ENGINEERING REPORT

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SAN LUIS REY IRRIGATION DISTRICT

W. L. [illegible], CIVIL ENGINEER

ENGINEERING REPORT

[redacted]

SAN LUIS REY IRRIGATION DISTRICT

W. L. [redacted], CIVIL ENGINEER

Property of Ed Fletcher
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CAL

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EARLE FREEMAN
SECRETARY

STATE OF CALIFORNIA
DEPARTMENT OF ENGINEERING
SACRAMENTO November 4th, 1918.

Colonel Ed. Fletcher,
920 Eighth Street,
San Diago, California.

Subject: San Luis Rey Irrigation Project.

Dear Sir:-

Agreeable to verbal request made by yourself to me some months ago, I had an exhaustive examination made of the properties of the Volcan Land and Water Company, by Mr. Walter L. Huber of San Francisco, with the possible plan in view of organizing an irrigation district to be called "San Luis Rey Irrigation District." Copies of this report are herewith submitted to you, dated November 4th, 1918.

The report is approved by myself as to values and suggested mode of procedure, and forms a part of the records of this office.

Very truly yours,

W. F. McClure

STATE ENGINEER.

WFM:LKA

WALTER LEROY HUBER
CIVIL ENGINEER

Mr. W. F. McClure,
State Engineer,
Sacramento, Cal.

Dear Mr. McClure:

I am submitting herewith a report of my investigation, made at your request, of a proposed Irrigation District in San Diego County to be known as San Luis Rey Irrigation District.

The plan proposed for the District is one by which it will acquire certain reservoir sites and water rights along San Luis Rey River from their present owners, the Volcan Land and Water Company. This Company proposes, in disposing of its lands and water rights, to reserve the right to generate hydro-electric power at two power drops on the main conduit and, in reserving this right, it relieves the District of the cost of constructing forebays and power houses and, also, steel penstocks, which comprise expensive sections of the District's main supply canal. My report covers the proposal submitted by Volcan Land and Water Company - no estimate of the cost of the hydro-electric works to be constructed at the Company's expense has been prepared, since your Department is concerned only with the burden which may be acquired by the District. A final agreement between the District and the Company will also involve payment for certain works at Warner Dam Site, including cut-off wall, outlet tunnel and a certain length of concrete lined conduit. While the total cost of works to be acquired or constructed by the District has been carefully considered and includes all of these necessary works at Warner Dam Site,

it was not believed necessary to include in this report a detailed appraisal which will be required only as a basis of settlement between the Company and the District.

I wish to particularly direct your attention to the difficulty of making estimates under present conditions. Prices for both materials and labor are now higher than ever before. The period of these high prices is indefinite, but it will probably not continue during the entire period of construction of the District's works. It is probable, however, that the more stable prices of pre-war times will not again be reached for a long period. It is thus evident that an estimate of cost of constructing the District's works cannot be made with accuracy because prices which will be effective when the work is actually contracted or performed cannot be foretold. Present prices, as utilized, are a safe basis for a report to govern the approval of the District by State authorities who are concerned with the security of a bond issue sufficient to supply funds for completing the system. It is hoped that interested land owners will appreciate the possibility of constructing the system, by the time the organization of the District has been completed, for a somewhat reduced cost.

I recommend that the works of the District be constructed in accordance with a plan for progressive development in order to avoid, so far as possible, expenditures far in advance of their need as occasioned by actual development of the District. For instance, Warner Dam need not be constructed to full height for some years. A plan for progressive

development should govern the construction of the distribution system.

My estimate of the safe yield of the water supply upon which the District will be dependent may be considered conservative since it is based upon the nine consecutive years of drought which produced the most critical period ever recorded in Southern California. Ordinarily a yield far in excess of that which I have determined to be a net safe yield will be available.

Very truly,

W. L. Huber
CIVIL ENGINEER.

San Francisco, Cal.
November 4,1918.

WALTER LEROY HUBER
CIVIL ENGINEER

E N G I N E E R I N G R E P O R T

UPON

PROPOSED SAN LUIS REY IRRIGATION DISTRICT

W. L. Huber, Civil Engineer,
San Francisco, California.

November 4, 1918.

WALTER LEROY HUBER
CIVIL ENGINEER

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W. L. Huber
CIVIL ENGINEER.

