.

Mormon Cañon Works and Project.

San Fernando Valley Improvement Company.

District and Works:—In the northwestern part of San Fernando valley a tract of land, which formerly belonged to the Rancho Ex-Mission San Fernando, comprising some twenty thousand acres, is owned by the San Fernando Valley Improvement Company. Four small streams from the Santa Susana and San Fernando mountains are available as sources of water-supply for its irrigation: namely, Aliso cañon, Limekiln cañon, Mormon cañon, and Walnut creek. The works at present under construction are the development and storage of waters of Mormon cañon, and their distribution over a tract of four thousand acres, which has been subdivided under the name of Chatsworth Park.

Storage and Delivery Works:—These works consist of a diverting and storage dam across Mormon cañon, and a pipe-line leading from the base thereof; a diverting canal to carry the winter waste from the level of high water in this reservoir, eastward, into two storage reservoirs to be formed by earthen dams, and the distribution system from these reservoirs to the lands below.

Mormon Cañon Reservoir and Dam:—The Mormon cañon dam is an earth embankment, seventy-five feet high from its bedrock foundation thirty feet below the natural surface, to the top. Its

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length is two hundred and seventy feet on top. Thickness at base, one hundred and thirty-six feet; at top, six feet. The slopes are one and a half to one on each side. A trench was cut twenty-two feet wide, from the surface to bedrock, all the way across the cañon, and filled with good puddling clay, which had to be hauled three miles, at a cost of $1 per cubic yard delivered on the dam. This was well rammed in place, and a puddle wall of it carried up from the surface of the ground to the top o the dam, its thickness gradually diminishing to two feet on top. The puddle wall contains three thousand yards, and the backing of earth on either side contains twelve thousand five hundred cubic yards.

The wasteway of the reservoir is cut in the solid ledge, on the west side of the cañon, thirty feet wide and eight feet deep, and is provided with flashboards to raise the level of water four feet, or to within four feet of top of dam. On the east side the dam abuts on a nearly vertical wall of rock, and against this the gate tower is built of stone masonry, six by ten inside, with walls two feet thick. The main outlet pipe is of cast iron, twelve inches in diameter, closed with a Chapman gate. The tower is divided by a brick wall into two compartments, in the inner one of which the gate is located.

At the bottom of the division wall is an opening, in which screens are placed to strain the water before admitting it into the gate. The outer compartment is provided with four inlets, the lower one of which is a pipe extending above the dam for draining the reservoir to the bottom. The others consist of short sections of sixteen-inch pipe, built into the wall at angles of 45 degrees upward, and at levels of eleven feet apart, and provided with hinged covers or gates, set on to the outer ends of the pipes, which are cut off, at angles of 45 degrees, to the level plane. These covers are designed to lift directly up with chains—thus admitting the water into the outer compartment of the tower.

The following table shows the capacities of the reservoir, at different elevations of the water-plane. The base of the dam is one thousand and forty feet above the sea.

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Elevation of Water Plane.		Capacities of Reservoir Above Ground's Surface.	
Above Sea-level.	Above Base of Dam.	Cubic Feet.	Mill. Gal.
1,050	10	57,834	0.43
1,055	15	214,732	1.61
1,060	20	563,983	4.22
1,065	25	1,096,737	8.20
1,070	30	1,887,981	14.12
1,080	40	4,005,200	29.96
1,090	50	7,084,077	52.99

The main delivery pipe leading from the dam is laid a distance of four thousand feet. It is twelve inches in diameter, of riveted wrought iron. A branch line, three thousand feet long, of seven-inch pipe, has also been laid along the north line of the tract. When completed, the distributing system from the Mormon cañon dam will comprise nine miles of seven-inch pipe, one half mile of twelve-inch, and one and a half miles of thirteen-inch.

Diverting Canal:—From the east side of the dam, at the full-water level, a diverting canal is carried two miles to proposed Reservoir No. 3. This canal is six feet on bottom, four feet deep, with side slopes of one to one—on grade of four feet per mile, and having a capacity of over three thousand miner's inches. It is carried in rock and earth excavation—passing *en route* by proposed Reservoir No. 2.

Storage Reservoirs; Proposed:—The latter reservoir was projected in a depression in the foothills, requiring four dams to close the basin, and having a capacity of four hundred and fifty-two million four hundred and seventy-eight thousand two hundred gallons, at an elevation of one thousand and eighty feet above sea-level, or forty-five feet above lowest base of dam. The dams had an estimated contents of ninety-two thousand and forty cubic yards in all. Satisfactory foundation was not found in boring at the principal dam site, and the construction has not been determined upon. Reservoir No. 3, as projected, requires three dams. Elevation, at lowest base of dam, nine hundred and ninety-five; capacity, to elevation one thousand and fifty, is four hundred and ten million five hundred and thirty-nine thousand five hundred gallons, and at elevation one thousand and seventy the capacity

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would be one billion five hundred million gallons. The dams built to elevation one thousand and fifty will contain ninety-seven thousand six hundred cubic yards. Good foundations as far as explored have determined the company to proceed at once with the construction of this reservoir.

COST OF THE WORKS:—The cost of the Mormon cañon dam has been about $10,000. The masonry tower cost $500. The puddle wall cost about $4,000. The cost of the diverting canal was about $5,000. Estimated cost of Reservoir No. 2, to hold one thousand million gallons, is about $50,000.

Operation and Maintenance:—The owners of the tract named organized an independent water company, whose objects are the development, storage, and distribution of water. This company sells, with the lands, where purchasers desire it, rights to water from its reservoirs, at the rate of $1,000 per miner's inch, giving the purchaser the right to do as he sees fit with it—to irrigate as much or as little land as he chooses, to sell or retain it, or to use it on any lands he chooses to irrigate. The water-right thus is in no way attached to the lands. On the basis of the company's calculations purchasers of water-rights are entitled to one fifteen hundredth of the capacity of the works for each inch purchased. If this capacity is one thousand million gallons annually, without allowing for evaporation, the supply per inch would be eighty-eight thousand eight hundred and eighty-eight cubic feet, or enough to spread a foot-layer over two acres, or a half foot-layer over four acres. If the irrigator is content with the latter quantity, his water-right costs him $250 per acre. The water rates per annum are to be fixed at sufficient to maintain and operate the works.

Water-supply and Use:—Mormon cañon has a low-water flow of about twenty miner's inches. The volume of its flood-waters are unknown. During the present season about eighty acres of newly planted orange orchard have been irrigated. Limekiln cañon has a flow of about fifteen miner's inches, and Aliso cañon supplies fifteen to twenty-five at low stage, half of which is the property of this company.

History: Organization:—The Water company is called the San Fernando Valley Water Company. It was incorporated in Octo-

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ber, 1888, with a capital stock of $1,500,000, divided into one thousand five hundred shares. The value of this stock was estimated upon the belief that the works could be depended upon to furnish one thousand five hundred miner's inches, ten hours per day, for one hundred and thirty days each year, and that a water-right for such an inch being salable for $1,000, the value of the stock was one thousand five hundred multiplied by $1,000, equaling $1,500,000. The works thus far have been constructed by the Improvement company, will be carried forward by it, and then turned over to the Water company in exchange for its stock, and the stock will be held by the Improvement company.

Sundry Small Irrigations.

There are quite a number of small but interesting water developments and utilizations within the scope of territory covered by this chapter—notably those at the opening of the little cañons north and east of San Fernando—which receive no mention in this place, and for reasons which must be apparent from what has been repeatedly said in similar cases. It is the intention to present some data of these in the closing summary of the work.

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CHAPTER XXIII.—LOS ANGELES[10]; WORKS AND PROJECTS[20].

LOS ANGELES VALLEY AND COAST PLAIN IRRIGATIONS.

GROUP[9].

SECTION I.—*The Los Angeles City System:*
District and Works;
High and Low Service;
The Old and New *Zanjas;*
Cost of Modern Works;
Operation and Maintenance;
Water Rates and Heads;
Administration; Expense; Revenue;
Water-supply; Irrigation; Cultivation;
Water-rights and Claims;
Old Conflicts and Cases;
Development of the Modern System;
A Relic of the Old Regime.

SECTION II.—*Old Outside Irrigations:*
The Feliz Ditch;
The Chavez Ditch.

SECTION I.

LOS ANGELES RIVER IRRIGATIONS.

The City System.

Districts and Works:—The pueblo limits of Los Angeles, now incorporated under the city charter, embrace a territory about five and a half miles square, at the pass or outlet of San Fernando valley, whence comes Los Angeles river as its main drain. The exterior lines of the city run north, south, east, and west. The river, in a southeast course, crosses the northern boundary almost exactly at the middle point; a mile and a half below it turns due

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south, and on this course continues forward to a point a mile beyond the southern boundary, and then bears off about south by east. Thus, of the city plat, about two miles in width lies east of the channel, and three and a half miles of the territory lie west of it—forming separate districts, as it were. Partly in accord with local nomenclature, and in part for convenience of this description, I shall refer to these districts, respectively, as Los Angeles-east and Los Angeles-west.

In general terms, the southern half of Los Angeles-west occupies an alluvial plain—the upper edge of the coast plain—which, spreading east and west, slopes away southerly seventeen miles to San Pedro bay, except as slightly interrupted by a transverse and broken range of low rolling hills (described on page 394 ante) occurring about twelve miles from the city limit. This plain within and also south of the corporation line constitutes the main district of the city irrigation system.

The northern half of Los Angeles-west occupies a rolling topped and hilly plateau, in general elevation, fifty to one hundred feet above the plain at its base, and which culminates at its eastern middle point in a group of comparatively rugged and steep hills, one hundred and fifty to three hundred feet in elevation above the river channel which sweeps around their eastern base—making here the turn from southeast to south, above referred to. These constitute the extreme outstanding foothills of the Cahuenga mountains to whose eastern point they extend, northwesterly, six to eight miles, gradually rising in altitude, but with one decided pass through them at the northwest corner of the city plat.

These, the Los Angeles hills, look down along their northeast side upon the lower part of San Fernando valley, locally called Los Angeles valley, through which the Los Angeles river courses, with a narrow strip of plain and bottom-land between their footing and its channel, and another, wider, space of valley, across the river and between it and the base of the San Rafael hills. These bits of plain and bottoms west of the river for several miles, and a portion of those east of the river constitute a second field of irrigation commanded by the waters of the river, and, in part, above the city, served by several outside ditches in the next section described, and also in very small part, where within the city, served by the city system.

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The Arroyo Seco comes out of its lower gorge (see page 386, ante) about a mile and a quarter northeast of the northeast corner of Los Angeles; enters the city limit, as a gravel and sand wash, several hundred feet wide, near a mile west of the northeast corner, and with a southwest course joins the Los Angeles river opposite the high and abrupt point of the west hills.

The northeast corner of Los Angeles, for a square mile or more, is occupied by a group of steep-sided round-topped hills, three hundred to four hundred feet in elevation above the river, which hills—a part of the chain described heretofore as the Coast Range—extend southeasterly out of the city. Los Angeles-east comprises a point of plain, at the northern boundary, several hundred acres in area, between the river and Arroyo Seco wash, and a strip of bottom-land along the river below Arroyo Seco junction, but, for the most part, it occupies a rolling topped plateau or higher plain, thirty to fifty feet above the river bed, cut by several deep arroyos and margined and broken by several high hill ridges which extend into it from the range on the east. This strip of bottom-land constitutes a district served by the city irrigation works, but the plains of the plateau, once regarded as demanding irrigation service, are now fast being occupied in small city lots, and irrigation, except as served in connection with municipal and domestic supply, is fast disappearing.

THE SYSTEMS OF WORKS:—With this understanding of the field, we are prepared to realize that the city irrigation works are divided into an upper and lower service, and an eastern and western system.

The high-service works take water from the river about five miles in a straight line above the city limits, at an elevation about four hundred and eighty feet above the sea (two hundred and twenty-five feet above city base), and deliver it upon the plains of the Los Angeles-west plateau and thence down on to the higher part of the lower plain on the extreme western side of the city, also, upon the plain east of the river above the Arroyo Seco, and, crossing that stream, upon the plains and lower rolling lands of Los Angeles-east. These are called, on the west side, the Canal and Reservoir system, and across the river, the East-side system.

The low-service works divert, on the west side, over a mile within the city limits, at an elevation about three hundred and ten feet

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above the sea, and where the river is close in against the point of the west-side bluff, and serve, on that side, the bottom-lands and plains, within and without the city so far as irrigated. The main conduit of this system, by far the largest and most important of the city irrigation works, is called *Zanja Madre* (Mother Ditch), and its branches, of which there are by secondary division eight or ten, are known chiefly by number and letter, as hereinafter described.

East of the river the low-service diversion is now made nearly two miles below the head of *Zanja Madre*, as hereafter described.

High-service System—West Side:—The upper service waters are diverted on the west side of the river by means of an ordinary brush and sand dam, into a ditch which extending thence first over the bottom-land and lower plain, somewhat more than a couple of miles, on a course generally parallel with the river and a quarter to half a mile therefrom; then getting back on the bench at the foot of the hills, and gradually out of the valley, for nearly three miles more, arrives at a point on the bluff overlooking and about fifty feet above the river, and at the head of a pass through the hills to the south. From here the east-side high-service waters are diverted and piped easterly across the valley and river, while the west-side supply is carried southerly through the pass in an open ditch, by a very winding course, to a reservoir, in an upper valley of the plateau, and located at about the center of the north half of Los Angeles-west. The ditch down to the point of division is called the "Main Supply" *zanja*, and thence to the reservoir it is known as the "Canal and Reservoir" *zanja*, or *zanja* "C. & R.," and the reservoir is known as "No. 4."

The main supply *zanja* is a plain earthen ditch, six feet wide on the bottom, twelve feet on top, and intended to carry three feet depth of water with a fall of about four feet per mile. It actually carries and delivers twenty-six cubic feet of water per second, or one thousand three hundred miner's inches; but in the city rating it is spoken of as four "heads" capacity, yet, in the same rating, one hundred inches is regarded as an irrigating head. There are in the line of the work three regular sand-boxes and gates provided for entrapping and sluicing out the sands brought into it; and twelve flumes, across ravines and washouts, from twenty to two hundred feet long, each provided with a sand gate. At the point of division is a well built partitioning structure of concrete,

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with wooden gates, by means of which the waters may be divided in any desired proportion between the west and east-side mains thence.

Zanja Canal and Reservoir, from the division gates to the reservoir, a little over two miles in length, is three feet wide on the bottom, eight feet on top, and carrying two and one half feet in depth of water, is rated at a capacity for four irrigating heads. It delivers its supply into the reservoir with twenty feet of fall, which is utilized for power purposes, and is a source of revenue to the city.

Reservoir No. 4 is formed by an embankment across the narrow outlet of a valley, which was intended to effect the ponding of water nearly a mile back and a quarter of a mile in width, and to a volume over twenty million cubic feet, but the dam is considered unsafe, the water is now never brought higher than sixteen feet below its crest, at which plane it has an effective capacity of about seven million cubic feet. The waste-way consists of three thirty-inch cement pipes simply laid through the embankment, ten feet below its top, over against the hillside at one end, with a grade of one foot in ten. The outlet is by a tunnel in sandstone bedrock under the dam. A square masonry tower stands out at the upper footing of the dam to a plane several feet above the top. A twenty-two-inch iron pipe, with a water-gate within the tower chamber, passes through the tower from near the bottom of the reservoir, a total length of over seventy feet, into the tunnel, delivering its waters freely therein. A box of heavy timbers encases this pipe from the tower to the tunnel; and a spur embankment, extending from the dam out to the tower, and nearly as high as the dam itself, heavily covers this box culvert in. The original construction was of the simple tunnel through to the base of the tower, and with a short piece of pipe delivering waters thereto, but the crown of the tunnel, only about four feet thick to the ground's surface in the basin, several years ago caved in—emptying the reservoir of its waters, it is said, in about two hours, and without injury to either tunnel or dam. The gap was then closed by the wooden culvert, the pipe prolonged, and the spur bank built over it. A well built and thickly settled part of the city lies in the path of drainage immediately below this reservoir. There is no

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provision for the escape of waste-waters beyond the dam waste-way.

From the tunnel outlet the waters are taken, on grade and out upon the west side of the valley, nearly due south, in a twenty-two-inch pipe for one thousand two hundred and forty feet, and then in a cast-iron pipe of the same size eight thousand feet, to where they are given a drop of seventy-eight feet—ordinarily furnishing, as actually registered, forty-five-horse power, which by lease to a woolen mill is also made a source of revenue to the city. From the shaft at this drop the waters escape by a tunnel about five hundred feet in length, and thence are carried forward for irrigation by a twenty-two-inch cement pipe, which has taken the place of an old distributing ditch, and is called by the name, *Zanja 8-R.* This *zanja* extends southwesterly on principal street lines (Flower, Pearl, and Figueroa) about two and a half miles to the city southern limit, and thence on for about four thousand feet beyond. For all but a few hundred feet through the city the old ditch has been replaced by the twenty-two-inch cement pipe, or by an open concrete conduit two feet wide and eighteen inches deep, built with eight-inch walls, in conjunction with a very low fencing wall along the front lines of highly improved residence property, and finished as an ornamental structure, with little concrete posts at intervals, and bridges of concrete at the carriage entrances to private grounds. Of this construction, which, built at the joint cost of the city and the property owners, cost $1 50 per foot, there is something over a mile.

Zanja 8-R. has five main branches, all going out from its right side by street lines, and then turning by street lines parallel with it, or extending beyond the city's western border. For the most part these are all sixteen to twenty-inch cement pipes as far as the city limits, and thence are open earthen ditches.

The high-service system in making the drop at the woolen mills comes to the plain but a few feet above the low-service system, and, indeed, it occupies an old low-service *zanja* which, however, had always been served with difficulty from that source. The irrigations within the city lines by this system are for the most part of ornamental grounds and small private orchards about residences. Beyond the city both west and south, however, the service is to a productive horticultural industry.

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High-service Works—East Side:—From the division point the eastern branch of the high-service system, for three thousand five hundred feet along the bluff to a favorable place for crossing, is a thirty-inch cement pipe, with a fall of thirty-six feet in that distance. Then follows seven thousand eight hundred and thirty-six feet of twenty-two-inch wrought iron riveted pipe across the valley, and carried across the river on a pile trestling, to and up on the slope of the hill east of the valley. Thence the work extends southeasterly on a grade of four and eight tenths feet per mile, as a twenty-two-inch cement pipe to the edge of the valley of the arroyo; as a twenty-two-inch wrought iron pressure pipe across this arroyo two thousand six hundred feet; and as a cement pipe again of the same diameter to Reservoir No. 5, lying on the eastern border of the city, about a mile and a half below its northeast corner, and fifteen thousand feet by the pipe-line from the east end of the river pressure-pipe. The cement pipe follows the line of the old east-side ditch, known as *Zanja 9–E.*, which formerly commenced on the river near where the west-side ditch now commences, or was brought across in a flume from the west side near that point, and had a total length above Reservoir No. 5 of twelve and three quarters miles. As now served by the pressure pipe across the river, and shortened by that across Arroyo Seco, the east-side high-service main is twenty-five thousand and forty-nine feet in length from the west-side divide to the east-side reservoir. The old *zanja* was of low grade, insufficient capacity, constantly choking up with weeds, and very wasteful of water-supply. The new work has, of course, remedied these defects, but has inherited the name of the old ditch—"*Zanja 9–E.*"

Reservoir No. 5 into which runs *Zanja* 9-E. is formed by an earthen embankment, about six hundred feet long on top and twenty-five feet in greatest height, built across the opening of a valley in the east-side hills. The dam rudely put up with scraper, of the soil and hard pan immediately adjoining the site, has always leaked at or under its base—maintaining a large pond below it. Its maximum capacity was originally about one hundred and twenty million gallons. The embankment has been raised within the past year by about ten feet additional, seemingly put on with the intention of adding to its strength by making it heavier, rather than to the capacity of the reservoir by making

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it higher, for the water surface is never allowed to rise above the old level.

There is a twenty-two-inch blow-off gate in the supplying *zanja* at its Arroyo Seco crossing; and a twenty-two-inch iron pipe laid under the embankment is provided with a gate for drawing water out of the reservoir; but there is no provision for the care of excessive storm waters in the valley where the reservoir is located, should the reservoir fill in spite of the discharge by its twenty-two-inch outlet pipe.

Zanja 9-R. is supplied by this discharge pipe and winds around the base of the hills in Los Angeles-east on a grade of ten feet per mile, a distance of twenty-nine thousand seven hundred and forty feet, commanding the high plain and part of the rolling and hill land there located. This *zanja* remains as an earthen ditch with the exception of an eight hundred-foot extension made this year of twelve-inch cement pipe.

Low-service Works—West Side:—The waters for the west-side low-service irrigation system are diverted from the river by the usual (in Southern California) brush and sand wing-dam, located near half a mile above the southern point of the west-side hills, already described. At this locality the river courses closely against the base of the hill, whose face is here a steep sandstone bluff, for nearly a mile, the Southern Pacific railway grade is cut into the hillside at a plane about eighteen feet above the river, and the *Zanja Madre* is built in the river bed along the base of the rocky slope from the railway. This construction practically consists, for most of the length, of a prolongation of the dam of brush and sand, parallel, and about twenty feet from the base of the rock slope, leaving the *zanja* water-way between. By this means—the sands having filled the bed of the *zanja* to an even grade—the waters are carried to an elevation six to eight feet above the river bed at the hill-point, and there turned in a deep cut away from the river.

Here a division is made and more permanent construction commences. A principal branch, *Zanja 6-1*, continues southerly, parallel with and near to the river bank, while *Zanja Madre* is carried west and southwest around next to the base of the bluff, which here recedes that way for near a mile, and then turns south again.

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Zanja 6-1, at a point a mile and a half in a straight line, below its head is divided into two channels—*Zanja 1* and *Zanja 2*—which, after separating, flow, about half a mile apart, due south, but with some jogging off, parallel with the river, near two and a half miles to the city limits, and there again branching continue in three or four parallel channels, nearly three to four and three fourths miles farther, and covering a district a mile to two miles in width.

Zanja Madre, at a locality a mile and a quarter in a straight line southwesterly from the head of *Zanja 6-1*, is divided into four channels—*Zanja 3*, *Zanja 4*, *Zanja 5*, and *Zanja 8*—which, separating, extend southerly and southwesterly from a quarter to half a mile apart, and with some intermediate quarter-mile branches, from two and a half to three and a half miles each to the south line of the city, and then, as a general rule, again branching, all run south on parallel quarter-mile lines, from two to three miles farther.

The west-side low-service system thus covers within the city a triangular space near four miles on its east side along the river, and three and a half west therefrom on the south boundary; and outside of this limit its district is two to four and a half miles wide, and four to four and three quarters long.

Zanja 8, the western branch of the low-service system, joins *Zanja 8-R.*, the lower and main channel of the high-service system already described. So that this west-side district, taking the upper and lower service together, is continuous around from the river to and out on the plain west of the city, embracing an area of about twenty-five square miles.

Low-service System—East Side:—*Zanja 7* is the only low-service work now in use on the east side. It diverts from the river by means of a sand and brush dam, about a mile and three quarters below the head of *Zanja Madre*, where the channel is over against the foot of a point of the east-side higher plain; thence it extends southerly along the base of the bluff, commanding a strip of bottom-land, from a few feet to half a mile in width, between it and the river, for near three miles in length to the southern line of the city. Here, the back lying plain having dropped to nearer the river's level, this *zanja*, with about two more miles of length, commands a couple of square miles of relatively higher additional territory.

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Description of Zanjas:—The following table contains a recapitulation of the data of the high-service works, and sufficiently describes those of the low-service system to render unnecessary a separate description of the details of each. Its data relate to the main works, only.

Conduit: Character; Dimensions.	Location; Remarks.	Lengths, Feet.	Total Lengths.
Upper Service Works.	West-side System.		
Main Supply zanja:	From Los Angeles river.		
Open ditch, 6′x12′x4′ . .	Head 480 ft. above sea .		
Grade 4 ft. per mile . .	To division point . . .	27,289	27,290
Zanja C. & R.:	From division point . .		
Open ditch, 3′x8′x3′ . .	To Reservoir No. 4 . . .	11,150	11,150
Drop of 20 feet . . .	Power utilized		
Woolen Mill zanja:	From Reservoir No. 4 .		
Cement pipe, 22-inch . .	Down west side of valley	1,240	
Iron pipe, 22-inch . . .	To the woolen mills . .	8,000	
Drop of 78 feet . . .	Power utilized . . .		
Tunnel	To Zanja 8-R	500	9,740
Zanja 8-R.:	Along Flower, Pearl, and Figueroa streets . . .		
Cement pipe	(Parts not located) . . .	8,600	
Open concrete canal . .	(Parts not located) . . .	6,000	
Open ditch	To city boundary . . .	2,000	16,600
	Total West side		64,780
Upper Service Works.	East-side System.		
Zanja 9-E.:	Main East-side line . .		
Cement pipe, 30-inch . .	Division point to bluff .	3,500	
Iron pipe, 22-inch . . .	Across Los Angeles river and valley	7,836	
Cement pipe, 22-inch . .	To Arroyo Seco	8,200	
Iron pipe, 22-inch . . .	Across Arroyo Seco . .	2,600	
Cement pipe, 22-inch . .	To Reservoir No. 5 . . .	7,800	29,936
Zanja 9-R.:	From Reservoir No. 5 .		
Open ditch, 9′x3′x2′ . .	Along base East-side hills		
Grade, 10 feet per mile .	End within city boundary	29,740	29,740
Total	East-side high system . .	. . . . .	59,676
	Total, high system . .	. . . . .	124,456
Low Service.	West-side.		
Zanja Madre:	From Los Angeles river .		
Embanked channel . .	Along bluff, to head 6-1 .	3,300	
Masonry lined canal . .	Out from the river . . .	3,500	
Brick conduit, 3 ft. diam.	To the Capitol Mills . .	1,800	
Drop of 18 feet . . .	Power utilized . . .		
Brick conduit, 3½ ft. diam.	To end at First street .	4,900	13,500

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Conduit: Character; Dimensions.	Location; Remarks.	Lengths, Feet.	Total Lengths.
Zanja 6-1:	From head on *Zanja Madre*		
Cement pipe, 30-inch . .	To crossing Downie av. .	1,200	
Wrt. iron pipe, 30-inch .	To crossing of Ann st. .	1,900	
Drop of 10 feet . . .	Power utilized		
Cement pipe, 30-inch . .	To Stearns mill	1,500	
Open ditch and flume .	. . . . .	1,700	
Cement pipe, 30-inch . .	To crossing Macy st. . .	400	
Wrt. iron riv. pipe, 30-in.	To crossing Aliso st. . .	1,500	
Drop of 8 feet	Power utilized		
Open ditch	To end at First street .	2,680	10,880
Zanja 1:	From end of *Zanja 6-1* .		
Flume box	(Parts not located) . . .	800	
Cement pipe, 16-inch . .	(Parts not located) . . .	1,300	
Open ditch	To city boundary . . .	9,625	11,725
Zanja 2:	From end of *Zanja 6-1.*		
Flume box, 3 ft.x1 ft. . .	To city boundary . .	13,200	13,200
Zanja 3:	From end of *Zanja Madre.*		
Open ditch	From 1st to 7th street .	4,800	
Cement pipe, 22-inch . .	From 7th to 12th street .	3,200	
Open ditch	To city boundary . .	4,750	12,750
Zanja 4:	From end of *Zanja Madre.*		
Cement pipe, 30-inch . .	(Combined with *Zanja 5*)	9,200	
Open ditch	(Below part combined) .	6,400	15,600
Old Zanja 4:	From *Zanja 4* combined .		
Cement pipe, 22-inch . .	East of *Zanja 4*	600	
Open ditch	End within city limits .	5,200	5,800
Zanja 5:	From end of *Zanja 4 & 5*		
Cement pipe, 22-inch . .	Washington and Main sts.	7,600	
Open ditch	To city boundary . .	1,100	8,700
Zanja 8:	From end of *Zanja Madre.*		
Cement pipe, 16-inch . .	To High Service *Zanja 8-R.*	8,300	8,300
Low Service.	East Side.		100,455
Zanja 7 (lower):	Heads above Macy-street bridge		
Flume	(Parts not located) . . .	400	
Cement pipe, 22-inch . .	(Parts not located) . . .	300	
Open ditch	To city boundary . . .	19,100	19,800
	Total, low system . . .	. . .	120,255
Grand total	Within the city . . .	. . .	244,711

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The exhibit next presented sums up the subject for each class of conduit for each *zanja* and each service, in the city system. Cement and concrete pipes, concreted, masonry, and brick lined canals and closed conduits are here put into one class. The data of this table include the main works of the foregoing exhibit, and also the principal branches.

Name of Zanja.	Capacities in Irrigating Heads.	Lengths in Feet.				
		Open Earthen Ditch.	Cement Pipe or Conduit.	Iron Pipe.	Wooden Flume and Tunnel.	Total.
High Service—West-side:						
Main Supply Canal . .	. .	26,290	. . . .	. . . .	F. 1,000	27,290
Zanja C. and R. . . .	4	11,150	. . . .	. . . .	. . . .	11,150
Zanja Woolen Mills. .	3	. . . . .	1,240	8,000	T. 500	9,740
Zanja 8-R.	2	2,000	14,600	. . . .	. . . .	16,600
Total mains	. .	39,440	15,840	8,000	1,500	64,780
Nichols branch . . .	1	. . . . .	. . . .	7,000	. . . .	7,000
West branch 8-R . . .	1	9,200	3,000	. . . .	. . . .	12,200
Washington St. Br. 8-R.	1	3,100	1,000	. . . .	. . . .	4,100
Ellis avenue Br. 8-R. .	1	. . . . .	600	. . . .	. . . .	600
Adams street Br. 8-R. .	1	. . . . .	2,700	. . . .	. . . .	2,700
Pico street branch 8-R .	1	. . . . .	450	. . . .	. . . .	450
Totals—Branches . .	. .	12,300	7,750	7,000	. . . .	27,050
Totals—West-side .	. .	51,740	23,590	15,000	1,500	91,830
High Service—East-side:						
Zanja 9-E.	. .	. . . . .	19,500	10,436	. . . .	29,936
Zanja 9-R.	. .	29,740	. . . .	. . . .	. . . .	29,740
Totals—East-side . .	. .	29,740	19,500	10,436	. . . .	59,676
Totals—High service	. .	81,480	43,090	25,436	1,500	151,506
Low Service—West-side:						
Zanja Madre	6	3,300	10,200	. . . .	. . . .	13,500
Zanja 6-1	4	4,380	3,100	3,400	. . . .	10,880
Zanja 1	1	9,625	1,300	. . . .	800	11,725
Zanja 2	2	. . . . .	. . . .	. . . .	13,200	13,200
Zanja 3	2	9,550	3,200	. . . .	. . . .	12,750
Zanja 4 and 5	2	. . . . .	9,200	. . . .	. . . .	9,200
Zanja 4	2	6,400	. . . .	. . . .	. . . .	6,400
Zanja 4 (old)	2	5,200	600	. . . .	. . . .	5,800
Zanja 5	2	1,100	7,600	. . . .	. . . .	8,700
Zanja 8	1	. . . . .	8,300	. . . .	. . . .	8,300
Totals—Mains . . .	. .	39,555	43,500	3,400	14,000	100,455

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Name of Zanja.	Capacities in Irrigating Heads.	Lengths in Feet.				
		Open Earthen Ditch.	Cement Pipe or Conduit.	Iron Pipe.	Wooden Flume and Tunnel.	Total.
Washington St. Br., Z. 5	1	. . . . .	2,100	. . . .	. . . .	2,100
Adams St. Br., Z. 5 . .	1	. . . . .	1,250	. . . .	. . . .	1,250
Brooklyn St. Br., Z. 5 .	1	. . . . .	1,250	. . . .	. . . .	1,250
Totals—Branches . .	. .	. . . . .	4,600	. . . .	. . . .	4,600
Totals—West-side .	. .	39,555	48,100	3,400	14,000	105,055
Low Service—East-side: Zanja 7	2	19,100	300	. . . .	400	19,800
Totals—Low Service .	. .	58,655	48,400	3,400	14,400	124,855
Grand totals—Low and High Service . . .	. .	140,135	91,490	28,836	15,900	276,361
Grand totals—Miles .	. .	26.5	17.3	5.5	3.0	52.26

From this summary, which is a fair approximation to the exact facts, it will be seen that the total length of conduits maintained by the city is fifty-two and three tenths miles, of which twenty-five and eight tenths miles, or nearly 50 per cent, consists of tight conduits—wooden flumes, cement and iron pipe, cement or masonry lined canals, brick culverts, etc.—and the balance consists of open canal, and ditches of various kinds and sizes. This total length is about two miles less than in 1879, when the works were first examined by the state engineering department; but at that time only about seventeen thousand feet of the total length was of tight conduit, and of this ten thousand feet was flume, and distribution had been extended but little beyond the city by the outside districts. Now, we find at least forty miles of leading ditches outside of the city extensions of and receiving supply from the city *zanjas*, but owned and controlled by associated irrigators and companies, as elsewhere explained. Thus, the entire system embraces about ninety-three miles of conduit, besides individual irrigator's farm or orchard ditches, of which there are many more miles, often of as large capacity as the local delivering works.

Cost of the Works:—The difficulty of arriving at the original cost of works, constructed by "piece meal," in a period of twelve years, under no definite plan, and supervised by successive city

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officials (and this refers only to the works regarded as permanent and not to the long-built earthen ditches) changed almost every year, without any system of keeping accounts of construction segregated from ordinary maintenance expense, can scarcely be appreciated until one attempts the task. Much of the work has been done several times over; ditches have been flumed, and after a time the flumes replaced with pipe; piped-lines have been, locally but radically, altered and enlarged; iron pipe substituted for cement pipe, and vice versa; and no small part of the work done has been abandoned and fallen into disuse. As nearly as may be determined, the existing works have cost, in round numbers, $350,000.

Some of the principal items of these costs are the following:

West-side, Low-service:		
Zanja Madre—tunnel and dam at head	$20,000	
Zanja Madre—concrete lining, 3,600 feet	9,855	
Zanja No. 3—flume lining, 8,000 feet	2,260	
		$32,115
West-side, High-service:		
Canal and reservoir ditch purchased	$8,000	
Main-supply canal—enlarged from C. & R.	29,749	
Other expenditures on this system	16,168	
		53,917
East-side, High-service:		
Zanjas 9-E and 9-R	$21,500	
Reservoir No. 5	18,000	
		39,500
		$125,532

These expenditures, made from 1877 to 1880, were chiefly met by the sale of $75,000 of twenty-year seven per cent bonds in 1877, and $40,000 of thirty-year seven per cent bonds in 1878. The first issue were called "Irrigation Improvement Bonds," and the second "General Irrigation Bonds."

After the expenditure of these funds, to the fall of 1886, it has been reported that a further sum of $32,550, raised by general taxation, was expended in laying pipes at various points in carrying the *zanjas* through the crowded parts of the city. In 1885 a separate "Pipe-line Fund" was created by the sale of certain city real estate, which realized the sum of $29,862 94, and was expended principally in laying the long iron pressure pipes across the river and Arroyo Seco, for the better supply of the east side high-service system. Consequent upon the recommendation of a board of engineers, and that of the council water-supply com-

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mittee, in 1886, the city voted to issue "General Improvement Bonds" to the amount of $245,000 for streets, sewers, city hall, and irrigation works. Of this amount $125,000 were to be devoted to the latter purpose, and up to date the "Irrigation System Fund" created by the amounts realized from the sale of these bonds has reached over $121,000, and has been principally expended during the current year in the laying of the new pipe-lines hereinbefore described. The contract price for twenty-two-inch cement pipe, of which the work largely consists, laid is $1 10 per foot. In addition to these bond funds, the "New Water Fund" (into which is placed all the revenue derived from sale of water, fishing permits, rental of water, privilege to the municipal-supply water company, etc., supplemented by some $4,000 to $5,000 per annum derived from direct taxation) has been regularly drawn upon for such new work as was from time to time required in driblets through the year. The exact amount so expended is impossible to determine, but it is not far from $50,000 in the aggregate in the past twelve years. Aside from these, a further source of revenue applied to improvement has been private subscriptions, amounting, in the aggregate, to $10,000 or $15,000. Parties interested in having the public *zanja* improved through or in front of their property have at times contributed various sums for such work.

It may be safely assumed that the existing works could be duplicated, as a whole, and materially improved at far less cost than they now represent—possibly not much over one half.

Operation and Maintenance:—The irrigation system of Los Angeles is under the direct control of the city council, from the heads of the *zanjas* on the river to the southern limits of the city, and from there on the distribution is managed by several associations of outside irrigators.

Inside City System:—The council appoints a general *zanjero*, or ditch overseer, and assistants, fixes the rates for sale of water, orders all *zanja* improvements that are made within the city, and maintains entire control over diversion from the river. In times past the council has apportioned the water to the land within city limits, at the rate of an irrigating head for twenty-four hours to each ten acres, every thirty days. This was when there was a scarcity of supply owing to the great loss of water in earthen

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ditches, and when the acreage irrigated inside the city limits was greater than it now is. This city-allotment is now, however, a dead letter, as the inside irrigators have more than they require, and the council has no concern for distribution of the water after it leaves the corporation limits. Every individual irrigator whose lands are inside the city bounds is allowed all the water he wishes to buy and pay for without restriction, and the surplus waters are sold to the outside associations.

Outside Irrigating Companies:—Outside the city limits the irrigators are organized in regularly defined districts on the extension of each *zanja*. These districts abut on the city, and when organized were considered to embrace all lands which could be reached by the spare water of the river. Some of them have been much extended, however, and in one or two instances secondary districts subject to and buying water from the primary districts, are found adjoining the latter. With the improvement of the *zanjas* and the diminution of cultivation within the city, the irrigable area has extended year by year, and is now carried even beyond the secondary outside districts. The outside organizations are incorporated associations of irrigators, which elect officers, are governed by sets of by-laws, and appoint *zanjeros*, whose duty it is to purchase surplus water of the city and sell it to the irrigators, each of his own district, at a premium fixed by the association, which constitutes its compensation.

Water-rates:—Water is sold by the irrigating head in measure of time. The rates, always subject to change, are at present, in the city, $3 per head per day (sunrise to sunset); $2 per head for half day (sunrise to noon, or noon to sunset), and $0 50 per hour. Current rates, charged the outside districts by the city, are $5 per head per day, $3 per night. Single-hour permits are not sold outside. These rates are 50 per cent higher than they were two years ago. In 1880 the city rates were, per day, $2; half day, $1 25; night, $1 50. In 1873 they were $1 75 per day, $1 25 half day, $1 per night, inside city limits. Outside they were $3 per day; $2 per night. In 1870, in the city, they were $1 50 per day and $1 per night, from March first to October first. After the latter date, $0 75 per day, and free at night.

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Year.	Inside City Limits. Rates per Irrigating Head.				Outside City Limits. Rates per Irrigating Head.	
	Day.	Half Day.	Night.	Hour.	Day.	Night.
1870 . . .	$1 50	. . . . .	$1 00	. . . . .	. . . . .	. . . . .
1872 . . .	1 50	$1 00	1 00	$0 25	. . . . .	. . . . .
1873 . . .	1 75	1 25	1 00	50	$3 00	$2 00
1878 . . .	2 00	1 25	1 50	50	4 00	2 00
1880 . . .	2 00	1 25	1 50	50	4 00	3 00
1888 . . .	3 00	2 00	2 00	50	5 00	3 00

Irrigating Heads:—The "irrigating head" is nominally rated at one hundred miner's inches, but in Los Angeles there is still no system of measuring these heads, and the quantity delivered as an irrigating head is as indeterminate a volume to-day as it was twenty years ago. The practice has always been to divide the total flow of the river into about seventeen heads, and divert it all, up to the limit of the capacity of the ditch. Various measurements at different times, of the heads flowing in the ditches of the low-service system indicate that they range from one hundred and fifty to two hundred and fifty miner's inches, while on the upper service they run from seventy-five to one hundred and fifty inches. The soils under the upper service are less absorptive of water, and irrigation can be performed with smaller heads than on the sandy soils of the valley. The twenty-two-inch cement pipes laid in many of the lines of *zanja* will carry, on grades of about ten feet per mile, nearly eight cubic feet per second, or four hundred inches. Yet they are said to carry two heads. *Zanja 9-E* of the upper service, with a total fall of forty and seven tenths feet to Reservoir 5, will carry about seven cubic feet per second, which is regarded as only two heads. *Zanja Madre*, below junction of *Zanja 6-1*, now supplies two heads each to *Zanjas 3, 4, and 5*, and in its smallest section where it is lined with brick, circular three feet diameter, will carry about twenty-four cubic feet per second, or four cubic feet per second (equal to two hundred inches) per head. This is but corroborative evidence to show that the heads are nearer two hundred inches than one hundred. The ordinary summer flow of the river is about four thousand inches, and its division into heads is further evidence in the same line, as the average of each would be about two hundred and thirty-five inches. The method adopted in the sale of water is about as follows:

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DISTRIBUTION:—*Sale of Water:*—On the twenty-fourth or twenty-fifth of the month each irrigator must make application in writing at the office of the city *zanjero* for the waters he desires to purchase during the following month, stating the number of acres he owns, the *zanja* from which he irrigates, the number of days, half days, nights, or hours that he wants the water, together with the date that he would desire it. When all applications from citizens are in, the *zanjero* makes up a schedule, arranging the allotment to each as nearly in accordance with the dates mentioned in the demand as possible, giving preference to the earliest applicants. On the twenty-seventh and twenty-eighth, following, the irrigators apply to the office for their permits, which are made out in accordance with the schedule, signed by the mayor and *zanjero*, and delivered to the applicants on payment for their water. The deputy *zanjeros* are alone empowered to open the gates and turn the water to each irrigator, which they do at times specified in the schedule and permits.

On the first day of the month following, if there be, of the month's supply, any surplus unsold, the *zanjero* is empowered to sell it, on demand, to outside irrigators, reserving a little to provide for emergencies until the sixth, when, if no citizen requires more, all is finally sold to the outsiders. It sometimes happens that after all these have been supplied there remains a surplus. In such case the water is allowed to run to waste, to be surreptitiously picked up and used by an outsider, or the opportunity thus afforded is taken for cleaning the *zanjas* and making repairs.

The permits sold to outside irrigators are very carefully worded, in the following form: "Received from ——— the sum of ——— dollars for the use of *zanja* No. ——, for the purpose of carrying one head of water through the same for one night (or one day) only, ———, 1888."

The purpose of this language, in which the use of the *zanjas* only is sold, and not any specific quantity of water, is to relieve the city from any responsibility in case of failure or breakage of ditch, or malicious diversion of water.

ADMINISTRATION:—The regular staff employed consists of a water overseer, or chief *zanjero*, having general charge of the works, and receiving $150 per month; a secretary, who attends to the applications for water, issues the permits, collects the water rates, and keeps the books. His pay is $75 per month. There

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are three deputy *zanjeros*, regularly employed at $75 per month, and at times four or five. The *zanjero* and his deputies are made special policemen, with power of arrest, and wear the star of authority, so that they may promptly check any infraction of the rules. These regulations are in the form of ordinances passed with all the formalities of other municipal laws, and are quite voluminous. They prescribe the duties of the chief *zanjero*, in detail, and make the mayor a court of appeal for the irrigators, from his rulings. Irrigators have to construct their own gates or outlets from the *zanjas*, but are absolutely forbidden to operate them in turning the water off or on. City irrigators are prohibited, under penalty of a heavy fine, from selling their water to outside irrigators. And the *zanjero* is obliged to be in his office to make the water sales at stated hours, and is prohibited from making them at other times or elsewhere. Irrigators are required to so construct their distribution ditches and banks as to control the waters, and are held responsible for damage done by their failure. Many other points covered by these ordinances are embodied incidentally elsewhere in this article, and very much relates to mere matters of police, which would suggest themselves to any one of thought, and, hence, need not be mentioned here.

MAINTENANCE; COST OF:—The cost of maintaining the system, including the salaries of *zanjeros*, the cleaning of ditches, and the ordinary repairs, is from $10,000 to $11,000 per annum. This is about met by the revenue derived from sales of water, etc. The cost of repairs on the city *zanjas* and pay of *zanjeros* for six years, from 1880 to 1885, inclusive, was $68,980 22. The receipts from the sales of water during the same period was $68,527 98, showing a deficiency of $452 24. The total revenue for twelve years ending November 1, 1883, was $124,792 03—an average of $10,399 per annum. During this period the total expense of maintenance was about[1] $131,311 91, a yearly average of $10,942 65, making an average yearly deficiency of $545 65. To the average expense should properly be added the interest on the bonds, whose proceeds have been spent in the improvement of the works. This interest is now $15,250 per year. The total average cost of irriga-

[1] The word "about" is used in this case because this is the figure remaining after deducting $50,000 from the total expenditure of the New Water fund in that period—the $50,000 being approximately the portion of that fund expended on construction.

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tion is therefore $26,192 65, or $15,795 65 more than the average revenue, and which is borne by general taxation. In other words, while the average cost of water to the irrigator is somewhat less than $1 per acre per annum, the cost to the public is $5 37 for every acre now irrigated inside the city limits. The average revenue from all the land irrigated inside and outside city limits is about 94 cents per acre, for the period above named, and 92 cents per acre for the last three years, while the average cost of maintenance and interest is about $2 37 per acre, per year, for the twelve-year period. These remarks are based on the present acreage. The following table shows the total receipts for each month for the past twelve years:

LOS ANGELES:—RECEIPTS FROM SALES OF IRRIGATION WATER.

MONTHS.	1876-77.	1877-78.	1878-79.	1879-80.
November	. . . .	$176 00	$230 50	$139 50
December	. . . .	169 25	267 00	5 75
January	$113 00	400 00	. . . .	. . . .
February	544 75	48 76	76 50	67 75
March	1,121 00	12 99	165 25	135 00
April	1,048 75	. . . .	1,167 75	138 00
May	1,138 50	1,045 25	1,597 00	849 50
June	1,387 75	1,547 50	1,533 50	1,645 00
July	1,163 75	1,611 75	1,593 00	1,643 25
August	1,016 75	1,652 75	1,551 50	1,723 75
September	594 00	792 00	1,367 75	1,334 00
October	448 25	435 75	408 75	512 75
Totals	$8,576 50	$7,892 00	$9,494 55	$8,194 25

MONTHS.	1880-81.	1881-82.	1882-83.	1883-84.
November	$240 50	$184 25	$328 25	$299 50
December	14 50	176 00	423 50	345 25
January	4 50	818 50	532 00	379 50
February	136 50	1,309 25	609 00	64 00
March	562 75	800 25	958 00	2 00
April	977 00	655 00	870 78	7 75
May	1,541 00	1,668 00	1,333 25	468 50
June	1,515 75	1,759 25	1,513 25	1,785 75
July	1,595 75	1,674 25	1,638 00	2,059 25
August	1,529 50	1,802 37	1,544 00	2,249 75
September	1,247 75	1,624 50	1,648 00	1,896 50
October	476 50	1,056 75	1,236 00	638 75
Totals	$9,842 00	$14,666 62	$12,944 28	$10,465 33

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Months.	1884–85.	1885–86.	1886–87.	1887–88.
November	$151 75	$358 50	$201 25	$410 50
December	62 00	14 00	194 00	34 50
January	4 00	5 00	589 50	35 00
February	259 50	43 50	627 00	53 00
March	530 50	47 00	95 00	50 75
April	1,429 50	98 50	360 00	282 50
May	1,258 50	481 50	1,083 00	936 25
June	1,605 00	1,699 75	1,581 00	1,374 50
July	1,705 00	1,699 25	1,714 50	2,521 50
August	2,455 00	1,763 00	1,681 25	2,417 00
September	1,969 00	1,444 50	1,250 50	2,178 00
October	555 50	790 75	808 50	1,376 75
Totals	$12,415 50	$8,445 25	$10,185 50	$11,670 25

Water-supply and Use:—From various gaugings of Los Angeles river, made by this department in years past, the summer flow is found to be about one thousand three hundred inches at, and immediately above the diverting dam of the high-service works. Below this point, for a number of miles to the head of *Zanja Madre*, springs rise in the channel which aggregate about two thousand seven hundred inches more. It has not varied greatly from year to year, but has increased, somewhat, subsequent upon the deepening of the channel by the scouring floods of 1884. The city of Los Angeles has always laid claim to the ownership of the entire flow, but this claim was successfully contested by the owners of Los Feliz rancho, and, in a measure, also, by the irrigators under the Feliz and Chavez ditches, in the valley immediately above the corporation limits. Now the city has purchased the rights allowed Los Feliz rancho by decision of the courts, for the sum of $50,000. Thus, the city owns the use of all the waters excepting that belonging to the Feliz and Chavez ditches. By arrangement, distribution in these is made by the city *zanjeros*, but these upper irrigators pay no water rates to the city, and their rights are secondary to those of the city for municipal, domestic, and irrigation service within its limits only.

Irrigation:—The aggregate extent of irrigation at present is about two thousand nine hundred and thirty-seven acres inside the city limits, and eight thousand and fifty acres outside; total, ten thousand nine hundred and eighty-seven acres. This is exclu-

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sive of about three thousand acres irrigated by the city sewage. There are now about one hundred and twenty-five irrigators inside the city, irrigating an average of about twenty-four acres each. The largest irrigator waters two hundred and sixty, and the smallest, of whom there are many, irrigates one half an acre or less. Outside the city the smallest irrigator has five to six acres, and the largest one hundred to two hundred acres, the total number being about two hundred. In 1880 the total irrigation was four thousand nine hundred and twenty-two acres inside, and three thousand four hundred and fifty-six acres outside, the city limits—eight thousand three hundred and seventy-eight acres in all. There were then two hundred and sixty-four irrigators inside and about one hundred and thirty outside. In 1886 the area irrigated inside the city limits had been increased to about six thousand eight hundred and ninety-seven acres, and the number of irrigators to three hundred and thirty-seven; while the outside irrigation reached four thousand two hundred and forty acres, or eleven thousand one hundred and thirty-seven acres in all. This was just at the beginning of the great "boom" of the city property, when hundreds of acres of vineyard and orchard, formerly cultivated, were cut up into town lots, and no longer irrigated. The effect of the movement was to give outside irrigators more water, and the area outside increased in almost precisely the same ratio as it diminished inside. The effect of the recent extensive piping of the *zanjas* will be to still further increase the outside irrigation. The area irrigated by each *zanja* for each of the three years referred to is shown by the following table:

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Zanja.	Acreage Irrigated, 1880.			Acreage Irrigated, 1886.			Acreage Irrigated, 1888.		
	Inside City.	Outside City.	Total.	Inside City.	Outside City.	Total.	Inside City.	Outside City.	Total.
6-1 . . .	170	....	170	92	....	92	50	....	50
1	459	100	559	483	250	733	178	500	678
2	557	1,027	1,584	589	900	1,489	328	1,500	1,828
3	597	789	1,386	732	800	1,532	532	800	1,332
4	581	340	921	678	835	1,513	309	500	809
5	613	200	813	650	427	1,077	168	1,500	1,668
7	520	200	720	250	150	400	398	1,000	1,398
8	174	....	174	201	....	201	4	....	4
8-R. . . .	771	160	931	876	247	1,123	148	2,000	2,148
C. & R. . .	200	300	500	556	200	756	159	100	259
Nichols. .	30	....	30	153	....	153	5	....	5
9-E. . . .	140	140	280	936	250	1,186	254	....	254
9-R. . . .	110	....	110	701	....	701	204	....	204
Feliz . }	....	....	....	....	100	100	} 200	150	350
Chavez . }	....	200	200	....	80	80	}		
Totals . .	4,922	3,456	8,378	6,897	4,239	11,136	2,937	8,050	10,987

A careful estimate made in 1880 gave the following proportions among the five principal classes of crops: Vines, 29 per cent; citrus fruits, 29 per cent; deciduous fruits, 18 per cent; alfalfa, 3 per cent; summer crops, gardens, etc., 21 per cent.

These were the ratios inside the city limits. Outside they were: Vines, 12 per cent; citrus fruits, 20 per cent; deciduous fruits, 20 per cent; alfalfa, 8 per cent; gardens, 40 per cent. The ratios have now considerably changed, as nearly all the newly irrigated land is planted in vegetable garden, and the acreage of that class of crops to the whole irrigated area is about 65 per cent.

History and Water-right:—The old Mission of San Gabriel, the first settlement in what is now Los Angeles county, was established in September, 1771. From that station, ten years thereafter almost to a day, Los Angeles was founded as a *pueblo* under the Mexican colonization laws and regulations. There was a special governmental order directing the establishment of this *pueblo*, and the key note of it was irrigation, as the following translated extracts will show:

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The Pueblo of Los Angeles:—"Before the foundation of the *pueblo* of the 'Queen of Los Angeles,' in the vicinity of the river Porciuncula, and on the land designated to this effect, there should be examined all the lands which may receive the benefit of irrigation, marking the place most proper to divert the water, so that it may be allotted to the largest portion of lands.

"The selection of the place in which the *pueblo* is to be situated should be on land moderately elevated and protected against the north and south winds, caring for the most commodious situation and in the immediate neighborhood of the mother ditch, providing that from the pueblo there can be seen the whole or a major part of the agricultural lands.

"There shall be measured outbuilding lots to so many allotments of land as shall receive the benefit of irrigation; leaving also where lands of cultivation are, a space of two hundred varas between them and the town.

"Each allotment of land, as well those irrigable as those of dry land, must be two hundred varas long and two hundred wide, this being the space commonly occupied in the sowing of *fanega* (a measure of about three bushels) of maize; and the assignment of said allotments (*suertes*) as well as of the building lots (*solares*) must be made to the new settlers in the name of our lord, the king.

"It must be made with equality and proportion by the government to the new settlers, after a preceding proper measurement of the land, which may receive the benefit of irrigation, reserving vacant the fourth part of the same. Then, enumerating the settlers, if there be a sufficiency, there shall be allotted to each one a *suerte* of irrigable land and two of dry land."

WATER-RIGHTS AND CLAIMS:—Under his order, the *pueblo* was founded; and there are, in addition, a large number of references to this irrigation feature of the new settlement, to be found throughout the ordinances and official correspondence of the early days of Los Angeles. It appears that the missions had been a great source of expense to the Mexican home authorities, that the stations did not produce sufficient food for their residents, and that the *pueblos* of Los Angeles and San José were established for the express purpose of promoting agriculture by irrigation, with the view of supplying this food deficiency. There is also some documentary evidence which tends to show that it was the purpose of

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the authorities to give the *pueblo* of Los Angeles exclusive control over the waters of the river Porciuncula, as the Los Angeles was at that time called; and up to the period of American occupancy and rule, the local municipal authorities did exercise exclusive political control and jurisdiction over the affairs of the stream, in the matter of distributing its waters wherever taken out.

Among the first acts of the state of California was the passage of laws ratifying and confirming to the city of Los Angeles those rights and privileges which had been held by the old *pueblo*. This was expressly done in the act incorporating the city, passed in April, 1850; and in an act supplementary thereto, approved in May, 1852, it is written "that the Common Council shall have power, and it is hereby made their duty, to pass ordinances providing for the proper distribution of water for irrigating city lands."

Again, in April, 1854, by an act explanatory, we find the following: "The act of 1850 is to be construed to vest and to leave vested in the Mayor and Common Council of the said city the same power and control over the distribution of water for the purpose of irrigation or otherwise, among the vineyards, planting grounds, and lands within the limits, claimed by the ancient *pueblo* and *ayuntamiento* of Los Angeles, and by the Mayor and Common Council, as the *ejidos*, or commons, of said city, the possession whereof is hereby declared to be in the Mayor and Common Council." (Statutes of 1854, page 205.) Another act, passed in 1857, supplementary to the act of 1850, provides:

SEC. 3. That "the corporation of the city of Los Angeles shall retain all the powers and rights by the former *ayuntamiento* over the public lands belonging to the city, and not included within its present incorporated limits, to lease, sell, or otherwise dispose of said lands, as also to take from the river of Los Angeles the water needed for irrigation of said lands by means of a dam or dams built without the incorporated limits aforesaid; but the corporation shall exercise no municipal authority over said lands, except to regulate the taking and distribution of water as aforesaid." (Statutes 1857, page 329.)

Upon the basis of these orders, ordinances, customs, and laws, it has been contended that the city of Los Angeles was vested with the exclusive ownership of the waters, and of the right to divert and use the waters of the river, for purposes of irrigation.

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The basis of the claim was that, under the Spanish laws, *pueblos* were accorded such rights and privileges, and that in this case the settlement was made and established, not only with all the powers and privileges of the ordinary *pueblo*, but that the very purpose of settlement at this point was the utilization of the waters with which to cultivate by irrigation—that this was a case wherein a special grant of waters, superadded to the ordinary *pueblo* right, was made for the public good.

Los Angeles vs. Baldwin:—This question came up in the case of the City of Los Angeles vs. Baldwin in 1871 and 1874, which cause was finally decided in the lower court, December, 1877, was appealed to the supreme court, and there disposed of in January, 1879. The cause was an action to quiet title to the waters of the river, and wherein the defendant was the successor in ownership to the grantees of Los Feliz rancho, which tract bordered the river of Los Angeles on the west side, next above the city, and where diversions of water were made for irrigation to the detriment of the city supply.

It appears from the findings of fact in the lower court that Los Feliz rancho, which was granted by the Mexican government to Maria Ynacio Verdugo de Feliz and to her son, José Antonio Feliz, in the year 1843, had been in possession of the family about thirty years prior to that time. That the grant was patented by the United States government in February, 1858, and about four thousand acres of it came into the possession and ownership of Leon McL. Baldwin and others, defendants to the action. That during the Mexican rule and jurisdiction, a large portion of the Feliz rancho was considered as being within the pueblo of Los Angeles, and those settled upon it were considered as being residents (*recinos*) of the pueblo, and entitled to rights and privileges as such. That water was taken out of the Los Angeles river for irrigation by some of the forefathers of those to whom the rancho was afterwards granted, in 1816, and used upon the Feliz rancho lands; these acts being licensed and supervised by the pueblo authorities. But that the irrigators had claimed, independent of the city, the right to use the water, and had simply submitted the manner of doing it to the supervision of the municipality, only in respect to its political authority. That the waters were thenceforward, to the time of commencement of the action, used on the rancho, to the extent of "two irrigating heads, that is, a flow of

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eight cubic feet per second," and thereafter up to the time of decision, this use was continued and claim maintained adversely to the city of Los Angeles and to all the world. That the defendants had not taken from the river any more than their fair proportion of water, for the purpose of irrigation or any other uses, and than they were entitled to as riparian proprietors, which was to the amount of "two irrigating heads, or a flow of eight cubic feet per second." That the city had shown no grant of said river or the waters thereof, to itself or predecessors, nor maintained rights thereto, other than such rights as inured to the *pueblo* of Los Angeles, from the fact that the said river flowed through the *pueblo* limit. In other words, that the *pueblo* right was no greater than that of any other riparian proprietor under the Mexican law, as well as our own. That in the matter of appropriation and use, the rancho people had for a long number of years irrigated very nearly as much land as was then being served, and had always used about as much water therefor. But that the city had, meanwhile, extended the area of its irrigations, had brought under its waters lands not before irrigated and not of old thought to be susceptible of irrigation. And that it was continually adding to its works and demanding more water. That of seventeen thousand five hundred acres within the city limits, eleven thousand were, on the new basis, entitled to irrigation; and that the city area of irrigation had doubled within ten years and had trebled within twenty years; while of the eleven thousand acres in the Feliz rancho only four hundred acres were irrigable. And, finally, quoting the words of the court, that "nothwithstanding the said amount of land irrigated has so largely increased, the city of Los Angeles has made no substantial improvement in its works to appropriate said waters, and that its present system of appropriation is very primitive, defective, and inadequate, and that by making proper expenditures and improvement in its system of appropriating the available waters of said river, the said city can have at its disposal more than sufficient water for all its uses, exclusive of the waters used as aforesaid by defendants."

The judgment of the lower court was, that the city, as plaintiff, should take nothing as against the rancho owners, but that these latter should be left in possession of the waters they had been accustomed to use.

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And on final decision by the supreme court, it was adjudged that the city was not the owner of the *corpus* or body of the water of the river, that her claims to its use were not of higher order than those of the rancho owners as riparian proprietors and appropriators, and the judgment of the lower court was affirmed.

Canal and Reservoir Company:—In the meanwhile, in 1868, the Feliz rancho people, defendants in the above cited cause, sold their old ditch to the Los Angeles Canal and Reservoir company, together with the right of way for continuing it through their lands to the city, reserving to themselves the right to use from the ditch all the water necessary to irrigate their ranch lands susceptible of watering. This company was organized as a private venture to supply water, by gravity flow, on the higher lands of the city, theretofore without such service, and had a charter from, or contract with the municipality, authorizing it to divert some certain amount of water on behalf of the city, from the river, for that purpose, and to construct works within the city. This company enlarged the old Feliz upper ditch, continued it into the city, and to reservoir number four, as already described. The city became the lessee of these works from the company and has finally bought them, and has purchased the riparian right of the Feliz rancho and all its water-rights except the right to water sufficient for the old irrigators, from the lower Feliz ditch.

Feliz vs. Los Angeles, and Elms vs. Los Angeles:—Two other cases of importance, involving the city's prior right to use the waters of the river, are those whose titles head this paragraph. These were controversies with the Feliz and Chavez ditches under which the plaintiffs above named were irrigators. It appears that in May, 1879, the waters of the Los Angeles river were unprecedentedly low, and that by reason of the diversion of about one hundred inches by each of these two ditches, the supply was made so short to the *Zanja Madre* that the irrigations in Los Angeles seriously suffered. Whereupon the municipal authorities took possession of the heads of the two outside ditches, turned the waters out of them, down to the city ditch, and held matters in that way for quite a time; so that the outside irrigators brought suits as above, one on behalf of each ditch, praying for injunctions against the city, restraining the authorities from interfering with their water privileges. The first case came up in 1879, was

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decided in the lower court in the same year, was appealed to the supreme court, and there finally disposed of in April, 1881. By agreement, the second case followed it, without separate contention.

The lower court found, in substance: That the *pueblo* of Los Angeles was entitled to all the rights and privileges accorded to *pueblos* under the Spanish laws, regulations, etc., which rights had been acknowledged and recognized by the authorities generally;—That the municipal authorities had at all times claimed and exercised the exclusive right of control over the waters of the river, which right had been acknowledged by the predecessors of the plaintiffs in the causes before the court, and by all parties, including the state authorities;—That only within two or three years prior to the commencement of the actions had the plaintiffs denied the authority and superior claims of the city in this regard;—That the waters of the river were all necessary for irrigation and domestic use in the city of Los Angeles, but had been made necessary as a whole, only within a few years then last past, by the extension of the city's works and irrigations;—That for the then past few years all the waters in the river had not been sufficient for the uses and purposes of the city, including irrigation; and that the city had expended more than $100,000 in works to husband and store the supply;—That the Feliz and Chavez ditches were constructed about 1844, and appropriations of water made through them by the predecessors of the plaintiffs, which water had for years been used by them to about the extent used at the time of commencement of the suits, and that the amount of water used by them was no more than enough for their irrigations and domestic requirements;—But that these uses of waters had, until within about three years then last past, been by permission and under control of the municipal authorities;—That at the time of the conflict in May, 1879, the upper irrigators were not taking any more water than they actually required;—And that by taking the water away from these upper diverters, the city authorities were not themselves taking any more than was required for the city purposes. But as conclusion of law, the lower court found that, as riparian proprietors, the upper irrigators were entitled to the use of the water taken by them, and it rendered judgment in their favor.

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The supreme court reversed this judgment of the lower court, as will be gathered from the following closing paragraphs in its decision: "Thus it will be seen that for nearly one hundred years the city of Los Angeles has asserted a claim to all the waters of the Los Angeles river, and such claim has been recognized by all persons interested from the head of the stream and along its banks, including the plaintiffs and their grantors. We say including the plaintiffs, because it appears from the sixth finding that the use of the waters of the river was under the license, permission, and consent of the defendant, until within the last two or three years.

"It was conceded on the argument that the city had appropriated a portion of the waters of the Los Angeles river, before the plaintiffs constructed their ditches, and that the use by the city to the extent of such appropriation could not be interfered with by any subsequent appropriation; but it was contended that the rights of the city were limited to the amount appropriated at the time the plaintiffs or their grantors built their ditch. Such a construction of the defendant's rights would not be in harmony with the facts found by the court. From the very foundation of the pueblo, in 1781, the right to all the waters of the river was claimed by the pueblo, and that right was recognized by all the owners of land on the stream, from its source, and, under a recognition and acknowledgment of such right, plaintiffs' grantors dug their ditches, and, by permission and consent of the municipal authorities, plaintiffs thereafter used the waters of the river. Can they now assert a claim adverse to that of the city? We think not. The city, under various acts of the Legislature, has succeeded to all the rights of the former pueblo. We have not examined the rights of the defendants as they existed under the Spanish and Mexican laws, applicable to pueblos, for the findings in this case render such examination unnecessary.

"From the fifth finding it appears that when the acts complained of were done by the officers and agents of the defendants, *all* of the waters of the Los Angeles river were required, and were not sufficient to supply the wants of the city; and we are of the opinion that it was the right of the municipal authorities to prevent any diversion of said waters, at that time, by the plaintiffs.

"We do not intend to be understood as holding, nor do we hold, that the city has the right at any time to dispose of the water for use upon lands situated without the limits, to the injury of the plaintiffs or other owners of land bordering on the river. On the contrary, we are of the opinion that the city has not that right. But as observed already, the findings in this case show that at the time of the acts complained of there was not sufficient water in the river for the needs of the inhabitants of the city, and we hold that, to the extent of the needs of its inhabitants, it has the paramount right to the use of the waters of the river, and the further

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right, long exercised and recognized, as appears from the findings, to manage and control the said waters for those purposes."

This decision seems to be in conflict with that in Los Angeles vs. Baldwin, already reviewed. The findings of fact and the conclusions of law arrived at by the lower court appear to have been practically the same in both cases, yet the one was heartily upheld, and the other squarely overthrown, it would seem, without the invocation of other grounds or principles, by the higher court.

This decision, and the purchase of the Feliz rights, before written of, has settled, apparently for all time, the right of the city of Los Angeles to the low-water flow of the river to the extent of municipal requirements and the necessities of irrigation within the corporate limits. For the stream does not course through to lower lands at that stage, and no claimant has ever appeared there for its waters.

DEVELOPMENT OF THE ZANJA SYSTEM:—The Los Angeles city irrigation works are a gradual development from the crudest possible system of irrigation ditches—the old Mexican low-land *zanjas*—and much of the general character of the primitive works themselves, as well as the generic name they bore, adheres to the works of the present day. These remarks, of course, apply more especially to the low-service *zanjas*. The high-service works inaugurated in 1877 have had, from the beginning, somewhat more of system and stability in their planning and their character. But even these, that might be called modern works, have been far from well ordered, and much has been done only to be abandoned, commenced only to be stopped, or planned only to be upset. The pipes and concreted conduits of very recent building are, of course, a long step in advance.

Previous to the year 1877, irrigation from Los Angeles river was confined to the low bottoms bordering the river, and the first bench above the bottoms, which could be easily reached by inexpensive ditches, requiring no engineering skill to lay out and little expense to construct. The irrigated district was almost entirely within the limits of the city of Los Angeles, with the exception of a few farms lying in the bottom-lands above it. The water rarely reached beyond the southerly limits of the city, and its use was attended with much difficulty to outside farmers owing to the great loss in

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transit in the rude earthen ditches of the time. The district commanded was fan-shaped—beginning with the wide end at the lower line of the city, where its spread was some three and one half miles; and then to the upper end of the district its length was about four miles. Its area comprised about four thousand five hundred acres and included all the then settled portion of the town proper, but not all of which was irrigated, by any means. The ditches were open earthen channels of irregular size and grade, flowing in many places and for long distances over porous, sandy ground. On the west side of the river they consisted of the one main ditch *(Zanja Madre)* leading out from a temporary dam or *toma*, and branching into six smaller diverging ditches, known as *Zanjas 1, 2, 3, 4, 5*, and *8*. On the east side of the river were two ditches, known as upper and lower *Zanja 7*, and of the same indifferent character; the former diverted its waters from the same *toma* as *Zanja Madre*, the other diverted at the point now occupied by it—near the Macy Street Bridge.

In 1877, in response to the demand of the people for a more extensive and improved system of works that should cover the hill lands, and more efficiently serve the valley, authorization was obtained for the issuance of city bonds to the amount of $115,000 for the purpose. A board of engineers was called into consultation, and plans were formed for additions to and remodeling the old work. These proposals were, in a way, carried out, and at once enlarged and extended the district commanded to an area of about ten thousand acres inside the city limits. Subsequent improvements in the conduits, and the recent conversion of much of the farming lands into city lots, have diminished the inside irrigated area, but have enlarged and extended the district below and west of the city, in a very considerable degree, until the water is now carried, as we have seen, several miles beyond municipal limits; and, for purposes of sewage irrigation, ditches are constructed several miles farther.

The Modern Works Outlined:—In the matter of increase of available water-supply, this commission recommended the construction of a submerged, or bedrock, dam across the river, either above or below the mouth of the Arroyo Seco, to throw the underflow of the stream to the surface; and the construction of storage reservoirs; but it was not in possession of data upon which to make definite recommendations as to sites and plans, or other than

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rude approximations to matters of cost. Some of the desired data was afterwards obtained, and estimates made. To a very small extent the recommendations of this commission have been followed in the matter of water storage, but the submerged dam in the river has never been built, although it is still looked to by the city's engineers as a thing which will surely come in the future.

In general accordance with the commission's recommendations the low-service works of the city have been improved, and the high-service works constructed. The Canal and Reservoir Company's high ditch was bought and further enlarged, and in some respects altered, down to the head of the pass, as elsewhere described, and is now known as the Main Supply canal or *zanja*. The east-side high-service ditch was built, and water crossed over to it in a flume (the commission recommended a pipe) at a location several miles above the point where the crossing has since been made in an iron pipe, as elsewhere described. The good work done by this commission, and the broad treatment of the subject which they brought to the front in formulating their report, while it has in a general way governed the subsequent planning and construction of the city's irrigation works, does not seem to have been appreciated or heeded, in many important details. Moreover, works recommended by the commission have, by bad construction or subsequent neglect, proven unsatisfactory, and thus its views, sound in themselves, have suffered in the opinions of others. The following instance may be cited as a case to the point:

Prior to 1877 *Zanja Madre* was an open ditch, diverting water from the river by means of a temporary dam, and carrying it along the base of the bluff that for some distance forms the west bank of the river. This section of ditch was difficult to maintain, and wasteful of water. As an improvement, a wooden pile dam was built across the river at its head, and from the dam, to take the place of the exposed ditch, and, in accordance with a recommendation of the commission, a tunnel, three thousand three hundred and twenty feet long, was cut in the soft sand rock of the bluff, a few feet in from, and parallel with the face thereof. This tunnel was intended to be five feet wide, and five feet high from bottom to the top of its arch; but its construction seems to have been made altogether without engineering supervision, as it

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had no regularity of grade or alignment—was most abominably crooked in every way. After a few months' use, it cut out in places, and filled with sand in others, and caved badly because of percolation from the Water Company's ditch, cut in the hill-side overhead. After costly repairs had been made, by partially lining it with brick, it was finally abandoned when a flood carried away the dam, and for some years past the original open ditch and wing-dam diversion have been returned to.

Later Developed Plans:—In January, 1884, when disastrous floods had caused great damage and demoralization to the ditches, the city council appointed another board of engineers to devise a plan for the improvement of the irrigation system, in order that the large expense for annual repairs and cleaning might be reduced to a minimum, and at the same time effect a greater saving of the water. In their report, this board recommended that pipes be laid in all the *zanjas* throughout the city, where not already piped; that the tunnel at the head of *Zanja Madre* be repaired and put in use again, and that *Zanja Madre* be carried in a close brick conduit, from the mouth of the tunnel to First street, and down First street to the river, as an outlet for storm waters; that *Zanja 6-1* on the west side, and *Zanja 7* on the east side of the river be abandoned, and the lands irrigated by them be supplied from *Zanja Madre* and *9-R.*; and that the dams be put in thorough repair. Also that *Zanja 9-E.* be abandoned for the upper seven miles of its course, and an iron pipe across the river be substituted, supplying it from *Zanja C. and R.*, lower down.

This involved the laying of twenty thousand six hundred and sixty-five feet of sixteen-inch pipe, ninety-five thousand six hundred and seventy-nine feet of twenty-two-inch pipe, fifty-three thousand four hundred and thirty-three feet of thirty-inch pipe, twenty-seven thousand two hundred and eighty-nine feet of forty-eight-inch pipe, seven thousand eight hundred and thirty-six feet of twenty-two-inch iron pipe, and twelve thousand feet of brick conduit. The total estimated cost of the proposed improvements was $288,505 75, and if carried out would have effected a radical change in the irrigation system of the city. Provision was made for admitting to the *zanjas* the storm waters of the streets, thus keeping them entirely separated from the sewers. The report was adopted, so far as the work of the pipe-lines across the river and Arroyo Seco were concerned, and these recommendations were

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immediately carried out; but further action was submitted to the council committee on water supply for consideration. This committee reported in June, 1885, recommending that the expenditures be limited to $125,000, and specifying the *zanjas* on which the work was to be done. The recommendation was adopted by the council, and the question of issuing bonds was submitted to popular vote and carried, and bonds were issued as elsewhere explained.

An Old City Irrigation Map:—One of the most interesting records of the archives of Los Angeles is a map hanging in the office of the city clerk, made in 1849, by Lieut. E. O. C. Ord, U. S. A., and William R. Hutton, assistant, under a contract with the *ayuntamiento* (local government) to make a detailed survey and map of the city, for $3,000. On it is delineated the residence and business portion of the city, and the adjacent fields, and, by conventional signs, the vineyards, cornfields, gardens, and pasture lands are shown in detail.

The map shows that the center of population was then on Main and Los Angeles streets, south of the Plaza to First street, and north about an equal distance. Spring street was built up from its junction with Main street to First. On either side a number of rectangular blocks had been laid out in the American fashion by Lieutenant Ord by the survey from which the map was made. The cultivated portion lay between Los Angeles as thus located and the river. Commencing about opposite the present Southern Pacific railroad round-house, and extending south to a point about where an east-and-west line from the intersection of Alameda street and the prolongation of Tenth street would lie between the river and Main street, it did not quite reach to what is now Washington street. The total area of irrigated land was from one thousand five hundred to one thousand six hundred acres; and the cultivations were nearly equally divided between vineyards, corn, gardens, and pastures. The *Zanja Madre* is shown in nearly its present position, following along at the foot of the bench on top of which Main street runs. A branch of it started at about the present site of the Capitol Mills, followed near to and almost parallel with it, and finally reached San Pedro street, which it then followed to near Washington; and another branch *zanja* is shown east of Alameda street, near the river. Nearly the whole of what was then the agricultural district is to-day cut up into lots and built upon, and scarcely two hundred acres of it is now attempted

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to be irrigated. The town has grown over it, and the cultivated lands are, chiefly, miles below.

SECTION II.

Old Outside Irrigations.

Feliz Ditch.

This work takes water from Los Angeles river through the west or left bank, nearly three miles above the city or *pueblo* limits, and serves a little bottom-land district lying between the river and the hills outside the city line. It is owned by a small community of irrigators. Its history is given in tracing that of the Los Angeles works. It is administered, by arrangement, as part of the city system, under control of a *zanjero* appointed by the city council. The extent of its irrigations is given in the table relating to the city irrigations.

Chavez Ditch.

This little work diverts its supply from the river, about a mile above the city line, and delivers it on a contracted and hemmed-in bottom-land tract between the river channel and the bluff, just above the narrows. It is a very old work, and, in common with the Feliz, of the most primitive class. Its rights also are subject to those of the city, as recited in the account of Feliz vs. Los Angeles, already presented, and, like the Feliz, it is administered as part of the city system, although it is owned by the cultivators whose lands it serves. The extent of its irrigations is shown in the table with those of the city.

Sewage Irrigation.

The sewage of the city of Los Angeles, which is ordinarily much diluted and increased in volume by waste *zanja* and irrigation waters, is used in irrigation on the plains below the city, just beyond where the city ditch water utilizations reach. Very much might be said to good purpose on this subject, but the limits prescribed for this report forbid further mention of it now.

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CHAPTER XXIV.—LOS ANGELES[11]; WORKS AND PROJECTS[12].

COAST PLAIN IRRIGATIONS.

CAHUENGA–BALLONA GROUP[7].

SECTION I.—*Cahuenga Cañons Utilizations:*
Lamaria, Brush, Lopez, and Cahuenga Pass Cañons;
Nichols, Kimball, and Coldwater Cañons;
Levering, Benedict, and Beach Cañons.

SECTION II.—*Ballona and other Springs Utilizations:*
La Brea Rancho and Santa Monica Rancho Springs;
La Cienega and Paso de la Tejera Ranchos Cienegas;
Ballona Creek and Ditches;
Aguaje de la Centinela Springs.

SECTION I.

CAHUENGA CAÑONS IRRIGATIONS.

Off the southern slope of the Cahuenga mountains, west of the city of Los Angeles, there come down to the head of Santa Monica plain and to the sea beyond, a number of little cañon drainages whose supplies are claimed and to some extent utilized for the service of local, domestic and small irrigation demand. It has been the purpose to include an account of these in this report, in the form followed throughout; but the necessity for shortening the publication has prompted the setting of this matter aside for briefer entry, with others of its class, in the closing summaries.

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SECTION II.

Ballona and Other Springs Utilizations.

In several depressions or arroyos of the Santa Monica plain, and at the footing of that plain against the Centinela hills, as elsewhere better explained, there are a number of little water-sources of the class called *cienegas*, and which have been referred to in this report, also, as *cienega* springs, and sometimes as artesian springs. A belt of these sources in the ranchos La Brea, Rodeo de los Aguas, and Santa Monica, is found one to three miles out from the mountain's base, and nearly half way down the plain; and another belt lies immediately at the footing of the plain, against the Centinela hills, and in the ranchos La Cienega, Paso de la Tejera, Rincon de las Bueyes, and La Ballona.

These are the reappearance of waters which have sunk during winter and spring freshets into the gravels of the cañons' mouths and mountain edges; and the ones of the lower belt—at the foot of the plain—are probably contributed to in great part by Los Angeles river, as will be maintained in a special chapter on the subject of this class of water-sources, in the closing part of this report.

La Brea and Santa Monica Springs.

The waters of the upper belt of springs are not utilized to any extent in irrigation; in fact, the output is quite small, and the demand for domestic supply and garden waterings will probably preclude the spread of irrigation as this report must view it. The Santa Monica *cienega* is developed and piped for the supply of the town of Santa Monica, and this is the largest development or utilization of this sub-group of sources.

Ballona Creek and Ditches.

Out from the central springs of the upper belt—on the ranchos La Brea and Rodeo de las Aguas—Ballona creek gathers its upper perennial waters, leads them south against the base of the Centinela hills. Here, reinforced by a little stream from the east, draining the springs of the ranchos La Cienega and Paso de la Tejera, it turns west and southwest, parallel with the hill's footing, into the Ballona flats and the sea five to six miles away.

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District; Works; Water-rights:—In the medium part of this southwest course it is bordered on either side by a rich plain of several thousand acres in area, and which, to some extent, it has served in irrigation for a long number of years. The lands irrigated are all within the rancho La Ballona and the waters have for many years been considered as appurtenant thereto. In the partition of the rancho among the individual owners, by decree of court some years ago, certain lands, which are good agricultural lands, and irrigable by ditches diverted from the creek within the limits of the grant, were designated as "first class" lands, and the water was apportioned to them.

A ditch is taken out on the south side, close to the eastern limit of the ranch, and which extends down about a mile, next the base of the hills, irrigating a narrow strip between it and the creek. Another, taken out on the north side, over half a mile below, exceeds three miles in length, and another, taken on the south side farther down, has a total length of over four miles. The south side ditches are both held in a course generally parallel with the stream, and not over three quarters of a mile from it, by the presence of the hill range along whose foot they skirt; while the northward course of the north side ditch is interrupted by the edge of a lower bench of the Santa Monica mesa, against which it rests for a couple of miles. They are all simple earth excavated ditches, ranging in capacity from one hundred to three hundred inches.

Operation and Maintenance:—These little works belong to those who use their waters, and are operated after the general community plan, hereinbefore repeatedly described; and present, in their organization, operation, and maintenance, no special feature of interest or instruction, except that for their kind or class of works they are well kept, and the cultivations under them are evidently much more thrifty than those of primitive works throughout the county, generally.

Water-supply and Use:—The water-supply is fluctuating, sometimes getting as low as two hundred and fifty inches in summer, but usually ranging, during irrigation months of dry years, between three hundred and three hundred and fifty inches, and, in the wetter seasons, averaging about three hundred and fifty.

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IRRIGATION:—In 1880 the total irrigation was, for the first time, reported for the state engineer, at between nine hundred and eighty and one thousand acres. Now we find the north-side ditch irrigating seven hundred and thirty-five acres, largely devoted to vegetable gardens and orchards; cultivated by nineteen owners—the largest individual irrigation being of one hundred and fifty, and the smallest of fifteen acres. The south-side ditch irrigates near eight hundred acres, is worked by twenty-four or twenty-five owners, and cultivated in similar crops. The soil on both sides is a heavy black loam, much more mellow and tractable than adobe. It is very fertile, and, although in places spotted with alkali, is, on the whole, susceptible of the highest cultivation.

The diversions are made at forty to fifty feet above sea-level, and some of the lands served are not over ten feet higher than tide-water. Altogether, this is the lowest irrigation of any importance in Los Angeles county.

Centinela Springs.

South and west of the main crest of the Centinela hills, at the head of an arroyo which, cutting into their western slope, leads around about three or four miles into Ballona creek, opposite the irrigation district just described, is an uprising of waters known as Centinela springs. This is probably an output from the same general artesian source lying east of the ridge, caused by the overlapping of some of the permeable gravel strata through a low sag in the primary hill formation. Indeed, borings, which have been made, quite well establish this idea.

Water-supply and Use:—The springs naturally flowed twenty to thirty miner's inches, and have recently been developed to yield something over fifty inches, as explained elsewhere. These waters were, for a number of years, utilized in a comparatively rude fashion in the irrigation of a mixed orchard, containing about one hundred and forty acres, near a mile away, and to which they were led in a little earthen ditch. Now they are piped into a reservoir and in part pumped to a higher reservoir for the service, under pressure, of the town of Inglewood.

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CHAPTER XXV.—LOS ANGELES[12]; WORKS AND PROJECTS[25].

COAST PLAIN IRRIGATIONS.

LOWER SAN GABRIEL GROUP[8].

SECTION I.—*New River Utilizations:*
Temple Ditch;
Workman Ditch;
Rincon Ditch;
Cate Ditch;
Standifer Ditch;
Banta Ditch;
Los Nietos Ditch;
Little Lake Ditch;
Section Line Ditch;
Agricultural Ditch;
New River Ditch;
Clear Water Colony Ditch.

SECTION II.—*Old San Gabriel River Utilizations:*
Arroyo Ditch;
Repetto Ditch;
Foster Ditch;
San Antonio Ditch;
Cerritos Colony Ditch;
Ryan Ditch.

SECTION I.

NEW SAN GABRIEL RIVER DITCHES.

Above the point where the San Gabriel river left its old channel in 1867–68, and carved out for itself a new channel five hundred to six hundred feet wide, and eight to ten feet deep, through the plains to the sea, and above the mouth of the Puente creek, there are, for several miles, a series of large springs bursting out on the east side of the river bed, whose waters are diverted by

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two irrigating ditches, known as the Old Workman ditch and the Rincon ditches, and which irrigate land east of New river. The water thus diverted is not, properly speaking, from the river above alone, but would add to the volume of that stream below if not diverted by the ditches. Similar springs rise in the channel of New river to augment its volume all the way to the lower coast plain, and furnish supply to the Cate, Standifer, Agricultural, and Bixby ditches on the west or right bank of the new channel, and to the Banta, Los Nietos, Little Lake, Section Line, and New River ditches on the east side. Thus, ten large ditches all carrying considerable streams, in the aggregate irrigating an extensive section of rich and fertile country, are fed by a succession of springs; and, in addition to these, the Temple ditch diverts water, to the west, from the main channel above the junction of Old and New rivers. These ditches will now be described in the order of location of their diversions.

Temple Ditch.

District; Work; Supply; Use:—The Temple ditch diverts waters from the river on the west side above the point of its former dividing, and its supply is used in irrigation in the lower part or basin of San Gabriel valley. Thus, properly speaking, this ditch might have been classed as one of the basin works, and described in Chapter XX, *ante*, but the line of division between these basin irrigations from the river, and those of the pass and coast plain, is so difficult of location, that it has been convenient to rank the Temple ditch as one of the lower-river works, notwithstanding the fact that they relate more especially to the coast plain and not to the valley districts. The head of the Temple ditch is about four miles above the narrowest part of the pass outlet of San Gabriel valley, and a short distance below the Southern Pacific railroad crossing. Its length is about four miles; its character that of a simple earth excavated ditch; its capacity, about two hundred to two hundred and fifty miner's inches. It now irrigates three hundred to four hundred acres of land lying west of the river, and for the most part within the Ranchos Felipe Lugo and Merced. There are a dozen or more irrigators, all but two of whom are tenants on the ranchos named. The cultivation is for the most part of summer crops and alfalfa. The ditch was built in 1854 by Mr. Temple, the former owner of the rancho property.

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Workman Ditch.

District; Work; Supply; Use:—Like the Temple ditch, the Workman ditch is a diversion made well within the limits of San Gabriel valley, and might, with propriety, have been ranked as one of the basin group. It takes waters half a mile or more below the Temple ditch, and a mile above the pass opening, and delivers them to a district within the pass, on the neck of land lying between the river and San José creek, where the soil is very light and sandy. The work is about three miles in length, is a simple earthen ditch of the crudest order, and has a capacity for about two hundred to two hundred and fifty inches. It is the property of the owners of the Puente and Paso de Bartolo ranchos, and is used by tenants, principally native Californians, on these two properties. It irrigates about three hundred and fifty to four hundred acres, planted principally to corn and other summer crops. It was built in 1877 by Mr. Workman, the former owner of the Puente rancho.

Rincon Ditch.

District and Work:—The Rincon ditch takes supply from springs rising under the east banks of the main San Gabriel river channel, a little more than a mile above the head of New river channel, in the pass, and just abreast of the district served by the Workman ditch; carries them around the east side of the pass, and serves a district lying at the base of the hills just below the pass, and immediately south of the river, and at the upper irrigable edge of the coast plain. Its total length is nearly six miles. Its first mile and a half is through a bottom-land formation of very sandy soil; crosses San José creek by a flume, thirty-six inches by eighteen inches, one hundred and forty feet long, and on trestles twenty feet high, and then, for the remainder of its length, is in firm red mesa soil. It is about four feet wide on the bottom, and carries one and a half to two feet depth of water, on a light grade, and with a delivery of about five hundred and fifty to five hundred and eighty miner's inches—ranked as three good irrigating heads. In 1880 it was accredited with one head of one hundred and forty-five miner's inches.

Operation and Maintenance:—This ditch is controlled by an unincorporated association of irrigators, embracing the owners of

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the unsold portion of the Ranchito, or Paso de Bartolo rancho, and four independent landholders, who purchased subdivisions of the Ranchito. The land when sold was guaranteed water for irrigation. The owners appoint three commissioners, who attend to the affairs of the association, appoint a *zanjero*, and see to the repairs of the ditch. These commissioners make an allotment of one irrigating head for twenty-four hours to each twenty acres, at every rotation—which is made in twelve to fourteen days. In 1880 the irrigating year was two thousand one hundred and sixty hours in duration, and is the same yet. The *zanjero* is allowed $1 per day per head of water, and collects it himself. This is the only charge made. The average cost is about 50 cents per acre per annum for *zanjeros'* fees.

Water-supply and Use:—In 1880 this ditch irrigated about four hundred acres; in 1888 the area irrigated is about five hundred and eighty-six acres, and the total having water-rights in the ditch is about seven hundred. Of the irrigation, about five hundred acres are in corn, barley, and potatoes; sixty acres in alfalfa, eight acres in citrus orchard, and eighteen in garden.

History:—The ditch was built by M. Strong, in 1871. It was at first taken out from Puente creek, above the Puente mill, and carried along the right bank of the creek to near the mouth thereof —crossing over it by a flume. This flume was once destroyed by jealous irrigators in the Los Nietos settlement, and immediately rebuilt and used under guard. After the first year, the head was changed over to the river, where it now is.

Cate Ditch.

District and Work:—The Cate ditch takes water from about the junction of New with the former head of Old river, and serves a district about three miles in length, and less than a mile in width, lying down the middle of the neck between the two channels. It diverts from the west bank of New river, follows the channel of Old river for a short distance, and then out on to the bottom-lands between. After reaching the irrigable belt, it follows along on a sandy ridge on the highest part of the land, on the west side of its district, and from the very porous nature of the soil loses, it is thought, full a third of its waters. The main ditch is about four and a quarter miles long, and there are about

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two miles of main branches. Its capacity in the upper portion is reported, in 1888, at about eight hundred miner's inches. In 1880, it was reported at five hundred and seventy-five inches.

Operation and Maintenance:—This work is a community property held by a number of irrigators, and managed by a board of three commissioners, elected by the irrigators annually, and serving without pay. They go over the ditch in spring, see what is necessary to be done in the way of cleaning, and order the irrigators to come, or to send a man each, to work one day for every forty acres owned, or pay an assessment to meet the expense, at the rate of $2 per day. The amount of the assessment increases in the ratio of the distance the irrigator lives from the head of the ditch—on the thoroughly established principle that no irrigator can be required to work on the ditch below the head of his lateral, but must work *pro rata* with the others above that point. The cost of maintenance and repairs is about $300 annually, and of the *zanjero's* fees about the same—making a total of $600—an average of 46 cents per acre, which is the total cost of water to the irrigators.

Water-rates; Cost; Heads:—The cost of water to the upper irrigator this year, on one hundred and fifty acres, including repairs and *zanjero's* fees, was $25, or 16⅔ cents per acre. Being the first irrigator on the ditch he has least to pay for cleaning. It cost the lowest man about $1 per acre. The net delivered flow, ranging between four hundred and say seven hundred inches, is divided and apportioned in two heads, at the rate of one head for thirty minutes per acre, at each rotation; the round being made about every twelve days. A skillful irrigator with the large head of water here used can irrigate twenty-five acres of corn in twelve hours. The management is simple, and everything works in harmony, there being no internal dissensions, and no conflicts with outsiders. The irrigation season is two thousand one hundred and sixty hours in duration. This reference to the length of the season in measure of hours instead of days, of course grows out of the division of water by hours.

Water-supply and Use:—The river's flow at the head of the work except in flood is very uniform. The ditch diverts it all during the driest months. It amounts to eight hundred to one thousand miner's inches.

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IRRIGATION:—In 1880 it was reported that there were twelve irrigators and about one thousand two hundred acres watered by this work. In 1886 there were one thousand two hundred and sixty acres irrigated. The total area irrigated in 1888 is about one thousand three hundred acres, of which about nine hundred acres are devoted to corn, two hundred and fifty acres to alfalfa, and the balance chiefly to walnuts, with some deciduous fruits, and a few citrus fruits. There are seventeen American shareholders, or owners of water-rights, in the ditch, irrigating about one thousand acres, besides a number of Mexican tenants on the Ranchito lands, irrigating to the extent of three hundred acres. The largest individual irrigation is two hundred and fifty acres, and the smallest five acres.

History:—The ditch was built, substantially as at present, in 1868, by J. W. Cate, and has gradually become a community ditch.

Standifer Ditch.

District and Work:—This ditch heads about three fourths of a mile below the Cate ditch, at the narrowest part of the pass, and serves all the land lying between the district of the Cate ditch and New river channel, as also a tract south of the Cate district, extending west almost to Old river channel. Its total length is about three and a quarter miles from the dam to its terminus at the Stockton ditch (near River station, on the California Central Railroad), into which its waste waters occasionally empty. Its alignment is very straight. It has one main branch, starting off two and a half miles from the head, and having a length of one and a half miles. Its grade is about ten to twelve feet per mile, and there are occasional drops. The capacity of the ditch is "two irrigating heads," approximately ten or eleven cubic feet per second, or five hundred to five hundred and fifty miner's inches. The soil near the head is very sandy, but through the greater portion of its course it is a sandy loam of firm quality, through which the loss by percolation is not as great as in many other ditches, but is, nevertheless, considerable.

DIVERSION; JOINT WORK:—It takes water from the river by the aid of a joint dam with the Banta and Los Nietos ditches which are situated on the east side of the river. This is done under a special agreement between the irrigators on each side, by the

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terms of which the water at that point is divided into four irrigating heads, one of which is apportioned to each of the three ditches, and the fourth is alternated between the Standifer and Banta ditches, flowing five days in the week to the former, and two days to the latter.

Headwork Dams:—The dam is formed after the usual fashion of willow stakes driven into the sand, interwoven with willow brush, and packed with an embankment of sand put in over the brush. It is partially or wholly destroyed every winter, but is replaced when the water lowers, at slight expense. All of the diverting dams on both Old and New rivers are of the same general character. They do not raise the water more than a foot or two. Sometimes they are made high enough to divert all the water for a little way into the ditch, and any surplus is returned to the river through a side gate below the dam. Other, simpler constructions, do not extend all the way across the stream, but are mere wingdams that lead a portion of the water into the head of the ditch.

Operation and Maintenance:—ADMINISTRATION:—The works are owned and controlled by irrigators who have a simple neighborhood association. They meet annually and elect two commissioners who act in coöperation with one commissioner elected by the Banta ditch owners, across the river. These commissioners select a *zanjero*, and levy assessments on the irrigators for cleaning and maintaining the ditch, payable either in money or in labor.

Distribution; Water-rights; Heads; Periods:—The only charge for water is the *zanjero's* fee, 6 cents per hour per head of water served out. The cost of the first spring cleaning is 5 to 30 cents per acre—the latter being about the cost to the lowest man on the ditch. The second cleaning costs about two thirds as much. *Zanjero's* wages amount in all to $200 to $300 per annum. The average annual cost of water to the irrigator is about 40 cents per acre, including everything. The allotment of water in the irrigating season is one head for twenty minutes to each owner (?), at each rotation—the period being twenty to thirty days, and the irrigating season two thousand one hundred and sixty hours. From September to June no *zanjero* is employed, and every one is at liberty to help himself as he likes. The water is not measured at

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all, but the ditch is crowded to its full capacity during the irrigating season. The heads are said to be one hundred and twenty-five to one hundred and fifty miner's inches, but are actually nearly double that quantity.

Water-supply and Use:—Although as before stated the Cate ditch leaves the river dry after its appropriation is made, the stream is reinforced by springs and by the volume received from the never failing discharge of Puente creek, so that in the one and a half miles to the Standifer-Banta dam, it has become a stream flowing at its minimum one thousand two hundred to one thousand five hundred inches—and in the spring and fall the flow is little short of two thousand inches. Water-supply has been good since the flood of 1884. About 1877 to 1880 it was very short.

IRRIGATION:—The total area irrigated or entitled to water is about one thousand three hundred acres. The irrigators number thirty in all, owning from ten to three hundred and twenty acres each, the majority having less than fifty acres. The cultivation is divided about as follows: English walnuts, seven hundred acres; orange orchards, fifty acres; corn, three hundred acres; deciduous orchards, eighty acres; and summer crops of all kinds, one hundred and seventy acres. It was reported in 1880 that there were sixteen irrigators under this ditch, and one thousand three hundred acres irrigated, but it would seem that this latter figure must have been in error. In 1886 there were twenty irrigators and one thousand two hundred and sixty acres irrigated. The district is a very prosperous one, the arms and orchards are neat and thrifty in appearance, and the soil is rich and generous in its yield. It requires an abundance of water, and has it—although more is used than is absolutely essential.

History and Water-right:—The ditch was made in 1871, by the settlers who purchased lands of Pio Pico on the Rancho Paso de Bartolo. The land had been cultivated and irrigated for many years, but in a very perfunctory, unsystematic way by the Mexican owners. It inherits the right acquired by prescription and riparian ownership from the rancho. The owners of this ditch successfully resisted the law, by which the control of all the ditches of the district was given to a board of three commissioners. The law and case will be reviewed in a subsequent chapter of this

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report relating to irrigating districts. After the decision was rendered all the irrigators on the Standifer and Banta ditches signed a compromise agreement by which the division of the water was made in the proportions stated. This compromise is a matter of record, and the irrigators say that by it the water is made a part of the realty of the land, and is referred to in all transfers of real estate. By this agreement it was stipulated that any one stealing water should be fined $50.

Banta Ditch.

District and Work:—The district watered by this ditch comprises seven hundred and fifteen acres—to which the rights under the ditch are confined—lying on the east of New river, on the Rancho Paso de Bartolo, and immediately below the lands served by the Rincon ditch. Its length is about three miles, including one and a half miles maintained in common with Los Nietos ditch. Its capacity is about one thousand five hundred inches at the head. The average width is five feet, carrying about two feet depth of water; on a grade of five feet per mile. It has five short branches or private ditches, each a quarter to three quarters of a mile long.

Operation and Maintenance:—This is a community property, having the simplest form of organization—an association held together by mutual consent of members, and delivering water only to themselves. The water is divided on a rotation of fourteen days, at the rate of one head for twenty-four hours to each forty acres. No water is sold. A *zanjero* is employed only in the irrigating season, and paid by each irrigator as he receives water.

Water-supply and Use:—The "head" in daytime is never less than about three hundred inches, June and July. In August, the supply begins to increase, and at times the "head" has reached to six hundred and forty-four miner's inches by actual measurement. Supply has been abundant of late years, but about 1877 to 1880 was disastrously short. There are fifteen irrigators, and cultivation is about as follows: Alfalfa, one hundred acres; corn, and young orchard, four hundred acres; oranges, five acres; walnuts, one hundred and ten acres; and summer crops, one hundred acres, making a grand total of seven hundred and fifteen acres. The district consists of very rich productive soil, of the best sandy

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loam, midway between mesa and bottom-land soil, and has a well-kept, thrifty appearance.

History and Water-right:—The ditch was built in 1867 by P. Banta, to irrigate one hundred acres then owned by him, and its use gradually extended to the limits of the present district. Occasionally waste-waters have been allowed to run down to farmers on the Santa Gertrudes rancho adjoining, but the Banta owners are very jealous of their claims, and to check any tendency to establish adverse rights in the ditch by prescriptive use, will sometimes arbitrarily shut off the water, and turn it back into the river, rather than let it be used below. They have received propositions from these lower landowners, offering to pipe the whole ditch and supply them with all they want, free of expense, as consideration for the right to use the surplus waters. Similar overtures have been made to Los Nietos and the Rincon ditch owners above, but there is such a general fear that they may lose their rights in some way, or that they may be enjoined by lower appropriators, considering themselves aggrieved if any surplus was not sent down the river to them, that no such agreement has yet been possible.

Los Nietos Ditch.

District and Work:—This ditch formerly took its rise a mile or more lower than the head of the Banta ditch, but the floods of 1884 washed out the bluff bank along which it was carried, and its owners made an arrangement with the Banta ditch owners to join with them in the enlargement of their ditch and thus to carry their waters together for one and a half to two miles. Below the junction it consists of two main branches, each about two miles long, and each with a capacity for "one irrigating head." The district specified in the incorporation of the ditch covers an area of one thousand five hundred acres; the soil of which is a fine red clayey loam, strong and tillable, and, with care, well adapted to irrigation.

Operation and Maintenance:—For a long number of years this work was owned as a simple community property and operated on the crudest plan. Its interests were incorporated in 1885 on the basis of one thousand five hundred shares. Of this number about one thousand three hundred have been subscribed and issued to stockholders. These shares are not transferable out of

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the district. It is a close corporation for the division of water only among its stockholders. Under the by-laws individual irrigators are entitled to one head of water for twenty-four hours for each forty acres, at each rotation, or in that proportion, and the rounds are generally made in twelve to fourteen days. Assessments for maintenance are limited by the by-laws to 10 per cent per annum. The only charge for water is the *zanjero's* fee of $2 per "head" per day. The cost of maintenance in the past five years has been $5,500—including some cost for right of way and for reconstruction of the head of the ditch. The average cost per acre has thus been about $1 per acre per annum, all expenses included. The officers of the company are five directors, and a secretary and treasurer who receives $40 per annum for his services.

Water-supply and Use:—The same remarks as to water-supply apply here as have been made for the two preceding ditches—seeing that they all head at the same place, and have always headed within a mile of each other.

IRRIGATION:—The total extent of irrigation in 1888 is about one thousand acres, which are cultivated as follows: Corn, five hundred acres; alfalfa, two hundred; vines, one hundred and eighty; oranges, twenty; and walnuts, one hundred acres. The extent of irrigation in 1881 was found to be about seven hundred and eighty acres, and was reported at one thousand one hundred in 1886, but it is likely this last was in error. The irrigations are not well regulated. Ditches and fields grow up with weeds—water standing in the roads and pools over the land, fields of "coldsour" land from careless and excessive irrigation and waste of water—all betoken the character of farming done in a primitive way. There are exceptions to this rule, and some thrifty, prosperous looking orchards and gardens are seen. But on the whole, there is every evidence that water is too abundant to insure good use of it by the methods employed.

History and Water-right:—This ditch was built over fifty years ago—some persons say over sixty—by Don Pio Pico, grantee of the Rancho Paso de Bartolo. It has been extended from time to time and gradually become a community property, from the condition of an individual property used by renters. For a long time

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it was controlled by a simple association of irrigators. The present incorporation was formed in the last part of 1884 and consummated in 1885, under the name of Los Nietos Irrigation Company, with a capital stock of $15,000 divided into one thousand five hundred shares.

Little Lake Ditch.

District and Work:—This ditch takes water to about one thousand acres of land lying east of New river and north of the Santa Ana branch of the Southern Pacific railroad, and commencing half a mile or more below the district served by Los Nietos ditch. Its total length is about three and a half miles, and it is reported as sometimes carrying "two good irrigating heads" (two hundred miner's inches each), though the owners claim but one. This ditch is taken out at the California Central railroad crossing, three miles below the head of the ditches last described, on the west side of the river; whence, it follows the west bank for about a mile, and crossing over to the east side in a flume nine hundred feet long, four feet wide, sixteen inches deep. It has a reported capacity of about thirteen cubic feet per second, or six hundred and fifty miner's inches.

Operation and Maintenance:—The ditch is owned by an association of eighteen stockholders, and the stock is divided into eighteen shares, a share representing forty acres. A number of the stockholders have sold a portion of their original interest and hold half a share, while others have as much as two and a half shares, but the number remains the same. As they ordinarily have an abundant supply for their purpose hey allow some outsiders who are not stockholders to have water for irrigation, so that the area actually served is more than the seven hundred and twenty acres supposed exclusively to be entitled to service. Some of the shareholders also flood more land than the shares they own really entitle them to irrigate. The stockholders meet annually and elect officers for the ensuing year and apportion the water. The three directors examine the ditch, decide on the proportion of work to be done by each shareholder, to clean and repair it for the coming season, and appoint a *zanjero*, who is paid $1 per day for managing the distribution.

DISTRIBUTION;—*Water Costs:*—The directors usually make an assessment in money for the necessary repairs and maintenance,

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but those who prefer can pay the assessment in work. The average cost for several years past has been $35 to $37 per annum per share. The cost to the irrigator for water, including *zanjero's* fees, average from 75 cents to $1 per acre per year. Water is apportioned by schedule in proportion to stock ownership; and the rotation is made every eighteen days. The supply of water being sufficient, there is no contest with other appropriators, and there is apparently no lack of harmony among the Little Lake people themselves.

Water-supply and Use:—The district is occupied largely by stockgrowers owning fine herds of Holstein cattle. Alfalfa and corn are the principal crops, and but little fruit is grown. The land is a firm, sandy loam, and not high, which does not absolutely require irrigation to mature its crops. Because of this fact, during 1883 and 1884, the ditch was not used, but gophers made such inroads on the alfalfa that a return was necessary to summer flooding, more to drown them out than to irrigate for moisture. The irrigation is conducted with very little system and in a very wasteful manner.

History; Little Lake:—This ditch was built in 1869 as a community property, and has been so held ever since. The Little Lake, from which the ditch takes its name, is about five acres in extent, and is maintained by springs. Its existence out in the plains is quite remarkable. A depression, occupied by *cienegas* grown up with tules, extends from the lake for nearly two miles, to the river. It suggests the possibility of quite a development of water by draining the lake.

Section Line Ditch.

District; Work; Supply and Use:—This ditch serves a district of about five hundred acres lying between the Little Lake country and the river. It diverts about half a mile below the head of Little Lake ditch; is itself about three miles in length, and carries one good irrigating head of about two hundred miner's inches. It is owned by a community of irrigators clubbed together in an organization somewhat similar to that of the Little Lake association, and the total water-right ownership is divided into sixteen and one half shares of twenty-four hours each. No limit is placed on the number of acres a shareholder may spread his water-right

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over. The repairs and maintenance of the ditch are attended to by the irrigators themselves. No *zanjero* is employed. The round of watering is made every sixteen and one half days. The water-supply is rarely short, and it is reported that there is usually more than enough. The total acreage irrigated is about five hundred acres, in corn and alfalfa. The ditch was made in 1869.

Agricultural Ditch.

District and Work:—The district watered by this ditch lies southeast and east of Downey City, bordering on the west bank of New San Gabriel river, and opposite to that served by the Section Line ditch. The ditch diverts about at the bridge on the highway to Anaheim from Los Angeles, and a mile below the head of Section Line ditch. With its main branch, it has a total length of four and one half miles. Its width on the bottom is about three feet, on top seven feet, carrying, as a maximum, about two feet depth of water on a grade of six to eight feet per mile. Its greatest capacity is stated at two irrigating heads, but as it can carry actually about sixteen cubic feet per second, or eight hundred inches, the size of the head is rather large. They are thought by the irrigators to be two hundred to three hundred inches, usually. The soil over the district is very sandy, and the loss in transit is very great.

Operation and Maintenance:—The works are controlled by an incorporated association of irrigators delivering water only to themselves; each share in the company represents the run of a head of water for one hour, and each shareholder owning forty acres has twenty-four "hours," or twenty-four shares. The only charge for water is the *zanjero's* fee of $2 per day, and the cost to the irrigator is his *pro rata* of the expense of maintenance. This expense amounts to about $1 50 per share per annum, and as there are eight hundred shares issued, the total annual cost is $1,200, or 85 cents per acre of the total area irrigated. The management is in the hands of a board of five directors, one of whom, the secretary, receives $40 per annum for his services. The *zanjero* is employed only in the busy irrigating season, during July, August, and September. The temporary dam at the head, and the flume about nine hundred feet long, leading from it along the bluff bank of the stream, is replaced annually at a cost of about

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$400. The flume is usually removed every fall and laid aside before floods destroy it.

Water-supply and Use:—The water-supply of late years is reported as being never less than three hundred inches. In 1880 it was reported that ditches diverting at this point had not had any summer supply for several years. This subject will be discussed elsewhere. The total number of irrigators is now about forty—the largest shareholder having forty-eight shares, and the smallest five shares. The total area irrigated is about one thousand four hundred acres, cultivated about as follows: in alfalfa, five hundred acres; corn, three hundred; orchards, fifty; and summer crops, five hundred and fifty.

History and Water-right:—The ditch was built by the irrigators in 1869, and managed in a haphazard way until 1885, when the parties interested decided to incorporate, and make a new filing on their water. A claim to eight hundred inches was posted and recorded, but the appropriation has probably never equaled the amount of the claim. They have had no conflict with others, no lawsuits, and no special internal dissensions. The Agricultural Ditch and Water Company was incorporated in May, 1885, with a capital stock of $10,000, divided into two thousand shares.

New River Ditch.

District and Work:—No appropriation or diversion of water is made below the head of the Agricultural ditch for about two miles, to the Southern Pacific railroad bridge, and here the New River ditch is taken out on the east side to supply a district next the river, and nearly three miles long by about one mile wide, and lying all within the artesian belt heretofore described. It is nearly four miles in length, is six to eight feet wide on bottom, and holds about one and a half feet depth of water, on a grade which is quite irregular, but does not exceed about five feet per mile. It carries, in local parlance, "two irrigating heads."

Operation and Maintenance:—It is managed by an incorporated association of irrigators, consisting of thirty-three shareholders, owning one to five shares apiece—each share representing a water-right for twenty acres. The total number of shares in the ditch is ninety-six, covering one thousand nine hundred and

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twenty acres. According to the by-laws of the company, the shareholders may sell their water to each other, but no individual may sell to outsiders. This power is reserved to the board of directors, who may and do sell, on company account, any surplus water, for which there is a demand, to parties lying outside the district, using the receipts to meet current expenses.

DISTRIBUTION:—*Water Costs:*—The amount or price of these sales is not uniform, and would be of little significance here. The cost of maintenance is about $15 per share per annum to those who use the water, and as less than half the shareholders irrigate their lands at all, or if any, but a small proportion thereof, the total amount of expense is not definitely known. Say $600 to $700 per annum. This is chiefly for cleaning the ditch, and for restoring the wingdam across the river. A *zanjero* is employed only in summer to turn on the water to those who need it. The officers of the company consist of a board of five directors, and a secretary, all acting without pay.

Water-supply and Use:—Prior to the flood of 1883–84, there was a decided scarcity of water for this ditch every summer, and the river was not infrequently dry, or practically so, during summer months at the head of the ditch. The freshet in the spring of 1884 greatly endangered the railroad bridge, and for its protection the railroad company hauled in a quantity of rocks, which were dumped around the piles of the trestle. These all sank out of sight in the quicksand—a clay bottom underlying at twelve to fifteen feet, it is said—and after that time the flow of the stream greatly increased. Indeed, the ditch has never been without a full head since—even when canals above are short of supply, and in the driest months of the year. The increase is attributed by local observers solely to the work of rock dumping across the channel, forming a sub-dam which throws the waters to the surface. The amount of water claimed is two full irrigating heads. The ditch now receives about two hundred and eighty miner's inches, perennially, which is its full capacity, and this is divided into two heads, in distribution.

IRRIGATION:—In 1880 there were twenty-nine irrigators and five hundred and ninety acres irrigated under this ditch. There was a rapid increase from 1884 to 1886, since which latter year the cultivation has remained about the same. The aggregate

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area irrigated now is somewhat less than one thousand acres, probably not to exceed nine hundred; chiefly devoted to alfalfa and corn, about two thirds of the former to one third of the latter. The smallest irrigation is of about ten acres, and the largest one hundred acres. There are thirty-three irrigators all told. The lands are naturally quite damp. Surface water stands at six to seven feet below the surface, and hardpan subsoil is but fourteen to fifteen feet down. Many of the farmers do not irrigate alfalfa at all, or only occasionally, to kill off gophers, and the use of water is ordinarily for second crops of corn, potatoes, and grain.

History and Organization:—This ditch was originally constructed in 1869 or 1870, and was known as the Washburn ditch. For a number of years it was owned and operated as a simple community or partnership property, and the number of its owners gradually increased. Its ownership was incorporated in May, 1883, under the name of the New River Ditch Company.

Irrigators' Troubles:—The company have had no conflict with other claimants over water-rights, but internal dissensions are not infrequent. As one of the farmers remarked: "If you want to git at the ornery, contrairy side of men jist you git into a water company." There are all sorts of things to wrangle over in a ditch association, and one of the most fruitful is the amount of work each irrigator is to do on the ditch. The same rule is applied here as in all of this lower San Gabriel region—each irrigator helps work all the ditch from the head down as far as his farm, and no farther. "The lowest man is out of luck," and has to do the most work. Now, if A, living near the head of the ditch, should sell his run of water to B, a lower owner, the water has to pass through a portion of the ditch which A has not assisted in repairing or cleaning, and the neighbors then raise the question as to A's right to receive a benefit in that way without working the ditch as far as he sells the water. Petty quarrels and jealousies of this nature are not confined to this ditch by any means.

Clearwater Colony Ditch.

District; Works; Claims:—About two and a quarter miles farther down the river is the head of a new ditch built this fall to carry water to the Clearwater Colony tract on the west side of the San Gabriel river. Only about half a mile of the work is new,

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the remainder being an old ditch built many years ago by J. W. Bixby to irrigate the lands now forming the colony. The ditch is about three miles long, three feet on bottom, ten feet on top, carrying two feet depth of water, on a light grade not exceeding three feet per mile. The soil is very sandy, and will require a large supply to run through the ditch. It is not expected to serve as a perennial ditch, and will be used chiefly in winter and spring when the water is not required above. The cost of the new work was $200 to $300. A claim has been filed to one thousand five hundred miner's inches for this work.

Water-supply:—When visited last be ore the rains set in, there was flowing past the head of the ditch not less than five thousand miner's inches, which must have extended through to the sea. The river at that point is about three hundred feet in width, and carrying from four to sixteen inches depth of water over the whole width.

SECTION II.

Old San Gabriel River Ditches.

The old channel of San Gabriel river furnishes water through the year to the Arroyo Repetto, Foster, San Antonio, Ryan, and Cerrito Colony ditches.

Arroyo Ditch.

District and Work:—The Arroyo ditch derives supply from the Old river channel at a point about a mile and a half below the pass, and about a mile and a half above the California Central railroad crossing, and serves an extended district of country lying between the two river channels, below the Standifer ditch and extending to and below Downey City, a length of nearly five miles.

Canal and Structures:—The canal, diverting on the east side, follows, approximately, parallel with the river, and about a quarter mile distant from it, until it crosses the California Central railroad, where the Sandridge ditch branches from it to the eastward; thence it continues farther from the river, crosses the Southern Pacific railroad about a mile west of Downey City, and terminates about a mile below the south line of the Santa Ger-

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trudes rancho; its total length being about seven miles. For the first one and a half miles its width on bottom is seven feet, and it carries at the maximum about two feet depth of water, on grades between five and fifteen feet per mile. For the first two thousand seven hundred feet, crossing the bottom-lands from the river to the low bench bordering the bottoms, the grade is very light, and the banks are built up on each side to carry the greatest possible volume on this light grade. At the end of this distance the canal is carried across an arroyo by a flume about one hundred feet long, forty-eight inches by twenty inches, at the upper end of which is a waste or sand gate, consisting of two gates six feet wide each.

Flume; Pipe-line:—From this gate a second flume fifty-four inches by twenty-four inches, diverging slightly from the main flume crosses the arroyo, and terminates in an asphaltum pipe, laid four to five feet below the surface, and generally parallel and close to the line of the canal, for a distance of five thousand six hundred and eighty feet, to the head of the Sandridge branch ditch. This pipe starts with a diameter of thirty inches for three hundred feet, then twenty-six inches for three hundred feet, then twenty-two inches for the remaining distance. At its terminus it is about four feet below the surface, and its total fall from its head to grade in the head of the Sandridge ditch is four and three quarters feet, or about eight and three quarters feet from the head of the pipe to grade at its own extreme lower end. It was designed to carry all the water of the canal, and be a substitute for it for that distance, but proved to be too small as it would deliver but three hundred and twenty inches. It was laid in the spring and summer of 1887, at a cost of about $860.

DISTRIBUTION WORKS:—*Ditches*:—The canal has four main branches, viz.: the Sandridge ditch, about three miles long; the Stockton ditch, a branch of the Sandridge, about two miles long; the Taylor ditch, which follows closely along the bank of the river on the highest ground, and is about two miles long; and the Cochran ditch, which, with its two branches, is about five miles long. Each of the branch ditches has a capacity of "one irrigating head." They are about three and one half feet wide on bottom, and carry six to ten inches depth of water. There are in all thirty-six laterals whose aggregate length does not fall much short of fifty

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miles. The soil throughout the district over which the ditches run is a light, sandy loam in which there is a great loss of water by percolation.

COST OF WORKS:—The original actual cost of the works cannot be stated. They are the simplest character of earthen ditches, easily thrown out with the plow and scraper, and built from time to time by the irrigators themselves. The pipe-line, as stated, cost $8,600.

Operation and Maintenance:—The works are controlled by an incorporated association of irrigators, to the number of one hundred and twenty-five, together with fifteen individuals who do not act in unison with the incorporated company. These refuse to recognize allegiance to the corporation, or be governed by its laws and regulations, help themselves to water when they want it, pay no water-rates or assessments, and act entirely independently.

DISTRIBUTION:—*Heads; Periods; Costs*:—The company's stockholders get water on an allotment of one head of water for thirty-six minutes per acre, every run. The runs are made usually in about thirty days. The charge for water is simply *zanjero's* fees or wages—8½ cents per head per hour, or $2 per twenty-four-hour run. The average annual cost of water to the irrigator, including the labor of cleaning and repairing ditches, and *zanjero's* wages, is estimated liberally at 45 cents per acre. The irrigating season is two thousand five hundred and twenty hours' duration. No schedules are made out, but the *zanjero* notifies each irrigator a day in advance that the water is about to pass him, and if he wants it he must prepare to use it, and can get it turned to him by paying the *zanjero's* fees. Two *zanjeros* are employed, but only in the busy irrigating season. At other times the ditch is supposed to care for itself, and everybody takes what he wants. Water is not measured at all, but roughly divided into three irrigating heads, which are supposed to be one hundred and fifty miner's inches, but are in reality often about double that amount.

ORGANIZATION:—The officers are five directors, one of whom is president. They hold meetings monthly, on the second Tuesday in each month, and each receives $2 50 per day for each meeting. A secretary, receiving $10 per month, and two *zanjeros*, who get $2 per day, as they can collect it from the irrigators, complete the

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list of employés. The cost of operation and maintenance can only be roughly estimated at about $2,000 per annum, of which more than two thirds consist of labor of the irrigators themselves—as they turn out to repair and clean their ditches.

Water-supply and Use:—At the lowest season of the year, the supply at the head of the ditch is about one thousand two hundred inches, with which supply seven hundred inches would be due to the Arroyo Ditch and Water Company. When the water reaches this low stage, in June and July, it is divided into two irrigating heads. Later in the season, say from October to May, the supply is from two thousand to three thousand inches, except during storms, when the stream is full, and carries much more. The ditch generally carries three irrigating heads, and sometimes five, measured through an orifice, fifty by two inches, under a head of four inches above the top, or about one hundred and eleven miner's inches per head. In 1880, it was accredited with three heads of about two hundred and twenty-five inches each, as a maximum.

IRRIGATION:—The total number of acres irrigated under the Arroyo ditch is about three thousand eight hundred, of which 40 per cent is in corn, 35 per cent alfalfa, and the remainder in deciduous fruits, chiefly walnuts. Corn is irrigated twice. Alfalfa twice; sometimes three times. With a head of water one can irrigate about an acre an hour, or say twenty-five acres in twenty-four hours, or about one and two tenths feet depth of water. Four heads would thus irrigate one hundred acres a day, or three thousand acres in each round of thirty days. Estimates of acreage served by this ditch in past years, made for the state engineer, have shown results greater than that above, but they, probably, were over statements. There were about two thousand five hundred acres irrigated in 1880.

History and Water-right:—When Governor J. G. Downey subdivided and sold off the Rancho Santa Gertrudes, the San Gabriel river had but one channel to the sea, and this channel was the western boundary of the rancho. It was not until the flood of 1867–68 that the New river channel was formed, and the main flow of the flood waters of the stream was diverted from Old river eastward from two to five miles. In selling lands, he sold

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no water-rights accompanying them, but gave purchasers a free right of way for any ditches they wished to make over his lands.

Water-right:—It was considered that they were all riparian to the stream, and equally entitled to go to it and help themselves. In 1864, twenty-two individuals, purchasers of land, and styling themselves the Arroyo Ditch Company, joined together, and diverted water from the river into a dry channel or arroyo that coursed down in a southwesterly direction to about the present site of Downey City. To get the water into this arroyo, it was necessary to go above the line of the rancho, into the Rancho Paso de Bartolo, but they obtained permission from the owners, through whose property they passed, to make the ditch. In 1866, seven other individuals, owning land between this arroyo and Old river, built a ditch on higher ground than the bed of the arroyo, but for some distance about parallel with its course, and used it up to 1869, when, other adjacent land owners wishing to take water from the same source, a new association was formed, including ninety-two individuals.

Water District:—This association was in the nature of a water township under the law of 1854, with three commissioners and a water overseer. The ditch built in 1866 was then enlarged, the arroyo bed was abandoned, and the canal substantially as it exists at present was made, at a total cost, including distributaries, it is said, of $6,820. At that time, one of the land owners in the Rancho Paso de Bartolo who had given free right of way for the smaller ditches as well as for the use of the Arroyo, demanded $1,000 for the right of way for the larger canal, which was paid. All the present water-rights in the canal date from that transaction, and it has ever since been understood that all land owners who paid their *pro rata* of this $1,000 are entitled to water from the canal, and none others.

Los Nietos Water Company:—In August, 1874, the ditch-rights were incorporated under the name of the Los Nietos Water Company, with no capital stock, but on the basis of one share for each five acres. Their incorporation papers stated that the water claimed was "four hundred square inches." The organization was defective, and was not maintained. By transfer and sale of stock, other lands than those then watered are now irrigated, and it has even been carried across the line of the Gertrudes rancho

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into Cerritos rancho, but all existing rights emanated from those who paid their *pro rata* of the $1,000 assessment for right of way. The history of the work has been a series of neighborhood quarrels over the use of the water—those living near the head, it is asserted, insisting on taking all they required, to the detriment of others living farther away.

Arroyo Ditch and Water Company:—For the purpose of trying to clear up this chaotic state of affairs, the majority of the irrigators incorporated in April, 1885, the Arroyo Ditch and Water Company, with a capital stock of $22,500, in four thousand five hundred shares. Of this number two thousand five hundred and seventy-four and a half shares were subscribed at the time by eighty-three holders. At present there are three thousand two hundred and fifteen and one tenth shares which have been subscribed by one hundred and twenty-five shareholders. The largest holding is one hundred and ninety-one and five tenths shares. The smallest, one and six tenths shares; average, twenty-five and seven tenths shares. Fifteen of the original irrigators interested in the ditch, owning lands irrigated by the Sandridge branch, about six hundred acres in all, have refused to come into the corporation, and will not be governed by any regulations established by the majority. It was for the purpose and with the hope of compelling these refractory ones to join the company and submit to general regulations and control, that the company decided to build the pipe-line heretofore described. If the company had been able to deliver all their water by the pipe at the division box at the head of the Sandridge ditch, the "outsiders," as they are called, would either have had to take their water through the pipe or maintain an independent ditch to the head, but as the pipe was too small to effect this purpose it has never been used, and the old canal is still maintained. The canal makes a drop of five to six feet below the head of the Sandridge ditch, and if the pipe were continued below this drop without attempting to raise its water to the level of the Sandridge ditch, it would carry about four hundred and fifty inches, or the two heads of the Arroyo main ditch, without difficulty. It is now proposed to do this, but the land owner through whose property this extension of the pipe must be laid is an "outsider," and refuses permission to lay the pipe on his land, and so the wrangle goes on.

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Arroyo Ditch and Water Company vs. San Antonio Irrigating Company:—The company have had a conflict with the San Antonio Irrigating Company, on the opposite side of the river, over the division of the water, and, in 1886, the latter brought suit against the individuals owning water-rights under the Arroyo ditch. This suit was compromised by a stipulation in court, allowing to the Arroyo ditch owners one hundred inches of water, and one half of all remainder, as well as one half of all the water rising in the river-bed in the three miles between the respective heads of the ditches. This quantity so rising has been found to be about one hundred inches, and, in consequence, the Arroyo owners take one hundred and fifty inches more than one half the water, at the head of their ditch.

Repetto Ditch.

Opposite the head of the Arroyo ditch is a small individual farm ditch, irrigating about one hundred acres of bottom-land on the Repetto ranch.

Foster Ditch.

District and Work:—This ditch is taken from the river, about a mile below the head of the Arroyo ditch, and serves to irrigate a small area of land lying about midway between the two railroads. It is a little over two miles long before it reaches the district where it is used, and is cut in the face of a clay and hardpan bluff, in one place tunneling through a point for more than one hundred feet. It was originally made three feet wide on bottom, five feet on top, carrying one and a half feet depth of water, on a grade of four feet per mile. Its capacity is considered as one irrigating head of about one hundred miner's inches. In 1880 it was accredited with one head of one hundred and twenty-five inches. It is owned by four individuals, who hold it in eighteen parts, owning each from one to eight parts. They employ no *zanjero*, but agree upon a rotation every nine days, each taking the water in the proportion of his interest. Its irrigation season is two thousand one hundred and sixty hours' duration.

Water-supply and Use:—As the oldest ditch on the river, its right to water is recognized and respected, as taking precedence over all others; and in the compromise between the San Antonio Ditch company and the Arroyo Ditch company, it was stipulated

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that the quantity due to the Foster ditch should be taken from the portion allowed to the San Antonio company. The total area irrigated is about four hundred and eighty acres, of which one hundred acres is alfalfa, three hundred grain and pasture land, ten oranges, sixty deciduous fruits, and ten of summer crops. In 1886 it was accredited with four hundred and fifty acres. The land is a mellow, sandy loam, of close texture, requiring but little water for irrigation. The ditch was made in 1858 by C. C. Foster, at an expense of $2,500. It is one of the best water-rights in the county, as the supply is unfailing, and the prescriptive right by long use seems secure.

San Antonio Ditch.

District and Work:—This ditch is diverted from the river near the bridge on the highway from Los Angeles to Downey City, and supplies a district some three miles long by two miles in width, lying between the San Gabriel and Los Angeles rivers. It follows closely along the bank of the river, which is the highest ground for about four miles, and has three branches, with a total length of five miles. The main ditch has a good fall for the first three miles, and then flattens out to a very light grade. Its dimensions are so irregular that they cannot be definitely stated. In general, it is some six or eight feet wide, and one to two feet deep. It is said to carry three good "irrigating heads," but the channel is allowed to grow up with weeds and tules to such an extent that the water has a struggle to get along to where it is wanted. In 1886 it was accredited with capacity for one and a half to two heads of one hundred inches each. In 1880 it was accredited with two heads of one hundred inches each. The district served is for the most part low and flat; soil, alkaline; ground-water at ten or twelve feet. Irrigation is not an absolute necessity; has even done harm on some lands.

Operation and Maintenance:—It is controlled by an incorporated association of irrigators, twenty-two in number, who deliver water to themselves, and occasionally to outsiders who apply for it. A round of service is made every seven days, and each shareholder is allowed the use of a head of water for one fourth as many hours as he has shares in the ditch—one share, presumably, representing an acre. Thus, a man owning forty acres

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has forty shares and gets ten hours' use of water every week. The irrigating season is two thousand eight hundred and eighty hours in length. The secretary of the company makes up a schedule at the annual meeting of the stockholders, the first Saturday in April, setting forth the time that each owner is to be allowed the use of water during the season. They employ no *zanjero*, but each irrigator turns on the water in his turn. The cost of maintenance is about 30 cents per share per annum, and as there are one thousand three hundred and three shares, the total cost is less than $400 per year. The work of clearing the ditch is done by the irrigators, who are warned by an overseer appointed for that purpose by the directors.

Water-supply and Use:—The water-supply is abundant, and in spring and fall is not less than two thousand five hundred to three thousand miner's inches. The area of land actually irrigated does not exceed eight hundred acres, of which three hundred acres are cultivated in alfalfa, two hundred and fifty in corn, and two hundred and fifty in barley.

History:—The ditch is claimed to have been built in 1856. It was incorporated in 1869 under the title of the San Antonio Irrigating Company, with a capital stock f $6,515, divided into one thousand three hundred and three shares of $5 each.

Cerritos Colony Ditch.

Near the mouth of the San Gabriel the last ditch on the river is taken out to irrigate some one thousand two hundred acres of corn lands on the fertile alluvial bottoms. The ditch was made about the year 1879, and has been used to some extent ever since. The supply of the stream in late years is constant, and amounts to several hundred inches, although there is no exact data at hand on the subject.

Ryan Ditch.

This little work takes water from the left bank of the Old river channel, below the San Antonio ditch, and serves a district near the river crossing of the California Central railway. It is a little less than two miles in length, and carries one irrigating head. It is owned by fifteen irrigators who have, in all, four hundred and thirty acres of land on which it has been used. It was taken

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out in 1864 and was once the only ditch on the Old river; but by some means has lost its precedence, and is now used only as a winter ditch. The lands commanded are moist and do not seem to receive irrigation kindly, and, hence, apparently, the decline of this water-right.

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CHAPTER XXVI.—LOS ANGELES[15]; WORKS AND PROJECTS[25].

COAST PLAIN IRRIGATIONS.

Lower Santa Ana River Groups[9].

Section I.—*Anaheim Union Water Company's Works:*
Bedrock Cañon of the Santa Ana;
Anaheim Old Canal;
Cajon Canal;
Anaheim New Canal;
The Canal System;
Operation; Irrigation; History.

Section II.—*Santa Ana Valley Irrigation Company's Works:*
Orange Canal;
Main and Distributary Channels;
Distribution; Apportionment, and Sales;
Administration; Cost;
Irrigation and Cultivation;
History, Local Irrigation Development.

Section III.—*Yorba Ditch:*
Old Mexican Rights;
Effect of Destructive Floods;
Respect of Prior Rights.

SECTION I.

Lower Santa Ana River Works: North Side.

Santa Ana Bedrock Cañon.

The Santa Ana river after leaving San Bernardino valley, on its course to the sea, breaks through the Coast Range by an open cañon. This is quite unlike the wild, almost impassable, rocky cañon which it occupies in its descent from the San Bernardino mountains, but is rather an open pass flanked by hills, which are

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nowhere nearer together, between the opposing sides, than about three hundred yards. This cañon lies nearly east and west, in quite a direct line—the total distance between its two openings being nine and one tenth miles in a straight course, and eleven and four tenths following the windings of the river. About a quarter of a mile wide near its upper end, it gradually becomes wider until at its lower end it is over a mile across from hill to hill. Thence, the plain widens out promptly northward, but the southern hills' edge continues westerly nearly three miles farther, and then turns at an acute angle southeasterly. The point of hill thus made is known as Burruel point. The river channel winds through the cañon, first approaching the base of the northern hills and then those on the south, to the lower opening, then takes a very direct course parallel with the southern hillside and three or four hundred yards from it, as far as Burruel point, and then turns sharply towards the southwest.

The following table sets forth, in summarized form, the data of elevations, distances, and grades of and between the points to which this report has occasion to refer, in this cañon:

In Santa Ana Bed-rock Canon.	Widths of Cañon.	Distances from Head.		Distances Between Points Named.	Elevations of River Above the Sea.	Grades of River Between Points.
		In Direct Line.	By Rivers Windings.			
	Miles.	Miles.	Miles.	Miles.	Feet.	Feet Per Mile.
Upper End of Cañon	0.35	0	0	0	422	13.9
Second mile reach.	0.2	1	1.6	1.6	. . . . .	
County line crossing.	0.45	2.3	3.05	1.45	. . . . .	
Head of Cajon Ditch.	0.2	2.7	4.1	1.05	385	15
Head, Santa Ana Ditch.	0.3	5.5	7.3	3.2	337	
Head, New Anaheim Ditch . .	0.5	6.1	8.05	0.75	. . . . .	14.2
Head, Yorba Ditch	0.7	8.1	10.15	2.1	. . . . .	
Head, Old Anaheim Ditch . .	0.8	8.5	10.60	0.45	284	
Lower End of Cañon	1.1	9.2	11.3	0.7	. . . . .	14.3
Burruel Point . .	3.7	12	14.1	2.8	224	

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The river, it will be observed, has a gradually increasing grade as it falls through the cañon—augmenting its slope as it has greater chance to spread, in order to carry its sands. After rounding Burruel point the grade continues to increase to nearly twenty feet per mile, until at four or five miles down the plain its profile commences rapidly to flatten out on lesser grades towards the low country bordering the sea.

Although the name is commonly, or at least often, applied to the entire pass or cañon above described, the term Bedrock cañon is also recognized as applying to that narrowest place in the pass, about four and one tenth miles from its head, where the Cajon ditch begins, and where bedrock cropping prominently in the northern bank of the river, it is believed that the sand and bowlder deposit of the bed is not very deep to the solid rock all the way across the river. The immediate channel is here about one hundred and twenty-five feet wide. Its bed is composed of shifting quicksands, fifteen to twenty feet deep, and underlaid with bowlders lying on the bedrock, as has been shown by borings made by the state engineering department. Below this point the channel opens wider, and the sands become deeper all the way out to the open plain. Hence, while the river is never dry at Bedrock cañon proper, from there on it gradually loses its supply, and eight miles below, where the last spur of foothill on the northern side is left behind, the flow is in summer entirely beneath the sands. For this reason diversion has to be made well up in the cañon to get any assured supply, and accordingly, as we have seen by the foregoing table, we find the canal's heading from one to seven miles above its lower end.

Lower Santa Ana Districts:—For ten to twelve miles out from the cañon the Santa Ana is flanked by two of the most important irrigation districts in Southern California. That on the south, embracing the well known towns and neighborhoods of Orange and Santa Ana, is served by the Santa Ana Valley Irrigation Company's canal, and that on the north and west side of the river by the several works of the Anaheim Union Water Company, whose district is best known by the general name of Anaheim. In addition to these there is an old independent work on the north side, known as the Yorba ditch, which has its field of duty in the recess in the plain opposite to and above Burruel point, and within a couple or three miles of the cañon's opening.

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ANAHEIM UNION WATER COMPANY'S WORKS.

District and Works:—The Anaheim Union Water Company owns three canals: the Cajon, New Anaheim, and Old Anaheim. The river-heading of the latter is now abandoned, but the work serves as a distributary by cross joining with the others which are used for diversion independently, or in conjunction, or alternating, as circumstances may prompt, and as will be presently explained. The district embraced within the spread of these works extends about twelve miles down the plain from the cañon mouth, and from near to the river, around, northerly, to the edge of the hills. The lands sought to be served by these works are those only which are owned by persons who have acquired water-rights by purchase of the company, or who have contributed to the construction of some of the works, in days gone by. The district embracing these lands is bounded by the winding line of the Cajon canal on the north, on the west and south by certain section lines, and on the east by an irregular property line, in all covering about twelve thousand acres.

Anaheim Old Canal.

District and Work:—The Anaheim old canal formerly commenced at points from a half to three quarters of a mile within the lower opening of the Santa Ana cañon or pass, and carried its waters west, nearly parallel with the river for about four miles, and continued nearly west over four miles farther and beyond where the river turns southwest around Burruel point. No headgate was ever constructed for this work, because of the very unstable character of the river, which here spreads out in a broad bed of quicksand, over a thousand feet wide, and with no defined banks whatever to guide it.

CANAL AND STRUCTURES:—The canal itself, located, for the most part, over coarse, sandy land, had a cross-sectional water-way of about twelve square feet, and grades of thirteen to fifteen feet per mile for the first four miles, and sixteen to eighteen feet per mile for the second four miles, placed upon the slope of the country, without drops. Its banks were protected on each side by willows, whose roots had formed a compact matting on bottom and sides—resisting the erosion which must otherwise have occurred in a

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ditch of its grade and occasional volume through a soil so readily moveable. But this did not prevent very great loss of water by percolation, and, of course, the willows themselves appropriated no inconsiderable part of the supply. The sand brought down by the water into the ditch was a constant source of annoyance and expense—actually filling it and the laterals below. Extensive sand gates were placed about two miles from the head, where for several hours each day the sluices were opened and the accumulated sands were washed out into the river channel; but the outfall for this purpose was so slight that the relief was quite insufficient.

Such was the condition of affairs in 1878, and in that year also, the water-supply failing early in the season at the head of the canal, matters were in a desperate strait for the Anaheim people, and so they purchased a half interest in the Cajon Irrigation Company's ditch (at that time an independent work) and which, heading far up in the cañon, received a more permanent water-supply. Connection was then made with this Cajon canal at the point where the latter turns northerly out of the cañon opening, by a flume six thousand nine hundred and seventy feet long, with a fall of one hundred and seven feet, into the old ditch over a mile and a half below its former heading, and this upper part of the ditch was maintained for use during time of plenty. Such was the condition of affairs when these works were examined by the state engineering department in 1879. Without stopping at this point to trace events or describe conditions at intermediate times, we to-day see the old work altogether abandoned for its upper mile and a half, and find it thence acting as a main branch of the present unified system, and receiving water by the flume out from the Anaheim new canal, which rounds the point a few hundred feet in distance below the Cajon ditch. From the flume delivery to Anaheim settlement, five and a half miles, the old work is reported as being substantially in the condition above described for 1879–80.

Cajon Canal.

District and Work:—The Cajon canal occupies about the highest practicable grade-line out from Bedrock cañon proper, on the north side of the river, and, swinging back against the base of low hills and rolling grounds, northward, commands all the plain below, and for a width of four to seven miles northwesterly from the river.

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CANAL AND STRUCTURES:—Its course from the head follows the extreme irregularities of hills for nearly eight miles before emerging upon the plains; throughout which distance it is exceedingly tortuous, and has been excavated in hillsides that are frequently very abrupt. The formation is in places sandstone, in others shale, and it passes through all gradations of soil, gravel, and soft rock. It crosses many gulches, some of which have been spanned with flumes, in others the drainage is carried across the canal with overchutes, and in others the embankment has been made solid across the gulch, with stone gates placed in the banks immediately below. After reaching the plains, the soil it passes over is a firm clay loam, in which there is but little percolation; its course is here more direct, but it crosses a number of ravines requiring long, high flumes. Its total length is sixteen miles from the head to the receiving reservoir at the terminus of the main work.

Headworks:—The head gate and diverting dam was moved in the summer of 1887 to a point one thousand feet lower down the stream, at the expense of the California Central Railroad Company, to permit the road to excavate in the bluff which formed one bank of the ditch, and occupy for a short distance around the point the ground on which the canal was located. This work was done under the direction of the canal managers, who were given *carte blanche* by the railroad company, to do the work permanently and thoroughly to suit them, and without limit as to cost. The expense was $3,000. The dam was made so strong, however, and so well directed the river into the head gate that in the flood of the following winter the whole force of the current was precipitated against the structure, and it was undermined and carried out. The company were then obliged to carry the canal up to its former position outside the railroad bank, and put in a new head gate at its own expense. This structure was completed recently at a cost of about $1,000. It is forty feet long, fifteen feet and eight inches wide in the clear, and has four main gates across the opening, with three waste or outlet gates on the side immediately above the main gate.

Receiving Reservoir:—The reservoir is formed by a low embankment of earth inclosing about three acres of ground, on which the maximum depth of water is six to seven feet. Its capacity is

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about three hundred thousand cubic feet. It receives night and surplus waters—preventing waste and damage by overflow beyond the end of the canal.

Main Canal:—The canal is eight feet wide on bottom for about ten miles, when its width is diminished to six feet. It is calculated to carry three feet depth of water, with side slopes of one to one. Its grade is two and eleven hundredths to two and a half feet per mile, its theoretical capacity almost three thousand inches or sixty cubic feet per second, but it does not generally carry over one thousand two hundred miner's inches, or twenty-four cubic feet per second.

The structures on the main lines are: One head gate, two sand gates, fifteen storm gates, three large culverts, sixteen flumes, two delivery gates, one relief gate, two drops, seven overchutes. The flumes are three feet deep, eight feet wide, and made of two-inch redwood plank. They are from eighty to eight hundred feet in length, the aggregate length being about three thousand eight hundred feet. Some of the shorter flumes have been replaced by solid filling. The highest flume trestle is forty-six feet. The widest of the overchutes is ten feet, the narrowest three feet.

DISTRIBUTION WORKS:—There are some fifty miles of distributing ditches, with one hundred and thirty-three delivery and measuring gates. These ditches from the canal have very heavy grades, as the fall is fifty to seventy-five feet in the first mile, necessitating frequent drops. These drops, instead of being made vertically, are as inclined chutes, some forty feet in length. The back-lash is very great and cuts out the ditch sadly at their lower ends. They lower the grades from two to ten feet each.

COST OF THE WORKS:—The first cost of the Cajon canal was $103,000, of which $40,000 was spent under the organization of the two irrigation districts formed under the Bush Act of 1874, and the remainder by the Cajon Irrigation company. The cost was considerably increased by the circumstances of its construction. When District No. 1 was organized the size of the ditch was planned but three feet wide on the bottom, and the first eight miles were excavated. Afterwards District No. 2 joined in the construction, and the ditch was widened to eight feet on the bottom. This necessitated cutting out the upper bank, and shoveling the material across the old excavation. Again, under the

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regime of the Cajon Irrigation company, the financial difficulties that the company labored under added materially to the cost, as work had to be stopped repeatedly and resumed again, and interest on borrowed money, etc., all had effect to increase the outlay. Probably the canal could now be built for half the money.

Anaheim New Canal.

District and Work:—The Anaheim new canal taps the Santa Ana river, three and one tenth miles by the river above the lower end of the cañon, at an elevation about two hundred and twenty-five feet above the sea, and extends to the lower canal supplying-flume at the cañon's mouth, into which it delivers its waters to be distributed by the old system.

CANAL AND STRUCTURES:—It is located along, under, nearly parallel to the Cajon ditch, and nowhere over a quarter of a mile from it, for its own full length, and lies in between the Cajon and the Yorba ditch for the lower mile, around the point, with the former location of the old canal, also parallel, and at a still lower level. After leaving the river it is at first located on bottom-land soil, at the base of the first bench. This it gradually surmounts and follows in good, firm clay loam along the base of the hills on whose sides, above, the Cajon canal winds. As far as it goes it is the most capacious and best canal in the district north of the river. It is three and a half miles long, and has capacity for three thousand miner's inches, when in good condition.

Headworks; Flume:—Its head gate is quite similar in plan and dimensions to that of the Cajon ditch; and it has four sand-gates, five overchutes for cross drainage, one delivery gate, and one drop. The old flume from its end, five thousand seven hundred and sixty feet in length as yet used, down into the original canal, is forty-four inches wide and sixteen inches deep, is in wretched condition, and has capacity for only eight hundred inches, so that the canal is practically limited to that duty. The flume connection, at this lower point, with the Cajon canal on the hill above has been taken up, but there is such a connection at a higher point, so that the lower system may yet receive its waters direct from the upper point of diversion, and it is operated that way at time of lowest flow.

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Reservoirs; Project:—This Anaheim new canal was projected to be carried about three miles farther on, northwest, to a couple of reservoir sites in the edge of the higher plain on which the Cajon ditch is situated. These storage basins, it is estimated, at a total cost for embankments of a little less than $30,000, could be made to hold two hundred and ninety million gallons, and one hundred and forty-five million gallons, respectively. Some work has been done on them, but it has been suspended. It is understood that the suspension is only temporary. The work should be carried out on even a broader scale than projected. Of course, it is apparent that the really good new work, on this canal, counts for much less than its cost, comparatively speaking, as matters now rest.

One of the reservoirs mentioned as projected at the terminus of the extension of the new canal was partially formed in 1887 by the building of a levee some seven feet in height and four hundred feet long, with a thirty-inch pipe through the bank, and a circular brick tower about ten feet in diameter, in which is placed the regulating gate. It can be filled by turning out water from one of the flumes of the Cajon canal, crossing the arroyo at the mouth of which the reservoir is located. On testing the reservoir it has been found to absorb water so rapidly as to lower at the rate of four inches a day. The company hope to make it tight by driving sheep and cattle through it. It has not been used. When used it will deliver water into the old Farmers' or North Anaheim ditch.

Kramer Ditch:—This was a very old ditch which diverted water from the river years before the original Anaheim canal was built, and after the construction of the latter, by special arrangement, took its water from it. The priority of its water-right was always recognized, although it was so small as to be insignificant. In the consolidation of the water companies into the Anaheim Union Water Company, it was allotted twenty of the twelve thousand acre-rights free of assessment. A portion of the lower end of the Kramer ditch is still used as a distributary.

The North Anaheim Canal:—This was a ditch built solely to take surplus winter water either from the river or from the Anaheim canal, at the sufferance of the latter, when there was water

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to spare. Its supply was so uncertain that when the Cajon canal was built its directors were willing to sell it to the latter for $500, to be used as a distributary. Its length was several miles, and its width on bottom about five feet, depth about two feet.

DISTRIBUTION WORKS:—The distributing ditches of the main Anaheim canal are in all some twenty-five miles in length, and all run over specially sandy soil, which absorbs water greedily, and they necessarily lose a large proportion of their supply in transit. The total number of delivery and measuring gates in and around Anaheim, on the old system of works, is two hundred. These are arranged very much as in Orange, Santa Ana, and Tustin.

Module:—A stop gate is placed in the main carrying the supply, and a side gate thirty-three and one third inches wide in the clear is located at the head of the delivery ditch immediately above. The latter gate is raised sufficiently to make the orifice below it equivalent in square inches to the number of miner's inches required to be delivered. Check boards are placed in the main stop gate, so as to raise the water four inches on the delivery gate. No other conditions are regarded. The side ditch may have a rapid fall, or it may have a light fall, and set back the flow upon the gate; it may have a free outfall or be in the condition of a "drowned" weir, so long as the water stands four inches high on the delivery gate with the proper size of orifice it is supposed to measure the output with sufficient accuracy.

COST OF THE WORKS:—The cost of the works built by the Anaheim Water Company before its consolidation with the Cajon Irrigation Company cannot now be ascertained. The old canal cost about $5,000. The long flume connecting with the Cajon cost about $3,500, and the new Anaheim canal cost will be stated in the summary hereafter.

Anaheim Canal System.

Works and Distribution:—Taken as a whole the three canals and branches which compose this system have an aggregate length something over one hundred miles, all under the control of the Anaheim Union Water Company—maintained and operated at its expense. The distributary works are all simple earthen ditches, thrown out with plow and scraper, and are of various sizes and grades and lengths. The three mains are called the Upper ditch, the Farmers' ditch, and the Lower ditch.

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These run for nine to ten miles, principally in a westerly direction. Their capacity is almost as great as that of either main canal, and any two of them will easily carry as much as one main brings down. The Farmers' ditch was formerly the main line of the old North Anaheim canal. Although consolidated with the others described, the works of the Anaheim canal are as distinct as though they were in a separate district. A broad former channel of the Santa Ana river separates the immediate neighborhood of Anaheim from North Anaheim, and water which flows down the Cajon canal past the gate where a part of its diversion is turned into the New Anaheim canal never reaches Anaheim, for there is no connection across this old river channel in the plain below. Except at the head, therefore, the waters are in no sense interchangeable through the district.

Operation and Maintenance:—The Anaheim Union Water Company is an incorporated joint stock company, having a capital of $1,200,000, divided into twelve thousand shares. It is an association of irrigators, owning their own works, delivering and selling water only to themselves, and selling no water-rights except to owners of land lying within the recognized and defined district. The new company issued its stock to the shareholders of the old companies on an agreed basis, and formed a district of twelve thousand acres, the limits of which are prescribed in its incorporation articles, and within which such shares might be located. The by-laws prescribe that the issue of stock should at first be limited to seven thousand shares, until it is demonstrated that the water-supply will serve a greater area. In 1886 there had been issued six thousand eight hundred and eighty-two shares, and it is believed the limit has now been reached. Ownership of canal stock is limited to one share for each acre held within the district. The exact tract of the land to which water stock applies is described in each certificate, and it is not permitted to irrigate any other than the land so designated, or any greater area than the certificate names, nor are stockholders permitted to transfer their stock to other lands except the transfer be recorded in the stock book of the company. If they do not choose to exercise their privilege of purchasing water when it comes to their turn in regular rotation, they may not rent or sell their privilege to another stockholder, but the water goes to the common supply and shortens the period of rotation by so much.

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COST OF OPERATION AND MAINTENANCE:—The cost of maintaining the ditches in repair, and operating them is quite heavy, and largely exceeds the revenue derived from the sale of water. This is shown as follows:

EXPENDITURES CLASSIFIED—1884 TO 1888.

ACCOUNT.	1884.	1885.	1886.	1887.	1888.
Salaries	$3,970 50	$5,336 99	$4,099 81	$5,635 73	$4,551 14
Construction . . .	. . . . .	. . . . .	. . . . .	683 49	206 80
Ditch Expense—Cleaning, and Repairs	23,081 16	5,615 17	7,873 78	6,602 27	2,485 13
General Expense, Legal Expense, Office Expense, etc.	1,472 34	972 68	2,947 12	612 86	. . . . .
Totals	$28,524 00	$11,924 84	$14,920 71	$13,534 35	$7,243 07

For 1879 the salary account was $4,027, and ditch expense, $1,253. For 1880 the salary account was $3,332, and ditch expense, $716. The first of these two years was a year of great demand for water, and the second was a year of plenty. In 1879 the cost of water to the company per twenty-four-hour head delivered, was $2 96; in 1880 this cost was $3 41. The rates to the irrigators at the same time were $2 50 per water-head per day.

The receipts from sales of water during the same time, compared with the expenses, shows a considerable deficiency, as follows:

ANNUAL RECEIPTS AND EXPENSES—1878–80 AND 1884–88.

YEAR.	Total Receipts.	Total Expenses.	Excess of Expenses Over Receipts.	Character Previous Winter.
1879	$5,497 00	$5,280 00	[1]($217 00)	Very dry.
1880	3,150 00	4,048 00	898 00	Moderately wet.
1884	1,078 97	28,524 00	27,455 03	Flood.
1885	5,290 35	11,924 84	6,634 49	Rather dry.
1886	3,426 92	14,920 71	11,493 79	Moderately wet.
1887	3,748 12	13,534 35	9,786 23	Average.
1888	[2]2,526 85	7,243 07	4,716 22	Rather dry.
Totals	$16,071 21	$76,146 97	$60,075 76	

[1] Excess of receipts over expenses. [2] To October fifteenth.

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The large ditch-expense account of 1884 immediately after the consolidation, was caused by the destructive effects of the floods of that year to both the Cajon and the New Anaheim canals, which were washed away in places and in others filled by landslides, etc. The deficiencies in the cash account are met by general assessments on the stock of the company.

Water Rates:—Water is sold by the head of one hundred inches, or fractions thereof, at the rate of 50 cents per head per hour in daylight, and 25 cents at night. The winter rate, after October first to about March first, is 25 cents per head per hour during the day, and 15 cents per head per hour at night. These have been the prevailing rates ever since the Union company was organized. The average cost per acre per annum is from 50 cents to $1, dependent upon the soil, crops, and cultivation, and economy and skill of the irrigator.

Year.	Day Time.		Night Time.		Full 24 Hours.
	Per Hour.	Per Day.	Per Hour.	Per Night.	
1879—Summer . . .	$0 12½	$1 50	$0 07½	$1 00	$2 50
Winter . . .	. . . .	. . . .	. . . .	. . . .	1 50
1886—Summer . . .	25	3 00	12½	1 50	4 50
Winter . . .	10	1 20	05	60	2 00
1888—Summer . . .	50	6 00	25	3 00	9 00
Winter . . .	25	3 00	15	2 00	5 00

For 1880 it was reported for the state engineer that the rates were: Summer time, day-water, fourteen hours, 12½ to 30 cents per head per hour; night-water, ten hours, 8 to 17 cents per head per hour; winter time, ordinary charge, $1 50 per head for twenty-four hours, or, if a week's run were taken, the charge was as low as 75 cents per head for twenty-four hours.

Distribution; Apportionment and Heads:—When water is plentiful, which is only in fall after general irrigation ceases and in winter when the river is flowing in abundant volume, the irrigator may purchase, without stint, all he wants, and whenever he wants it, but when there is a general demand for it, and the flow is diminished, the directors order the distribution to be made in runs, by rotation, beginning at the head and serving all in turn who have applied and paid for their water at least forty-eight

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hours before it is to reach them, and the apportionment is limited to a given time of run, or what is equivalent to it, the irrigator is permitted to buy only a certain value per share. During the past season this limit was 50 cents' worth on the first share and 15 cents' worth on each remaining share owned, which one could buy on each run. Thus, a man owning ten shares may purchase water to the value of $1 85 on each run. If he took it at night it would give him water enough to be equal to a rainfall of one and one half inches on his land, supposing it to be spread over the whole area. If he took it in daylight it would be half that quantity. But the practice is to wet only a part of the land at once, and thus give it a better flooding. The heads ordinarily used on the heavy, loam soils under the Cajon canal are about fifty inches. Around Anaheim, where the soil is more sandy and absorptive, the heads are from one hundred to one hundred and fifty inches. Water is turned on and off by *zanjeros* who attend to that duty exclusively.

ADMINISTRATION:—The officers of the company consist of a board of seven directors, who meet twice a month, and receive $2 per month each as their compensation; a secretary, who keeps the books of the company, attends to the sale of water, and issues receipts or tickets; a treasurer, receiving $25 per month for keeping and disbursing the funds of the company; a superintendent, having charge of the entire system of works, their maintenance and repairs, receiving $65 per month, and furnishing his own transportation (horse and buggy); two distributing *zanjeros*, who attend to the running of the water to the irrigators, and receive $70 per month each; and three permanent watchmen, or patrolmen, who live along the line of the main upper canals, and attend to their current repair, one of whom receives $50, and the others $40 per month. Three assessments of 50 cents each have been levied this year, amounting to $10,326 in all, upon the six thousand eight hundred and eighty-four shares issued. In 1879 there were $14,824 collected on assessments.

Water-supply and Use:—The supply of water for this district is short. As to the actual facts with respect to volumes, those, so far as known, will be found in the special chapter on water-supply, to follow. The works are not economical of the supply. A perfected system would probably greatly relieve the district from

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embarrassment on this score. The problem is not a simple one. Just what should be done for economy's sake and to insure best results is a point not to be quickly or lightly determined.

IRRIGATION:—The total area on which water stock has been placed is six thousand eight hundred and forty-four acres, and the area actually irrigated every year is somewhat less, probably not exceeding six thousand five hundred acres, of which considerably more than half is supplied by the Cajon canal. The total number of irrigators is three hundred and fifty, of which the greater number are on the Anaheim canal, in and around the town of Anaheim. The largest individual irrigator cultivates about one hundred and ninety acres, the smallest irrigates one acre. Vineyards cover about 60 per cent of the irrigated area, citrus orchard about 10 per cent, deciduous orchard about 5 per cent, barley, corn, and vegetables about 20 per cent, alfalfa 5 per cent. In 1886 the irrigation covered somewhat over four thousand acres.

History of Works and Water-supply:—The present organization has succeeded to the rights of the Anaheim Water Company, the Cajon Irrigation Company, and its successor, the (new) North Anaheim Canal Company, the original North Anaheim Canal Company, and the Kramer ditch, as well as to the work done under irrigation district commissioners in districts one and two, and to the rights of the Cañon or Santa Ana Water Company.

The Old Kramer Ditch:—The first of these works in point of time is the Kramer ditch, which was in use some years prior to the founding of Anaheim. At that early day prior to the beginning of general irrigation higher up the stream it received an ample supply and irrigated lands in what is known as the Kramer tract, on the rancho San Juan y Cajon de Santa Ana. After the building of the Anaheim ditch, the Kramer received its supply through the head of the new work. This was never a considerable amount, but in the consolidation of interests under the Anaheim Union Water Company, the priority of its water-right was recognized by the allotment to it of twenty shares of unassessable stock in the new company.

Anaheim and the Old Anaheim Ditch:—In 1856, in San Francisco, a private association composed of fifty individuals was

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formed under the name of the Los Angeles Vineyard Association; the object being to acquire a tract of land, with water-rights, in Los Angeles county, to divide the same into fifty vineyard lots and fifty town lots, to work the land upon a coöperative plan for about three years, and then make an allotment of the subdivisions, one of each kind, to each member, and thus colonize the tracts by the members themselves. In September, 1857, these individuals incorporated their association under the name of the Los Angeles Vineyard Society, with a capital stock of $37,500, divided into fifty shares. This incorporation was formed for the avowed purpose of wine making, only, but it was understood that it should carry out all the purposes of the original association. Its term of existency, however, was to end on the first of May, 1860.

In the same month (of 1856) a tract of one thousand one hundred and sixty-five acres of the rancho San Juan y Cajon de Santa Ana, which tract was afterwards known as the Anaheim colony, was purchased for the company, together with right of way for a ditch through the part of the rancho lying above, and the "privilege of using so much of water from the Santa Ana river as appertains to the said rancho for the purpose of irrigating the same, by virtue of the grant of the said rancho by the former Mexican Government, and by the laws and customs of the country at the time of said grant, and by virtue of the existing laws and customs, as may be sufficient for the purpose of irrigating" the one thousand one hundred and sixty-five-acre tract. This water privilege was based on the riparian right of the rancho named, which bordered on the river for a number of miles, and upon a right acquired from the owners of the rancho Cañon de Santa Ana, which was also riparian to the stream. During 1857, a ditch six feet wide on the bottom, eight feet on top, and two feet deep was constructed, and water was diverted sufficient to fill it and to irrigate the one thousand one hundred and sixty-five acres. Up to 1869, water was used through this ditch only on the Anaheim tract, but commencing with that year some was sold to owners of other lands, until, several years afterwards, as much as six hundred to eight hundred acres additional were irrigated. The property was divided and cultivated, and the town of Anaheim built up in the years of 1857, 1858, and 1859, during which time it was held for the company by trustees. In November,

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1859, the property and water-rights were conveyed to the Vineyard Society by the trustees.

Anaheim Water Company:—In December, 1859, the Anaheim Water Company was incorporated, and the Vineyard Society conveyed to it in January, 1860, all of its water-rights, canals, and ditches, and rights-of-way therefor. In the same months the fifty vineyard lots and the town lots were distributed to the individual stockholders in the society. The stock of the Anaheim Water Company was divided into fifty shares, which were issued, one each, to the owners of the fifty vineyard lots, with the understanding that each certificate of stock and the water-right represented thereby, were to be appurtenant to the vineyard lot having the corresponding number and letter, so that no sale or transfer of the stock, or of the water-right represented thereby, could be made or would be recognized, acted upon, or binding upon the company, except by a conveyance of the vineyard lot to which the stock was appurtenant.

In November, 1878, the Anaheim Water Company increased its capital stock to $50,000, in five hundred shares, having shortly before purchased an undivided half interest in the Cajon Irrigation Company's canal (not of its water-right) for the sum of $20,000. In March, 1879, they began construction of a flume, six thousand nine hundred and seventy feet in length, to connect the Cajon canal with the Anaheim canal, through which to carry their half of the water thus acquired. This flume was finished in May, 1879, and for some years was used exclusively to supply the Anaheim ditch during the dry months.

Anaheim New Canal:—This joint use of the upper part of the Cajon canal by the two companies led to friction and open rupture, and during the pendency of ensuing litigation the Anaheim Water Company constructed its new canal, in 1882, as heretofore described. Severing all connections with the Cajon canal, by removing part of the connecting flume, it determined to take its water independently from the river, at a point almost opposite the Santa Ana canal, which diverts on the south side.

North Anaheim Canal Company:—The North Anaheim Canal Company, formed in 1872, to supply irrigation, etc., to a region north and west of Anaheim, constructed a ditch from the river, six feet wide on bottom, with a carrying capacity of one thousand five

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hundred inches, claiming all waters not otherwise appropriated. Its supply, subordinate to the other appropriations, was not continuous, and it rarely received water, except in winter, when there was a surplus. In June, 1878, it conveyed its claims to the Cajon Irrigation Company, and all of its ditches, in consideration of $500 paid in the stock of the Cajon Irrigation Company. Thereafter its stockholders received water solely from the Cajon ditch, under the regulation of that company.

Cajon Canal:—The Cajon canal has had a checkered history. It was begun in 1875, under the commissioners of a local district formed under the Bush Act of 1874, an act applying solely to Los Angeles County, and providing for the formation of irrigation districts, under the supervision of a county superintendent of irrigation. District No. 1 was organized with the view of building a small work but three feet wide on the bottom. A ditch of this size was completed for eight miles to the mouth of the cañon. District No. 2 was subsequently organized, and the ditch was enlarged to its present dimensions, to serve as a joint work for the two districts. After the expenditure of $40,000 the work was abandoned, as many of the landowners refused to pay the tax levied by the commissioners to continue.

In April, 1876, subsequent to the abandonment of the work, the Stearns ranchos syndicate, who owned a large proportion of the land in the two districts, and who had paid their tax for the construction of the ditch, organized the Cañon de Santa Ana Water Company, with a capital stock of $200,000, and took possession of the canal. The people who had made such efforts to get water for their lands were encouraged to see a wealthy company of capitalists take hold of it, but when two years passed without any work being done they began to despair.

Cajon Irrigation Company:—In July, 1877, seven individuals, landowners in the district, organized the Cajon Irrigation Company, with a capital stock of $20,000, in two hundred shares of $100 each; made a filing at the head of the partially completed ditch, appropriating four thousand three hundred and twenty inches of water, and began construction. They took possession adversely to the claim of the Cañon de Santa Ana Company, and brought suit to quiet title as between them. This action was never tried, and possession was never strongly resisted by the

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defendants. At any rate the new company maintained their possession and continued the work of completing the canal. None of the stockholders were very wealthy men, and the company had a hard struggle to raise the means to carry on the work. They were attached for debt several times, and at one time filed a petition in insolvency. Finally, when they were most deeply involved, they effected a sale of half interest in the canal to the Anaheim Water Company for $20,000, which enabled them to pay their indebtedness and continue the work. Prior to this sale they had increased their capital stock to $25,000, but this was insufficient to complete the ditch, and they called in assessments in excess of the capital stock. Some of the stockholders thereupon refused to pay the later assessment. The company brought suit to compel them to do so, and were defeated on the ground that the company could not legally assess its stock in excess of the amount of its nominal capital. Their organization was declared defective, and their only alternative was to reorganize, which they did under the title of the North Anaheim Canal Company, in October, 1882—taking the name of the old company which had been absorbed by the Cajon Irrigation Company four years before. Meantime, after the sale of half the canal to the Anaheim company, trouble was brewing over the division of the water between the two.

Anaheim Water Company vs. Cajon Irrigation Company:—At the beginning of their joint ownership the Anaheim company and the Cajon company entered into contract by which the division of the water was to be managed by a board of two directors, one from each company, with the provision that they should select a third in case of a disagreement. But this arrangement did not work well. The Anaheim company wanted the Cajon company to give them three fifths of the water, and release them from their half of expenses of maintenance below their connection, and all expenses when they were not using the Cajon canal to carry water. At last, shotgun arguments were about being used, and then the Anaheim company brought suit for injunction to restrain the Cajon company from diverting water from the river, asserting their priority of claim and use, etc. A temporary injunction was granted, but modified so far as to allow the Cajon company to use one hundred and fifty inches pending final judgment. The decision of the case was virtually a victory for the Cajon company,

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as the decree limited the appropriation of the Anaheim company to water sufficient for the original one thousand one hundred and sixty-five acres, only. And as their irrigation had spread to more than three thousand acres, all the remaining area, above one thousand one hundred and sixty-five acres, was made subject to the appropriation of the Cajon company.

Anaheim Union Water Company:—This decision led to the consolidation of all the conflicting interests, and the formation of the Anaheim Union Water Company, organized in January, 1884. To this company were conveyed all the water-rights and property of the Anaheim Water Company (including about one thousand acres of irrigable land), the North Anaheim Canal Company, and the Cajon Irrigation Company. Since this consolidation was effected, perfect harmony has prevailed, and the area of irrigation has considerably extended. The only controversy they now have is with the owners of the Yorba ditch, whose rights by reason of long appropriation must be respected, and with whom they now have to share the half of the water in the river belonging to the north side. A suit is now pending to restrain the Yorba ditch owners from diverting more than one hundred and twenty-five inches of water, but it has never been brought to trial.

The people of the district now wish to organize under the Wright act, and have filed their petition for that purpose. The boundaries of the proposed new district include the lands irrigated by the Yorba ditch, and cover an area of about fifteen thousand acres in all. A general improvement of the works, by cementing the main canals, and piping the laterals, is contemplated under the district organization.

Financial Status:—When the Anaheim Union Water Company was organized the Anaheim Water Company owed about $34,000, and the Cajon Irrigation Company about $16,000, which indebtedness was assumed by the new company. They now owe $48,300, upon which they are paying interest. The stock of the company was selling at $15 per share in 1886.

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SECTION II.

Lower Santa Ana River Works: South Side.

Santa Ana Valley Irrigation Company's Canal.

District and Works:—The Santa Ana river, after leaving San Bernardino valley, on its course to the sea, breaks through the Coast Range in an open cañon. [See preceding section.]

Location of Canal and Branches:—The river in this cañon is the source of supply of the Santa Ana Valley Irrigation Company's canal, whose head is some four miles below the line between Los Angeles and San Bernardino counties (which is at the narrowest part of the cañon), and about twelve miles from the town of Orange. The canal follows a decidedly tortuous course from its head to the spur of hills called Burruel point, at the extreme lower limit of the pass, which it pierces with a tunnel, and there emerges upon the plain. Near the mouth of the tunnel it is divided into two main channels, one of which keeps upon the grade-line, skirting the foothills and swinging around the valley to the town of Macpherson, the other, making a drop of fifty-seven feet (of which thirty feet are utilized as water-power for a flouring mill), runs nearly due south, passing three fourths of a mile to the east of Orange, and terminating below Santa Ana. Both of these main branches have a number of laterals which ramify through the district. These lateral ditches are very extensive. Those owned and maintained by the company, taken together with the main canal, have an aggregate length of seventy-five miles; while the private ditches maintained by the individual irrigators are thought to be even greater in mileage.

The District Commanded:—The area of the district upon which the water is rigidly confined is twenty thousand acres, all within the limits of the rancho Santiago de Santa Ana. Its shape is first, a strip between the canal and the river, averaging about one quarter of a mile in width by some four miles long, reaching to Burruel point; second, a body of land south of the point, having an extreme length of eight miles north and south by a maximum width of five miles east and west.

Canal and Structures:—The conduit, as an irrigation work, is the largest and most important in Southern California, judged

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either from the number of acres irrigated, the number of irrigators and stockholders interested, or the amount of water distributed and applied. Owing to the treacherous nature of the quicksand bed of the stream, no permanent works of diversion have ever been built. A temporary dam of brush and sand replaced after every high flood serves to divert water into the canal. The upper portion of the canal for about one and one half miles was originally built over the quicksand bottom-lands, and was subject to great loss by percolation as well as to damage from floods. This section was reconstructed in 1885, and was thrown into the more solid ground next the hills, with a long, deep, through-cut near the head, and for the whole distance was lined with cement, two inches thick—carried on the side slopes at least six inches above high water mark. This work gave the canal much greater permanence at its head than it had before. No regulating head gate has been put in yet. After the first three miles, the character of the ground passed over by the canal is a firm, black loam, which affords good solid material for the banks. The third mile is largely in embankment, crossing low ground, in loose, sandy, and gravelly material.

Cement Lining of Canal:—This section has been lined with cement for about a mile, and it has been decided to line the greater portion of the gap between the two cemented sections immediately. The cementing work is very satisfactory, stands with little or no cracking, and reduces the cost of clearance to a mere trifle, for the sands seem to find no lodgment. Hence, the work of releveling the bottom of the canal to true grade, which is periodically rendered necessary in the earthen channel, by the sand deposit, is avoided where the lining has been made. A further advantage is the saving of water, the extent of which has not been determined, but it is believed to be considerable. The general sentiment of the irrigators is to continue this cement lining as fast as possible, until all the main canals and laterals are thus improved.

Dimensions and Capacity:—The main canal may be said properly to end at the Burruel point tunnel, where it is divided into two mains. The length of the section is about seven and a quarter miles. Its average bottom width is twelve feet; depth, three feet; side slopes, one to one; grade, three and three fourths feet per mile; claimed capacity, seven thousand five hundred inches.

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As calculated, the discharge would be eight thousand seven hundred inches if it were lined with cement, five thousand eight hundred inches unlined but kept tolerably clean and free from weeds, and four thousand and sixty inches if it were neglected somewhat, and weeds and stones were left in the channel. The maximum supply found in it at any time was forty-five cubic feet per second, or two thousand two hundred and fifty inches. The *zanjero* says it has never carried over thirty-three heads of one hundred inches each, during summer.

Sluice-ways and Overchutes:—The embankment on the lower side is usually about six feet wide on top, and is carried two to three feet above high-water mark. There are seven large sluice gates, where surplus water may be turned back into the river, and the sand sluiced out of the canal. They consist of gates across the canal, and side gates immediately above on the lower side—through the embankment. These are placed in or near natural channels leading to the river. The amount of sand carried down is very considerable, and necessitates a frequent opening of the gates to give it vent.

The cross-drainage from the hills was originally carried under the canal by drain boxes, but these were constantly liable to choke, and cause a break in the banks, so the drains were all removed, and flumes carrying the storm waters over the canal were substituted. Ditches lead the drainage to these flumes and overchutes, of which there are thirteen.

Pipe Creek-crossings:—The waters of both main branches of the canal are carried under the bed o Santiago creek at their crossings, in pipes adopted to replace flumes which were washed away in 1884. These pipes are of cement, four inches thick—the upper one three feet in diameter, and four hundred and sixty feet long, and the lower one four feet in diameter, and of the same length.

Distribution Works:—The lower branch canal (the larger of the two) has a length of about ten miles, is generally about six to seven feet wide on bottom, one and a half to two feet deep, and a capacity of about seventeen heads. Its grade is very irregular from the mill to Santiago creek, where a relief gate is placed to turn out surplus water. The upper canal is about six miles in length, and has a capacity of about fifteen heads as far as Santiago creek. The lateral ditches are smaller, and carry one to

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five heads each. They have irregular grades, generally greater than is necessary. The principal laterals are as follows: The Travis ditch, four to five miles in length, with a carrying capacity of two and a half heads, runs along the western limits of the district on a sand ridge nearest the river, from the mill to near the lower end of the district. This ditch loses such a large proportion of its flow that it has been decided to lay a cement pipe in it for about eight thousand feet of its worst part. The Chicago drop carries three heads, is about one mile in length, and supplies the immediate neighborhood of Orange. The Contention drop carries three heads, and is about three miles long. The S. Kowhegan drop carries three heads, leaving the lower canal south of Santiago creek crossing. The Ross drop starts with five heads, supplying the Maclay ditch with one head, the Spurgeon ditch with three heads, and the Santa Ana ditch with one head—the latter running into the town of Santa Ana. The Tustin branch of the lower canal carries five to six heads, and receives the surplus of the Gutherie drop, which leaves the upper canal at its crossing of Santiago creek. This Gutherie drop carries five to six heads. The Hughes ditch is the name applied to the extension of the upper canal below the crossing of Santiago creek. Its capacity is three heads. The Snow drop is a branch of the Hughes ditch, carrying three heads. This runs over fine gravel for a mile or more, and is to be lined in part with cement. The Bowers drop connects the upper and lower canals along the south bank of Santiago creek. It has a capacity of two and a half heads. The slope of the ground westward from the upper canal to the river is very great, necessitating frequent drops or weirs to break the grade and prevent washing. The loss of water in the laterals is excessive. For example, at the lowest stage of supply in August, the water in the main canal measured eight hundred and thirty inches, while the most that could be delivered at the lower end of the settlement was three hundred and fifty inches, showing a loss of 58 per cent.

COST OF THE WORKS:—The cost of the old Chapman ditch, the original of this work, was $18,000. The enlargement and extension, in 1878, by the Semi-Tropic Water Company, cost $44,000. The entire construction account on the books of the company aggregates $116,225. Of this amount, $49,300 has been

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expended since 1884. The cementing of the main canal has cost about 55 cents per square yard or about $1 20 per linear foot of canal. The by-laws of the company allow the directors to levy an annual assessment of 50 cents per share on outstanding stock, to be applied to new work—other than maintenance and repairs, which are paid for by the receipts from sale of water, etc. This assessment has been levied regularly for many years past, and now gives a fund of about $7,000 a year for construction. This is being expended in permanent improvements. In 1887, a pumping plant was erected on the river bank about one and a quarter miles below the head of the canal, at a cost of $11,000, for the purpose of lifting an additional supply into the canal.

PUMPING PLANT:—The works consist of a sixty-five-horse power engine and boiler, forty-two-inch centrifugal pump, with seventeen-inch suction and twelve-inch discharge pipe, and a flume about one hundred feet leading into the canal. The engine is set on a good bed of concrete, and the boiler on brick, and all is well housed. A wooden "caisson" or box, twelve feet wide, twelve feet high, and ninety feet long, was sunk across the river bed. The top of this box was placed some two feet below the level of the river bed, and covered over with inch boards. In the following winter, when the river rose it covered the box with sand, and the light covering gave way, allowing the box containing the suction pipe to fill with sand—rendering it useless when required. Other expedients for getting at the water have been suggested, among which is the sinking of an iron well curb, sixteen feet in diameter, forty feet deep to gravel bottom.

Additional Water-supply Plan:—Another plan for obtaining an additional supply is to lay a pipe-line from a lake which lies between the ditch and the river about four miles from the head of the former. This lake is a long, narrow lagoon, some eight hundred yards long by thirty to forty yards wide, and two to eight feet deep. The lake has no apparent inlet but from its lower end there flows thirty to forty miner's inches. By tapping it, and dredging it out, it is thought a reservoir can be made of no small capacity, and the available flow increased. The lake was formed during the flood of 1884 by water from a side stream coming into the river. The pipe-line from the lake would follow the line of the old Bush

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and Watson ditch, and empty into the main lower canal below Burruel point.

Operation and Maintenance:—The Santa Ana Valley Irrigation Company is an incorporated association of irrigators, owning and controlling their lands and works. It is organized on the basis of one share of stock to each acre of land—twenty thousand—in the district. The stock has a par value of $5, but its present market value is $16 90 per share. Of the total number, fourteen thousand seven hundred shares have been sold and issued to the land owners, and the remainder are still in the treasury of the company. The proceeds of the sales of stock are put into the company's construction fund. The price is increased, year by year, by the amount of the assessments levied and interest on all assessments to date. This places all land owners in the district on an equal footing. Those who hold land for speculation without cultivating it, or who cultivate without irrigation, may, at any time, buy water stock for their land, but will have, virtually, to pay for all prior improvements on the works, the same as the rest have paid. The certificate of stock describes the tract to which it is applied, and it is not separable from the land; but if an irrigator does not want to use the water to which he is entitled, he may rent his stock to any other stockholder, and the renter may thus in time of scarcity obtain a larger quantity than would otherwise be apportioned to him on his own stock alone.

DISTRIBUTION:—*Apportionment and Sale of Water:*—No water or water-rights are allowed to be sold or used or rented outside the district. When water is abundant, any irrigating stockholder may purchase, from the company, all the water he wants to pay for at the regular rates, and the water is said to be "on application." When it is scarce, which is almost every season from May to September, the supply is apportioned to the stockholders on a time limit, by resolution of the directors, and is carried through the canals in regular "runs," beginning at the head, and serving all in turn who make application, in the measure of the limit of the allotment fixed. This limit has sometimes been as low as twenty minutes per acre per "head" of one hundred inches; but is usually not lower than thirty minutes per acre per head. Thus, if a man has ten acres, he would be allowed to have one hundred

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inches flow for two hundred or three hundred minutes, or half that head for double the time, and so on, every time his turn came. As the runs sometimes occupy sixty days, the twenty-minute limit would put the irrigator on very short allowance, and would practically give him but four thousand eight hundred cubic feet of water per acre at each irrigation. This amount would only be equivalent to about one and one third inches of rain. The thirty-minute limit would give him but seven thousand two hundred cubic feet per acre, equal to about two inches of rain. This is on the assumption that he had all of his land under cultivation and irrigation, which is not always the case. He may have a portion in grapes which will get along without water, except in winter when the limit is off, or with a very little during the limit season; consequently the remainder of his land would receive a proportionately greater quantity. These restrictions work no special hardships as yet, although they act as a stimulant to compel the payment of the assessments for improving the works and increasing the water-supply. It is a noticeable fact, however, that the grape growers have been until quite recently less in favor of increasing the assessments and water-supply than the citrus fruit growers and general orchardists.

Water Rates:—In 1886 the summer rates for water were 25 cents per head per hour for day irrigation (6 A. M. to 6 P. M.), and half that price at night. The winter rates after October first were 10 cents per head per hour in day time, and 5 cents at night. In 1888 the summer rate was 30 cents per head per hour, and 15 cents at night; the winter rate being 20 cents per head per hour during the day, and half rates at night. In summer the day is now (1888) from 5 A. M. to 7 P. M. The water rates are adjusted so as to barely meet running expenses, and the cost of clearing ditches, etc., and are subject to change at any time by the directors, at their discretion. The average cost of water to the irrigator is from 60 cents to $1 25 per acre per annum, depending upon the season, the crop, the soil, and the skill and care of the irrigator. Oranges require more water than any other crop. Vineyards need water chiefly in winter, when it is cheap, and irrigation costs less to the vineyardist than to the orchardist.

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Irrigation Head; Module:—The irrigating head is measured through an orifice thirty-three and one third inches in length, by three inches in height, one hundred square inches, under a pressure of four inches. This orifice is produced by raising the gate at the head of the lateral canal, three inches, and the pressure is obtained by raising the level of the water in the canal, by means of check boards in a gate across the canal, immediately below the lateral, until the water in the canal stands four inches higher than the water in the lateral. The actual volume delivered is a trifle more than one hundred inches (about one hundred and seven inches), and the contrivance is crude, although apparently uniform, depending, however, on fluctuations in the canal and on grade of the lateral away from the point of delivery to it. If a half head is to be delivered the gate is raised one and one half inches. This is the quantity usually preferred, and at least three fourths of the water is sold in half heads. From the foregoing, it will be seen that in winter the waters are ordinarily apportioned out by measure of volume, alone, and in summer by time "runs" and volume both—especially in times of scarcity. Applications for water are made to the secretary at the office, or to the *zanjero*, but no orders or tickets are issued. The applicant must give notice at least forty-eight hours before he requires the water, and the *zanjero* notifies all irrigators at least twenty-four hours before the water reaches them to prepare to receive it. This is during the period of time limit. The *zanjero* is the only person authorized to turn the water on or off.

ADMINISTRATION:—The officers of the company are a board of five directors (one of whom is president), receiving a salary of $5 per month each. Their duties are to inspect the works every fortnight, to hold meetings monthly, or declare dividends whenever the surplus profits warrant it; to issue stock to stockholders, and to generally supervise the affairs of the company. A superintendent, elected by the board, receives $100 per month, and has charge of all the canals and general direction of all labor. The *zanjero* is paid $125; the treasurer receives $100; the secretary, $60. There is no engineer. Hydraulic works, as a general thing, appear to be considered by their owners in Southern California rather things of the law than scientific or constructive entities. Perhaps they are right. The *zanjero* has to provide what horses

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he needs (three to four), hence his pay is only apparently greater than his superior, the superintendent, who provides himself with but one horse.

COST OF OPERATION AND MAINTENANCE:—During the past year the maintenance account was as follows:

Cleaning ditches and repairing bridges	$2,291 66
Repairing dam at head of canal	268 95
Wages of employés	4,462 75
Directors' salary and expenses	318 95
Taxes on real estate	59 54
Tools	58 25
Printing, advertising, and stationery	183 75
Freight bills and miscellaneous expenses	125 87
Attorneys' fees	37 50
Post Office box, stamps, and expressage	28 29
Total	$7,835 51
During the same time the receipts from sale of water were	$6,846 30
Rent of water power and real estate	1,021 17
Fines	25 00
Miscellaneous	253 96
Total	$8,146 43

Hence there was a surplus of revenue over the ordinary running expenses. In former years the receipts have been greater. In 1887 they were $12,274. In 1886, $7,051. The expenses also fluctuate. For example, after the flood of 1884 the cost of repairs ($42,000) largely exceeded the receipts, and money had to be borrowed in excess of the annual assessment.

Water-supply and Use:—The supply of water to this work is not sufficient, by present means of delivery, to meet the demand, nor for the lands within its district. There have been years of decided deficiency for existing cultivations. The question of increase of supply, and conservation of that now commanded, is one continuously before the communities, and considered by the directors of the company. It has been already stated that the maximum diversion, claimed by officers of the company to have been made by the canal, is about three thousand three hundred miner's inches. It has been gauged when carrying two thousand two hundred and fifty inches and inspected when carrying probably two thousand five hundred inches. The matter of water-supply in the river will be considered in a special chapter on the general subject.

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IRRIGATION:—The area of irrigation served by this work was found, in 1879 at six thousand four hundred acres, in 1880 at seven thousand acres, in 1886 at fourteen thousand acres, and in the present year it is between fifteen thousand and sixteen thousand acres. There is a much higher percentage of citrus fruit culture in this district than in Anaheim, and vines are grown more for raisins and table shipments, and less for wine, so that they are more freely irrigated late in the season. Data of cultivation will be given in a chapter on Duty of Water.

History of Works and Water-rights:—The rancho Santiago de Santa Ana, bordering on the south side of the Santa Ana river for a number of miles, and claiming, by virtue of the terms of the original grant, a right to one half of the waters of the stream which came to it, was partitioned amongst its owners by decree of court in 1868, each owner being accorded the privilege of diverting his share of the water for irrigation. Water was thus diverted by a number of small individual farm ditches which were from time to time taken out and gradually afterwards abandoned. The Chapman ditch, succeeding to the rights of one of these, was dug in 1870, and about July, 1871, was carried as far as the site of the town of Orange, and water was diverted for irrigation there. In May, 1873, this ditch and water-right were sold to the Semi-Tropic Water Company, who extended it to the towns of Tustin and Santa Ana, and it then supplied all these neighborhoods with water.

The Semi-Tropic Water Company:—In May, 1873, the Semi-Tropic Water Company was incorporated for the purpose of supplying water generally for agricultural purposes within its district. The Semi-Tropic company did not own any land, or cultivate or irrigate of itself, at all, but was a water-supplying company solely and only.

Prior to 1857, the measure of diversion was about three irrigating heads of one hundred miner's inches each. The little ditches were generally neglected and filled with weeds. In 1869, one of these ditches was cleaned out, by one Watson, to carry about five irrigating heads. The Chapman ditch in after years, to some extent, supplied the Watson ditch. In 1876, the Chapman ditch was enlarged to carry five or six heads of one hundred miner's inches each. In June, 1877, the Chapman ditch, or Semi-Tropic,

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diverted half the water in the river—being five or six heads—part of which was dropped into the Watson ditch. The other half of the water was for the most part lost in the sandy bed of the river before reaching the head of the Anaheim ditch, so that the Anaheim people were deprived of a flow, and had to haul water in carts to save their vineyards. The Semi-Tropic diversion was made with consent of the owners, generally, of the Santiago rancho, and its claim was based on the alleged right of the ranch to one half of the waters of the stream.

Anaheim Water Company vs. Semi-Tropic Water Company:—In consequence of these diversions by the Semi-Tropic ditch the Anaheim Water Company brought suit. The lower court decided that the Anaheim ditch was entitled as against the Semi-Tropic ditch to a supply of water to its fullest capacity—a stream six feet wide on the bottom, eight feet on top, and two feet deep. This was in February, 1883.

An appeal was taken to the supreme court which, in September, 1883, rendered an elaborate opinion, reviewing the facts and law of the case, and reversing the judgment of the lower court. The fundamental point in this decision is the upholding of the riparian rights of the rancho Santiago, served by the Semi-Tropic Water Company, as against the acts of appropriation by the Anaheim Water Company. The opinion concludes with the following paragraph:

"But, as for the reasons already given, the plaintiffs have acquired no right to any portion of the water that appertains to the owners of the rancho Santiago de Santa Ana, the decree of the court below which secures to the plaintiffs sufficient of the water of the river to keep their ditch flowing full to its utmost capacity at all times and seasons of the year, without regard to the quantity of water that may be left in the river after such diversion, and irrespective of the wants and necessities of the owners of the rancho Santiago de Santa Ana, cannot be sustained. We must, therefore, reverse the judgment and remand the case for a new trial. In doing so we think it not improper to suggest, in view of the value of the water in dispute and the large interests at stake, whether it is not advisable for the parties to the controversy to divide the water upon an equitable basis, and devote the money that may otherwise be expended in litigation, to the proper development and use of it."

A concurring opinion contains this sentence: "The rights of the respective parties originated in a riparian source, are held by

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them in common, and invest each with equal rights to the use and enjoyment of the water of the stream." Although the judgment of the higher court did not undertake to settle the cause finally, but remanded it for new trial, the opinion of the court as to the merits of the case was so apparent and the suggestion offered so plain, that the litigants seem to have taken it as final, and agreed to divide the water.

Santa Ana Valley Irrigation Company:—For the purpose of providing an organization which might extend the benefits of irrigation to all lands acknowledged to be entitled to water on the south side of the river, the Santa Ana Valley Irrigation Company was incorporated in July, 1877, with a capital stock of $100,000, divided into twenty thousand shares. The intention was to attach its stock to the twenty thousand acres of land in the rancho. It promptly acquired the rights and properties of the Semi-Tropic company, and immediately commenced the enlargement of the system. As the district thus covered by the works of the Santa Ana Valley Irrigation Company embraces all the territory of the rancho Santiago de Santa Ana, and as there are no other lands riparian to the stream, on the south side, which require water for irrigation, the decision of the supreme court in this case would seem to give the company a clear title to one half the water of the river flowing at Bedrock cañon. No further contests involving this right are suggested, and the question has evidently been settled for good and all.

There is no co-existing land company. There are no conflicts now, and no internal dissensions. Everything is working harmoniously and smoothly. There are differences of opinion regarding the policy of the company in the extension of improvements. Some of the shareholders want to issue bonds, on the basis of the franchise, for $150,000, and pipe all laterals and cement all main canals at once. Others, and probably the majority, favor a ditch assessment for this work, to be done more gradually, but all are pretty well united in favor of increasing the water-supply.

Financial Status:—The financial status of the company is good. Their total indebtedness is but $13,061 50; and their assets in the way of real estate and personal property, aside from their canal and ditches and water-rights, are estimated at $15,000. The directors state in their annual report that their franchise is estimated by experts to be worth at least $250,000.

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SECTION III.

Lower Santa Ana River Works.

Yorba Ditch.

District; Work; Operation:—The Yorba ditch diverts water from Santa Ana river on the north side, about a mile within the cañon mouth, and serves a district lying at the head of the plain and bordering the river, all within three and a half miles of its point of beginning. It is a primitive work, claiming water to fill it a foot deep on a width of a "shovel's length"—about five feet. The work is located throughout in a sandy, permeable bottom-land, and thus loses a large part of its waters. It is owned and managed by a community of twenty-five to thirty irrigators, almost all of whom are native Californians of Mexican descent.

Water-supply and Use:—Its water-right is the oldest on the river, and has to be respected as such by the other ditches. There is much dispute, however, as to the measure of its appropriation and prior right. Its owners claim at least three hundred inches at their head-gate. The Anaheim ditch people acknowledge only one hundred and twenty-five inches. It serves seven hundred and sixty to seven hundred and eighty acres in irrigation, which is about the same as it has supplied since first examined by the state engineering department. Its owners assert that in years ago it irrigated much more land—before the water was partially taken away by other appropriations. In 1880 the ditch was reported as irrigating about six hundred acres, and carrying four hundred and fifty miner's inches, ordinarily, during the irrigating season, with a sectional area of six square feet of water-way.

History:—The original of this ditch was built by Bernardo Yorba, in 1835, then owner of the entire rancho Cañon de Santa Ana. It first took its waters at Bedrock cañon, and irrigated lands of the bottoms on the way down, and also used to furnish water-power for a mill. Two other irrigation ditches were built out of the river by the same proprietor about the same time. The flood of 1862 destroyed them all, and then the present ditch was built, and has ever since been used.

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CHAPTER XXVII.—LOS ANGELES[14]; WORKS AND PROJECTS[34].

COAST PLAIN IRRIGATIONS.

SANTIAGO CREEK-GROUP[10].

SECTION I.—*Serrano and Carpenter Water Companies:*
Santiago Creek and Valley;
Old Ditches and Rights;
Submerged or Bedrock Dam;
Joint and Independent Pipe-lines;
Operation and Maintenance;
Water-supply and Use;
History; Organization.

SECTION I.

SANTIAGO CREEK WORKS.

District; Stream:—Santiago creek receives its waters from a Coast Range catchment area, twelve to fourteen miles in length, five to seven miles in width, and embracing seventy-eight to seventy-nine square miles of territory. Lying lengthwise along the mountain face, it has a comparatively low ridge in front of it, and discharges its waters at its northwest corner, three miles south of the opening of Santa Ana Bedrock cañon. Coming from a narrow gorge the creek passes west and southwest, for two and a half miles, through a neck of the coast plain held between two spurs of rolling hills. This valley of the Santiago is in the form of a triangle two miles on its base and two and a half miles on the perpendicular, therefrom, to the cañon opening. It holds the irrigation districts of the creek. Across its open base the upper branch of the Santa Ana company's canal is found—limiting the spread of Santiago irrigations in that direction—and the hills

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limit it on each side. Santiago creek is a perennial stream, and affords an irrigation supply to a district on each side of it, lying above the reach of the upper canal of the Santa Ana Valley Irrigation Company.

Serrano and Carpenter Water Companies' Irrigations.

Works:—JOINT DEVELOPMENT AND DIVERSION:—The northern district is supplied by the ditch and pipe-lines of the Serrano Water Company, and the southern district by the works of the Carpenter Water Company. The companies join in the diversion of the water in a common main pipe, and make an equal division of the supply at a point two thousand four hundred feet below the submerged dam at which the water is turned into the pipe. The principal conduits, thence, of both companies are cement pipes, which command some two thousand three hundred acres of rich, sandy loam within the triangular district described.

The works, taken together, rank third in importance in this section of the country, the Santa Ana canal being first, and the Anaheim works second, while, for simplicity and economy of management, they may be taken as a model for other communities.

Submerged Dam:—Prior to the dry season of 1879, the water was diverted in earthen ditches on either side by primitive dams, but in that year all parties interested combined in the construction of a submerged dam in the cañon. The point selected was at a narrow pass, between vertical walls of cemented gravel and stone. An excavation was made and bedrock exposed at an irregular depth of twelve to nineteen feet below the surface. This excavation was about twelve feet wide on the bottom, and was filled with a puddle-wall of clay, which for some years effectually cut off the underflow, dried up the willows and cottonwoods growing along the stream below, and apparently threw all the water to the surface. The top of the clay dam was left unprotected, however, and subsequent floods effected a breach—eroding it to an unknown depth—and now no trace of the dam is apparent. The length of the dam between walls was one hundred and one feet, and its cost was $2,600. The water companies are now contemplating the reconstruction of the dam in concrete, carrying it some ten feet high above the surface.

Main Pipe and Flume:—From this dam a cement pipe, twenty inches in diameter, two thousand four hundred feet long, was laid

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on the left bank of the creek to a partitioner, where the water is equally divided. At present a gap of four hundred feet exists in this main pipe, commencing seventy-five feet below the dam, which has been filled in by a flume, sixteen inches wide, eighteen inches deep. This break in the line was caused by erosion and change of channel undermining the pipe, in the flood of 1884, and again in 1888. The flume is in places incapable of carrying more than one hundred and thirty inches, the amount now flowing into the pipe. The remainder flows over the dam, and is diverted into open ditches below.

SERRANO WATER COMPANY; SEPARATE WORKS:—From the division box, a fourteen-inch pipe is carried across to the north side of the creek beneath its bed, and extends along the foothills about one mile, followed by half a mile of twelve-inch pipe, and one mile of ten-inch pipe, and with a branch line of three quarters of a mile of twelve-inch, and one mile of ten-inch. These constitute the pipe-lines of the Serrano company. On top of their main pipe (which has a capacity of about two hundred inches) they have an open ditch, in which is carried all the waste water, escaping through the dam, which they can pick up in the creek—amounting to sixty or eighty inches. This water might be carried in the pipe, if the flume were larger and better arranged, at least in summer, but in winter it affords an additional supply beyond the capacity of the pipe.

CARPENTER WATER COMPANY; SEPARATE WORKS:—The pipe-line of the Carpenter company starts from the division box with a few lengths of fourteen-inch pipe, which is then reduced to twelve-inch, for one mile, with a grade of "two and a half inches per rod," at the end of which is the first stand-pipe. The diameter is then reduced to ten inches, of which there are about two miles, terminating in and around El Modena. This line is laid on a materially lighter grade. Stand-pipes at intervals along the line relieve the pressure. Wherever water is to be delivered to consumers a stand-pipe "turn-out," of larger diameter, is placed over the main, with small iron gates across the main and lateral, inside the stand-pipe. The capacity of this line is also claimed to be two hundred miner's inches. This company has likewise an open ditch picking up the water not diverted by the other ditch, a mile below, and irrigating about one hundred acres. This is the upper part of the old Oge and Bond ditch.

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Operation and Maintenance:—Both the Serrano Water Company and the Carpenter Water Company are incorporated associations of irrigators, owning and controlling their own works, and operating them for individual and community benefit. The two companies divert the water under a joint right, and claim the sole right of use of the entire stream. They each have a board of three directors, one of whom is secretary and treasurer, and all acting without pay. They meet only when necessary.

DISTRIBUTION; *Schedule; Head; Cost*:—In the spring, when the regular irrigation season opens, each company prepares a schedule by which the irrigators know definitely for the season the date and the length of time each is entitled to water, viz., the use of the entire head flowing in the pipe of his system, and each turns off his water when the time is up. The apportionment is made by time alone, and each has a right to the full head for a length of time proportioned to the acreage owned by him. On the Serrano system the ratio is twenty and a half minutes per acre, every eighteen and a half days. Under the Carpenter system the allotment is made at the rate of twelve minutes per acre, every twelve and a half days. The reason for making the rotation a fractional number of days is to alternate the use of water at night. The total head carried by the pipe-lines, September, 1888, is about sixty-five inches each, and the practice is general of lumping runs and thereby increasing the time, as well as the subdivisions of heads, among two or more irrigators taking water at once. The system works smoothly and satisfactorily, and without any expense whatever for distribution. When any accident occurs requiring expenditure of labor or money, an assessment is levied to meet it. The assessment for repairs on flume and headworks this year was 10 cents per acre, which was the entire cost of water to the irrigators during the season.

Water-supply and Use:—Santiago creek is a torrent in winter. Where it emerges upon the plain, its gravel and cobble channel is five hundred to eight hundred feet wide and several feet deep. It is often impossible to ford it for a week at a time. It drains a large water-shed extending up to the highest peaks of the Coast Range, and is the largest tributary of the Santa Ana below San Bernardino. In summer the flow dwindles ordinarily to about two hundred and fifty to three hundred inches, although in the

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dry year of 1879, it got as low as ninety inches. Since 1884 it has never been below two hundred and fifty inches in August, September, and October. The building of the submerged dam increased the flow twenty inches, as was ascertained at the time. As before stated the claim of the two companies is to the entire volume of the stream, based on appropriation and riparian ownership.

IRRIGATION:—The total area irrigated by the Serrano works is (1888) one thousand three hundred acres, and by the Carpenter works, about eight hundred acres. About one third of this total area was once in citrus orchard, but on account of the ravages of the red scale these are being rooted out and replaced by other plantations. Somewhat more than half is in vineyard, now sadly afflicted with an unknown blight which is destroying the vines. About 10 per cent is in summer crops, and the remainder, say 5 per cent, in alfalfa.

In 1879 Oge's ditch, now the Carpenter Company's right, was reported as irrigating about five hundred acres, and the Santiago company's ditch, now the Serrano right, served about two hundred and fifty acres. In 1880 the last named company served three hundred and thirty acres, and Oge ditch one hundred and fifty. The return for 1880 was obtained by thorough canvassing and was probably nearest right. In 1886 the Serrano works were serving about one thousand two hundred acres, and the Carpenter eight hundred.

History and Water-right:—Messrs. Oge and Bond were formerly owners of all the land embraced in the district of the Carpenter Water Company, and in the year 187(?) built their ditch from a point a mile or more below the submerged dam down to the valley of the creek and to the southwest along the base of the foothills, terminating near Tustin. The rights they acquired were to one half the water of the creek, and they placed these rights upon one thousand six hundred acres of land forming the original district. In dry season, however, the ditch could not deliver at its lower end enough to be of any use in irrigation. The upper canal of the Santa Ana Valley Irrigation Company, having been extended, in the mean time, into the portion of the same field around Tustin, a number of irrigators who had acquired rights from Oge and Bond in their ditch, by the purchase of land, con-

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cluded that they could get a more permanent and satisfactory supply from the new canal. They offered their shares in the Oge and Bond ditch and water-rights to their associates for sale.

These rights amounted in the aggregate to exactly half of the whole, and for convenience were divided into eighteen shares. These floating shares were, in part, purchased by the remaining parties in interest, and in part by outsiders. As a consequence, some of the irrigators, now owning a share, or a fraction of a share, in addition to their regular *pro rata* on acreage, have a greater supply than others, who did not buy floating stock. These floating shares have sold as high as $1,500 each. As the eighteen shares represent the water-right for eight hundred acres, each share would represent forty-four and forty-four hundredths acres, and its value would be $33 80 per acre.

Santiago Land and Water Company:—A number of the floating shares were bought by individuals who formed the Santiago Land and Water Company, one of whose objects was to furnish a domestic supply to the towns of McPherson and Orange. They built a circular brick-lined reservoir, eighty feet in diameter, ten feet deep, on the hillside below the pipe, near Modena and laid a six-inch iron-pipe to Orange and McPherson. This pipe has a fall of eighty-six feet from the reservoir to McPherson, and about one hundred and fifty to Orange.

Serrano Water Company and Carpenter Water Company:—In 1883 the Serrano Water Company as the successor to the old Santiago creek ditch, on the north side, agreed with the Carpenter Water Company to make improvements in their conduits and substitute cement pipes for the ditches throughout. The joint main pipe was laid in that summer, and the other pipes were laid as fast as possible during the two following seasons. They work in harmony with each other; there is no conflict between them and never has been. The water-supply is abundant, if properly cared for, to furnish all that is needed, and there is no occasion for strife.

Modena Domestic System:—The town of El Modena is provided with water under the irrigation schedule, the supply being the allotment to sixty acres. This is delivered into a reservoir, thirty by forty feet, and thence distributed in iron pipes through the town. The reservoir is filled weekly by a sub-apportionment.

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CHAPTER XXVIII.—LOS ANGELES[15]; WORKS AND PROJECTS[29].

COAST PLAIN IRRIGATIONS.

SAN JUAN CAPISTRANO—GROUP[11].

SECTION I.—*Old Mexican Ditches:*
San Juan River and Trabuco Creek;
Mission Viejo Ditch;
Lower Trabuco Ditch;
Upper Trabuco Ditch;
Boca De La Playa Ditch.

SECTION I.

SAN JUAN CAPISTRANO IRRIGATIONS.

Districts; Streams:—Draining from the Coast Range in the southeastern corner of Los Angeles county, and having a combined mountain catchment area of seventy to seventy-five square miles, the San Juan river and its tributaries, of which the Trabuco is the chiefest, come together in San Juan valley three or four miles from the sea. This valley is three-pronged, and contains ten thousand to twelve thousand acres.

Works; History; Water-rights:—The Mission San Juan Capistrano was established in 1776, and was one of the wealthiest and most extensive of all the missions of Southern California. It was located on a bench or low mesa, between two forks of the river San Juan, three miles distant from the coast, and overlooking the whole valley below as far as the beach, as well as the Trabuco and Mission Viejo valleys that join to form the San Juan valley. In these valleys surrounding the mission the *padres* established a system of irrigation that embraced a considerably greater area than is now under cultivation. From each side of both the trib-

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utary streams they constructed ditches that may still be plainly traced at considerably higher levels than the existing ditches. Erosion of the beds of both streams has taken place to such an extent that they are now from eight to twelve feet deeper than formerly, and this has gradually led to the abandonment of the higher and more commanding ditches for others on lower ground, more easily maintained. The ditches of the district are now four in number, viz., the Upper and Lower Trabuco ditches from Trabuco creek, the Mission Viejo ditch from the creek of the same name, and the Boca de la Playa ditch from a *cienega* or spring rising in the valley below the mission.

Mission Viejo Ditch.

District and Work:—This ditch takes its waters from the right bank of the creek about half a mile within the limits of the rancho Mission Viejo, at the foot of a low slate bluff, and follows along the foot of the mesa at the margin of the valley, terminating at the town of Capistrano, a total distance of two and one half miles. It is irregular in grade and cross-section, but has an average fall of about thirty feet per mile. It is a simple earth channel, having a width of about two feet on bottom, and carrying six to eight inches depth of water. Diversion is made by a temporary dam of brush and sand, replaced annually. There is no head gate, nor any other structure worthy of mention, on the whole ditch. The district irrigated extends for about two miles along the stream, from the line of the Mission Viejo rancho to the mouth of the Trabuco immediately below the village.

Operation and Maintenance:—The old Mexican customs are still adhered to, in the management and distribution of the water, that have prevailed for more than a century past. The irrigators meet at the village early in the season, when the ditch is to be put in use again after the rains, and agree as to what is to be done to clean the ditch and put it in order, allot to each the amount of work required of him, in the ratio of his acreage to the whole, and appoint one of their number as *zanjero*, who serves without pay. All the water of the ditch is used in one irrigating head, and each takes it all, in rotation, commencing at the head. The round is made every seventeen or eighteen days, and the length of time is roughly agreed to, that each is entitled to take water. There is no incorporation or association; no records.

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Water-supply and Use:—All of the water flowing in the creek at the point of diversion is ordinarily turned into the ditch. It is an unfailing stream, which, although dry in summer, for some miles above the head of the ditch, rarely carries less than one hundred and eighty miner's inches in the driest years. In ordinary seasons the summer flow is about two hundred and fifty inches. Below the head of the ditch an additional supply, amounting to about seventy-five inches, rises in the bed of the stream, at different points above the town, which is utilized.

IRRIGATION:—Irrigation is practiced from May to September, inclusive. The remainder of the year the water is allowed to run in the ditches for domestic supply as long as it is uninterrupted by the washing away of the wingdam. There are twenty-one irrigators holding water-rights in the ditch, and irrigating from one to seventy acres each. There are about two hundred and sixty acres of summer crops, forty acres of vines, fifteen of alfalfa, forty-five of English walnuts, eighty of oranges, five of apricots and other deciduous fruits, and ten of olives, or about three hundred and eighty-three acres in all. The soil of the district is a black, alluvial loam, with surface water at six to eight feet. It is easily irrigated, retentive of moisture, and does not require much water, consequently the great loss experienced in transit is not felt.

Water-rights:—This ditch succeeds to the rights of the mission and *pueblo* of San Juan Capistrano—one of the oldest in the state—and its owners consider their title without flaw or blemish. No water controversy has ever arisen, and no actions at law have ever been brought to disturb the peaceful and continuous enjoyment of the privilege. The water is held to be inalienable from the land—and the district to which it is made to apply is delineated by a map on record in the clerk's office of Los Angeles county. A systematic development of the water is desired and contemplated by the more progressive parties in interest, and it is probable that a pipe-line will be laid as a substitute for the wasteful ditch, on a higher grade line.

Lower Trabuco Ditch.

District; Work; Operation:—The district watered by this ditch is continuous with the long narrow belt irrigated by the Mission Viejo ditch, and extends from the village, or immediately

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below, to within a mile of the sea coast. The waters of Trabuco creek are all diverted into the ditch at a point about half a mile above Capistrano, and carried along the foot of the higher lands that bound the main valley on the southwest. The total length of the main ditch to the fork is about one and a quarter miles, to a point where the water is carried alternately to the east and west sides of the district. The two branches are each about one and a half miles long. The ditch is quite similar in construction and capacity to the Mission Viejo ditch, and is without head gate or any other permanent works. Its management and method of distribution and character of organization is entirely similar to that just described.

Water-supply and Use:—The flow of Trabuco creek is quite like to many other Southern California streams that play hide and seek in their beds. For long distances it is, in summer, entirely dry. This is the case of a stretch of five or six miles above the village of Capistrano. Its waters begin to reappear about a mile above the town, and within a distance of half a mile a clear crystal stream of some three hundred inches is gathered into one channel, affording an unfailing irrigation head for the ditch which makes use of it. There are fifteen irrigators interested in this ditch, their holdings varying from three to sixty-five acres.

The cultivations are: Summer crops, chiefly corn, one hundred and sixty-eight acres; English walnuts, ninety-five; alfalfa, twelve; oranges, five; vines, three; deciduous orchard, two—making a total of three hundred and twenty-seven acres. The district is in a high state of cultivation and in a flourishing condition. Water is so abundant, and its use so little imperative, that urgent need for a betterment of the condition of the irrigation works has been altogether absent. The old style of doing things, inherited from the Mexican pioneers of the country, is an easy and inexpensive one, and such costly innovations as cement pipes or concrete lined ditches, masonry headworks, and systematic sand-boxes and measuring gates, which other neighboring communities have carried into effect, are not as yet projected.

The water-right is probably as old as any of the other mission ditches, to one of which it has succeeded. The old ditch was, however, some twenty feet higher at the head, and is traceable on the hillside for a long distance. A brick aqueduct, of which

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the ruins are still visible, led from the same source at which the Lower Trabuco ditch is fed, directly to the mission from the left bank of the stream, but no water is now diverted on that side of the Trabuco. The channel is cut down so low that neither of these old ditches could now reach the water, even if they were in repair.

Upper Trabuco Ditch.

District and Work:—This ditch is owned equally by three individuals, and irrigates a limited tract in the fork of Trabuco creek some six miles north of the mission San Juan Capistrano. Its length is about five miles, and, although irregular, it has a general width of about one foot on bottom, carrying six to ten inches in depth of water, on a grade following the slope of the valley. Its capacity is one hundred to one hundred and twenty-five miner's inches.

Water-supply and Use:—It has in times past irrigated about one hundred and seventy-five acres, but all the water is now used by one of the owners of the water-right to irrigate eight acres of vines and deciduous orchard, and twenty-eight acres of summer crops. The others continue to pay their proportionate share of the expense of maintenance, which is about $150 per annum. Owners of sheep grazing on the adjacent lands use the ditch for supplying their herds with drinking water, and assist in meeting cost of maintenance. The loss of water in the ditch is very great, and usually but one fourth, sometimes even less, of the amount taken in at the head, reaches the lowest end of the ditch. The ditch was built in 1852 or 1853 by Americans and Indians, and has been used continuously ever since to a greater or less extent.

Boca de la Playa Ditch.

District; Work; Supply; Use:—In 1880, and for many years prior, the waste waters of the San Juan river were diverted below the mission through a ditch about a mile in length to a *cienega* covering about nine acres, from which they were conducted, together with the waters flowing from the *cienega*, by a ditch half a mile in length, and used to irrigate a small tract on the Boca de la Playa rancho. For some years past the deepening of the channel of the San Juan has rendered it impracticable to divert its waste waters into the *cienega*, and the supply is limited to

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what is afforded by the latter. This is now used to irrigate a single farm, consisting of some eight acres of orchard, and forty acres of summer crops, located near the railroad station of "San Juan by the Sea."

It is believed by the most intelligent residents of the valley that the water-supply in both the Trabuco and Mission Viejo creeks has been greatly diminished since the early settlement of the country, and they attribute this result to the wholesale destruction of timber and brush upon the mountains by forest fires. One of the grounds of this belief is the evident large size of the old mission ditches, as shown by the traces yet visible, and the fact that at least two of them took their head from points in the stream which are now permanently dry.

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IRRIGATION IN SOUTHERN CALIFORNIA.

APPENDICES.

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APPENDICES TO PART II.

CONTENTS.

Appendix I.—Table of Drainage Areas of Los Angeles and San Bernardino Counties; to accompany the Outline Map.

Appendix II.—Memorandum: Plans of Storage Dams—With twelve plates to illustrate the chapters on Water-storage, projected for a future volume.

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APPENDIX A.

TABLE of Drainage Areas of Los Angeles and San Bernardino Counties; to Accompany the Outline Map.

	SAN FERNANDO DRAINAGE BASIN.			
1	*Cahuenga Mtns.* Northern slope	31.56	31.56	
2	*Santa Susana Mtns.* Los Angeles river . .	14.37		
3	*Santa Susaaa Mtns.* Several cañons . . .	0.68		
4	*Santa Susana Mtns.* Several cañons . . .	7.87		
5	*Santa Susana Mtns.* Several cañons . . .	8.68		
6	*Santa Susana Mtns.* Several cañons . . .	6.25	37.85	
7	*San Fernando Mtns.* Mormon cañon . .	15.50		
8	*San Fernando Mtns.* Limekiln and other cañons	11.00		
9	*San Fernando Mtns.* San Fernando cañon	8.62		
10	*San Fernando Mtns.* Grapevine cañon . .	0.68		
11	*San Fernando Mtns.* Hanson and Harp cañon	2.00		
12	*San Fernando Mtns.* Wilson and Lundies' cañons	3.06		
13	*San Fernando Mtns.* May cañon	2.06		
14	*San Fernando Mtns.* Loop cañon	1.09	44.01	
15	*Tejunga Mtns.* Pacoima creek	17.31		
16	*Tejunga Mtns.* Small intermediate cañons	3.93		
17	*Tejunga Mtns.* Little Tejunga creek . .	28.10		
18	*Tejunga Mtns.* Big Tejunga creek . . .	125.68		
19	*Tejunja Mtns.* Intermediate slopes . . .	3.37		
24	*Tejunga Mtns.* Intermediate slopes . . .	1.00		
25	*Tejunga Mtns.* Cañada cañons	12.65		
36	*Tejunga Mtns.* Intermediate slope . . .	1.81		
37	*Tejunga Mtns.* Arroyo Seco	16.62		
38	*Tejunga Mtns.* Millard cañon	4.93	215.40	
	San Fernando basin—Mountain slopes. . .	. . . . .	328.82	328.82
21	*Verdugo Hills.* Southern slope	11.43		
22	*Verdugo Hills.* Northern slope	1.81		
27	*Verdugo Hills.* Northeastern slope . . .	11.68	24.92	
28	*San Rafael Hills.* Verdugo slope	1.56		
29	*San Rafael Hills.* Eagle Rock arroyos . .	4.43		
30	*San Rafael Hills.* Los Angeles slope . .	4.18		
31	*San Rafael Hills.* Arroyo Seco slope . .	4.87		
33	*San Rafael Hills.* Arroyo Seco slope . .	1.93		
34	*San Rafael Hills.* Cañada slope	1.68	18.65	
	San Fernando basin—Outstanding Hills . .	. . . . .	43.57	43.57

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TABLE OF DRAINAGE AREAS—Continued.

23	*Cañada.* Western end	2.31		
26	*Cañada.* Middle part	6.46		
35	*Cañada.* Eastern end	2.75		
			11.52	
32	*Arroyo Seco.* Lower basins, etc.	6.37		
			6.37	
	San Fernando basin—Passes, etc.	.....	17.89	
				17.89
20	*San Fernando valley—Plains and mesas*	.....	182.31	
				182.31
	SAN FERNANDO BASIN. TOTAL			572.59
	SAN GABRIEL DRAINAGE BASIN.			
	SAN GABRIEL MOUNTAINS.			
39	*Canons West.* Hill slopes	0.81		
40	*Canons West.* Los Flores cañon	1.72		
41	*Canons West.* Rubio cañon	1.95		
42	*Canons West.* Eaton cañon	3.23		
43	*Canons West.* Kinney cañons	0.40		
44	*Canons West.* Davis cañon	1.91		
45	*Canons West.* Intermediate slope	0.30		
46	*Canons West.* Bailey cañon	1.40		
47	*Canons West.* Intermediate slope	0.25		
48	*Canons West.* Little Santa Anita cañon	4.10		
49	*Canons West.* Intermediate cañon	1.31		
50	*Canons West.* Santa Anita cañon	10.05		
51	*Canons West.* Intermediate cañons	1.37		
52	*Canons West.* Sawpit cañons	8.10		
53	*Canons West.* Several small cañons	5.37		
54	*Canons West.* Fish creek	2.93		
			45.20	
55	*San Gabriel river*	220.71		
			220.71	
56	*Canons East.* La Fetra, Harrow, etc.	4.93		
57	*Canons East.* Dalton cañon	9.64		
58	*Canons East.* Sycamore and other cañons	7.62		
59	*Canons East.* San Dimas Cañon	17.56		
60	*Canons East.* Live Oak and other cañons	4.43		
			44.18	
	San Gabriel river basin—Mountain slopes	.....	310.09	
				310.09
61	*San José hills.* Northwest slope	12.31		
62	*San José hills.* Southeast slope	9.06		
			21.37	
63	*Puente and Coast hills.* Puente, north slope	24.87		
64	*Puente and Coast hills.* Gabriel, north slope	7.50		
			32.37	
	San Gabriel basin.—Hills	.....	53.74	
				53.74
65	*San Gabriel valley.—Plains and mesas*	.....	192.75	
				192.75
	SAN GABRIEL BASIN. TOTAL	.....	.....	556.58

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TABLE OF DRAINAGE AREAS—Continued.

	SAN BERNARDINO DRAINAGE BASIN			
66	*Cucamonga Mtns.* Several small cañons	7.12		
67	*Cucamonga Mtns.* San Antonio creek	24.57		
68	*Cucamonga Mtns.* Intermediate slopes	2.06		
69	*Cucamonga Mtns.* Cucamonga cañon	6.75		
70	*Cucamonga Mtns.* Horse Shoe, Sycamore cañons	5.25		
71	*Cucamonga Mtns.* Days cañon	3.75		
72	*Cucamonga Mtns.* Youngs or Garcias cañon	2.18		
73	*Cucamonga Mtns.* Dear and other cañons	6.25		
74	*Cucamonga Mtns.* Bozeman and other cañons	4.18		
			62.11	
77	*Cucamonga Mtns.* Lytle creek	54.43		
			54.43	
78	*San Bernardino Mtns.* Cajon Pass creek	61.37		
76	*San Bernardino Mtns.* Intermediate hills	3.43		
79	*San Bernardino Mtns.* Several cañons	12.18		
80	*San Bernardino Mtns.* Devil's cañon	7.68		
81	*San Bernardino Mtns.* Several cañons	4.50		
82	*San Bernardino Mtns.* Twin creeks	18.25		
83	*San Bernardino Mtns.* Several cañons	10.01		
84	*San Bernardino Mtns.* City creek	23.87		
85	*San Bernardino Mtns.* Intmdt cañons	3.12		
86	*San Bernardino Mtns.* Plunge creek	18.50		
87	*San Bernardino Mtns.* Intmdt cañons	3.93		
			166.84	
88	*San Bernardino Mtns.* Lower Santa Ana R.	36.56		
92	*San Bernardino Mtns.* Upper Santa Ana R.	96.43		
89	*San Bernardino Mtns.* Lower Bear creek	17.11		
			150.10	
91	*San Bernardino Mtns.* Bear valley	73.12		
90	*San Bernardino Mtns.* Tributary valley	10.31		
			83.43	
	Santa Ana river—total	.....	233.53	
93	*San Bernardino Mtns.* Mill creek	58.00		
94	*San Bernardino Mtns.* San Timoteo creek	154.60		
95	*And Hills and* Redlands hills	20.70		
96	*San Jacinto Mtns.*	14.00		
			247.30	
104	*San Jacinto Hills.* Riverside cañons	129.87		
105	*San Jacinto Mtns.* Temescal creek	92.62		
106	*Coast Range.* South river cañons	24.12		
107	*Coast Range.* Chino Hills	19.37		
			265.98	
	San Bernardino basin. Surrounding Mtns.	.....	1,130.19	1,130.19
75	*Outstanding Hills.* Glen Helen hills	2.93		
97	*Outstanding Hills.* Slover Mtn.	0.25		
98	*Outstanding Hills.* Spanishtown hills	1.25		
			4.43	
99	*Outstanding Hills.* Jurupa hills	3.12		
100	*Outstanding Hills.* Jurupa hills	6.81		
101	*Outstanding Hills.* Jurupa hills	0.87		
102	*Outstanding Hills.* Jurupa hills	2.81		
			13.61	
	San Bernardino basin. Outstanding hill	.....	18.04	18.04
103	*San Bernardino Valley. Plains and mesas.*	.....	508.81	508.81
	SAN BERNARDINO BASIN. TOTAL	.....	.....	1,657.04

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TABLE OF DRAINAGE AREAS—Continued.

	COAST PLAIN DRAINAGE AREA.			
115	*Coast Range.* Trabuco, San Juan, and Alisos creeks, etc.	110.68		
114	*Coast Range.* Hill slopes	32.12		
113	*Coast Range.* Santiago creek	78.68		
112	*Coast Range.* Burruel point hills	2.68		
111	*Coast Range.* Burruel point hills	2.10		
110	*Coast Range.* Santa Ana cañon	35.75		
109	*Coast Range.* Brea, and other cañons	61.56		
			323.57	
108	*Coast Range, Hills, etc.* Puente hills	20.81		
134	*Coast Range, Hills, etc.* San Gabriel hills	7.06		
133	*Coast Range, Hills, etc.* Rolling hills (E. L. A.)	19.06		
132	*Coast Range, Hills, etc.* Rolling hills (W. L. A.)	9.37		
			56.30	
131	*Cahuenga Mtns.* Slope to Santa Monica plain	29.31		
130	*Cahuenga Mtns.* Slope to the sea	64.25		
			93.56	
	Coast Plain, Drainage Area, Mountains, and Hill Slopes—total	.....	473.43	
				473.43
121	*Outstanding Hills.* Palos Verdes	19.31		
122	*Outstanding Hills.* Palos Verdes	4.18		
123	*Outstanding Hills.* Palos Verdes	6.31		
			29.80	
124	*Outstanding Hills.* Redondo hills	13.78	13.78	
128	*Outstanding Hills.* Centinela hills	9.37		
127	*Outstanding Hills.* Rolling hills	7.18		
126	*Outstanding Hills.* Rolling hills	11.12		
			27.67	
120	*Outstanding Hills.* Long Beach hills	13.68		
119	*Outstanding Hills.* Mesa	3.62		
118	*Outstanding Hills.* Mesa	11.12		
			28.42	
	Coast Plain, Drainage Area, Outstanding Hills	.....	99.67	
				99.67
117	*Coast Mesa*	.....	177.00	
				177.00
135	*Coast Plain.* Coast plain proper	721.58		
129	*Coast Plain.* Santa Monica plain	88.81		
125	*Coast Plain.* Redondo, etc., valley	71.75		
	Coast plain—total	.....	882.14	
				882.14
116	San Juan valley	.....	12.50	12.50
	COAST PLAIN, DRAINAGE AREA. TOTAL.	.....	.....	1,644 74

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APPENDIX B.

PLANS OF STORAGE DAMS.

There are included within the covers of this volume twelve plates, illustrating the construction of dams for the storage of water. They are not properly a portion of the contents of this part of the report; but for reasons already given for inserting herein the larger maps, the dam plans are also now put forward. These cuts, of which the originals have been made at various times during the past four years, were intended to accompany a general and quite full discussion of the subject of water storage, which was written for the closing volume of this report. The whole work has dragged so lamentably, however, for want of sufficient means to carry it promptly forward to a termination, that now, as will be recognized by engineers, some information on several of these plates is behind the times.

They will, it is hoped, serve a good purpose to convey to the general reader a better idea than is had of the water-storage subject. Accompanied with the descriptions, discussions, and tabulations which, it is hoped, will be published, they may be of service to engineers, for purposes of generalizing and comparing projects and preliminary plans. Credit will be given sources of information on this subject, when the descriptions are published. It is believed that this is the first presentation of plans of a number of the Californian dams.

Plate No. 1—Masonry and Concrete Dams.

Fig. 1.—THE HABRA DAM—masonry; 116.5 feet high; built by the French in Algeria, for purposes of water-storage. Has failed.

Figs. 2, 3, and 4.—THE BAN DAM—masonry; 157 feet high; St. Chamond water-works; river Gier, France. One of the handsomest and best works.

Figs. 5, 6, and 7.—THE FURENS DAM—masonry; 170 feet high; St. Etienne water-works, river Furens, France. One of the highest and finest works.

Figs. 8, 9, and 10.—THE GEELONG DAM—concrete; 51.4 feet high; Geelong water-works; Stoney creek, Australia. A monolithic concrete work, notable because of methods of construction.

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Plate No. 2—Masonry Dam.

Figs. 1, 2, and 3.—THE GILEPPE DAM—masonry; 154 feet high; Verviers water-works; Gileppe river, Belgium. A magnificent structure, but generally considered by engineers much heavier than necessary.

Plate No. 3—Masonry and Concrete Dams.

Figs. 1, 2, and 3.—THE TIBI DAM—masonry; 134 feet high; Irrigation water storage; Monegre river; Alicante, Spain. Old style. Unnecessarily massive.

Figs. 4 and 5.—THE OLIVA OR LOZOYA DAM—masonry and rock; 105 feet high; Madrid water-works, Spain. No special type.

Fig. 6.—SETTON'S DAM—masonry; 72 feet high; river Yonne, France.

Figs. 7, 8, and 9.—OLD CROTON DAM—concrete and masonry; 78 feet high; New York water-works. A notable dam in its day.

Plate No. 4—Masonry and Concrete Dams (California).

Figs. 1, 2, and 3.—BEAR VALLEY DAM—broken-coursed masonry; 60 feet high; storage of water for irrigation; Bear valley, San Bernardino county, California; described on page 179 of this volume; Mr. F. E. Brown, constructing engineer. Remarkably light section. See artotype illustration.

Figs. 4, 5, and 6.—SWEETWATER DAM—uncoursed rubble masonry; 90 feet high; storage of water for irrigation and domestic supply; Jamacha valley, Sweetwater river, San Diego county, California; described on page 59 of this volume; Mr. James Dix Schuyler, constructing engineer. [These cuts were made from the preliminary plans of the work, and do not do it justice as it has been constructed, in matter of appearance, at least.] See artotype illustrations.

Figs. 7, 8, and 9.—CRYSTAL SPRINGS DAM—concrete blocks built in place; projected 170 feet high; now in construction; Spring valley water-works, San Mateo county, California; for San Francisco city supply; Mr. Hermann Schussler, constructing engineer. [These cuts were made from preliminary plans, and probably do not do the structure justice in matters of appearance. The work will be described in the special chapters on water storage to appear in the closing volume of this report.]

Plate 5 (1)—Masonry and Concrete Dams.

Figs. 1 to 9, inclusive.—COMPARATIVE CROSS-SECTION cuts of nine principal masonry and concrete dams built or projected in the world, and whose forms approach the accepted or most approved types or styles. [It was supposed at the time these drawings were made that the Quaker bridge dam, of New York, would certainly be in construction by the time they were issued, and so it was thus marked, but it is understood to be still in abeyance.] (1) This plate is erroneously numbered 6 in the lithograph.

Plate 6 (2)—Masonry and Concrete Dams.

Figs. 1 to 15, inclusive.—COMPARATIVE CROSS-SECTION cuts of notable masonry and concrete dams in the world; showing, in some cases, great eccentricity of sectional forms and dimensions. The first of these—the Puentes dam—failed, from defective foundation. (2) This plate is erroneously numbered 7 in the lithograph.

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Plate 7—Earthwork Dams.

Figs. 1 and 2.—LLANNEFYDD DAM.—Earthwork with clay puddle-wall; one hundred and fifty feet from bottom of puddle trench to top of dam; a remarkable instance of great depth to get a foundation, of large proportion of cost below ground, and variety of materials encountered in going down. Rhyl District water-works, River Clyde, Wales.

Figs. 7 and 8.—YARROW DAM.—Earthwork with clay puddle-core; one hundred and seventy-three feet from bottom of puddle pit to top of dam; another remarkable instance, in the matter of foundation, and notable for same reason as that next preceding. Liverpool water-works, England.

Figs. 3 and 4.—DODDER DAM.—One hundred and fifteen feet, foundation to top; notable instance of good rock foundation easily obtained; drainage and water-power purposes, river Dodder, Ireland.

Figs. 5 and 6.—VEHAR DAM.—Eighty-four feet, extreme height; another notable instance of foundation easily obtained. Bombay water-works, river Goper, India.

Plate No. 8.—Earthwork Dams.

Figs. 1 to 9, inclusive.—COMPARATIVE CROSS-SECTION cuts of English, Irish, and French earthwork dams; showing peculiarities of form, disposition of materials, arrangement of outlets, and placing of revetments.

Plate No. 9 (2)—Earthwork Dams (California).

Figs. 1 and 2.—PILARCITOS DAM—earthwork with clay puddle-wall; 95 feet high above ground-line; Spring Valley water-works, San Francisco city supply.

Fig. 3.—UPPER CRYSTAL SPRINGS DAM—earthwork; a notable instance of difficulty in getting to impervious foundation, and of great variety of materials encountered in the attempt; Spring Valley water-works, San Francisco city supply.

Figs. 4 and 5.—SAN ANDRES DAM—earthwork with clay puddle-wall; 93 feet high above ground-line; instance of an old dam added to, showing stepping-in of new work and splicing of puddle-wall; Spring Valley water-works, San Francisco city supply.

Plate No. 10.—Earthwork Dams (California).

Figs. 1, 2, and 3.—TEMESCAL DAM—earthwork with clay puddle-wall; 95 feet high above old bottom of creek; an instance of construction, in great part, of a dam by the sluicing process; Contra Costa Water Company, Oakland water-supply, Alameda county.

Figs. 4 and 5.—SAN LEANDRO DAM—earthwork with selected core; 120 feet high above ground-line; another instance, more marked, of construction by means of sluicing; Contra Costa Water Company, Oakland water-supply, Alameda county.

Plate No. 11—Rock and Crib Dams (California).

Figs. 1, 2, and 3.—BOWMAN DAM—old crib work added to with rock; planked upper face; 100 feet high above foundation; water storage for hydraulic mining; Cañon creek, Nevada county.

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(2) On this plate the title of the English dam, of which the cuts are on plate 11, has been erroneously shown by the lithographer.

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Figs. 4, 5, and 6.—FORDYCE DAM—rock work faced with plank; not completed to full intended height; now 90 feet in extreme altitude; water storage for hydraulic mining; South Yuba river, Nevada county.

Fig. 7.—(1) ENGLISH DAM.—Old crib work added to with rock; one hundred and thirty-one feet in extreme height; one of three dams forming the reservoir; water storage for hydraulic mining; branch of the Yuba river; Nevada county, California. This dam gave way and went out several years ago. (1) The title for this cut was placed by error in lithographing, on plate No. 9.

Figs. 8 and 9.—TUOLUMNE COUNTY DAM.—Timber cribwork; forty-five feet in height; storage of water for hydraulic mining; south fork of Stanislaus river, Tuolumne county.

Plate No. 12.—Comparative Dam Section.

Figs. 1 to 18.—CROSS-SECTION cuts of dams of various styles and materials, drawn to a uniform height of fifty feet. Illustrating pure types of dams and intermediate or component examples; comparative sectional area; disposition of materials, etc. Intended to be accompanied by a discussion and tabular data in a special chapter of closing volume. Of course, not all of the examples in this exhibit are to be commended; and some are radically unsound in principle.

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MEMORANDUM.

ACKNOWLEDGMENTS.

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[1] Review of this case held out for insertion in chapter on Irrigation and Water District Laws. It should have been noticed, herein, under head of *Cate* ditch, and not under head of *Standifer* ditch.

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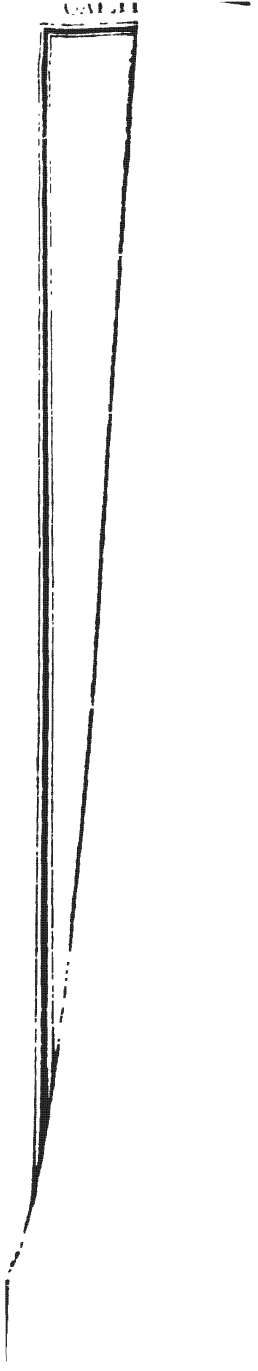
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