San Francisco, Cal.
November 4, 1918.

TABLE OF CONTENTS.

Page

TABLE OF CONTENTS.

Page

TABLES.

PLATES.

Plate 10. - Fig. 1. Metal Flume Section, Escondido Mutual Water Company's Supply Conduit.
Fig. 2. Hellhole Power Drop, Proposed Conduit of San Luis Rey Irrigation District.

Plate 11. - Fig. 1. Escondido Mutual Water Company's Supply Ditch.
Fig. 2. Storage Dam, Escondido Mutual Water Company's Bear Valley Reservoir.

Plate 12. - Cross Sections of Main Supply Canal.

Plate 13. - Cost of Concrete Pipe in Place.

Plate 14. - Fig. 1. Concrete Trestle on San Dieguito Mutual Water Company's System.
Fig. 2. 42" Concrete Siphon on San Dieguito Mutual Water Company's System.

WALTER LEROY HUBER
CIVIL ENGINEER

PLATES.

Plate 1. - General Map San Luis Rey Irrigation District.

Plate 1(a). - Fig. 1. A View in San Marcos.
Fig. 2. San Marcos Valley.

Plate 2. - Fig. 1. Warner Reservoir Site where principal storage Reservoir for District is to be constructed.
Fig. 2. An Orchard Near Vista.

Plate 2(a). - Fig. 1. Grazing land in Warner Ranch comprising portion of Warner Reservoir Site.
Fig. 2. One of the many lakes in Warner Ranch.

Plate 3. - Capacity and Area Curves Warner Reservoir.

Plate 4. - Diagram showing conserved evaporation from swamp lands - Warner Reservoir Site.

Plate 5. - Mass Diagram for Warner Reservoir.

Plate 6. - Tabulation of Duty of Water for Crops in San Diego County.

Plate 7. - Fig. 1. Progress View of Construction of Cut-off Wall, Warner Dam Site.
Fig. 2. Stream Gaging Station, Warner Dam Site.

Plate 8. - Fig. 1. Upper Portal of Outlet Tunnel, Warner Dam Site.
Fig. 2. Settling Basin at Lower End of Outlet Tunnel, Warner Dam Site.

Plate 8(a). - Figs. 1 & 2. Concrete Lined Canal completed by Volcan Land and Water Company, part of Warner Hellhole Conduit Line.

Plate 8(b). - Fig. 1. Merriam Dam Site from the Reservoir Site.
Fig. 2. A Street in Vista.

Plate 8(c). - Map of Merriam Reservoir Site.

Plate 9. - Plan of Proposed Warner Dam.

ENGINEERING REPORT UPON
PROPOSED SAN LUIS REY IRRIGATION DISTRICT.

DESCRIPTION

Location:

San Luis Rey Irrigation District is located in the northern portion of San Diego County, California, from two to twelve miles inland from the Pacific Ocean and immediately south of the San Luis Rey River. It extends most of the distance from Oceanside to Escondido. The towns of Vista, Buena, San Marcos and Richland are included within its boundaries. The Atcheson Topeka and Santa Fe Railroad Company's branch line from Oceanside to Escondido extends almost through the center of the District. (See Plate 1 for general map.)

Topography:

The entire District is rolling land - most of it suited for growing orchards. Citrus orchards thrive except in the area nearest the coast. The bottom lands of some of the valleys, particularly in the region of San Marcos, are well suited to other crops. While most of the land is hilly, it is not generally of such broken character as to make its cultivation particularly difficult.

CLIMATE.

Rainfall:

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CLIMATE.

Rainfall:

Fig. 1. A View in San Marcos.

Fig. 2. San Marcos Valley.

A record of precipitation has been kept at Escondido, just above the District, since 1894 and, although there are some breaks in this record, it is practically complete since July, 1897. This record shows a normal rainfall of 14.56 inches up to and including the calendar year 1917. A record of eight years is available at Oceanside, just below the District and on the coast. This record is hardly long enough to very definitely establish the normal precipitation but, by comparing it with the record of Escondido for each year of record, it is found that the precipitation at Oceanside averages 74% of that for Escondido. It is probable that the average precipitation throughout the District is approximately 13 inches. Many crops are produced without irrigation, but farming in this manner is not at all certain and offers, on the whole, a very uncertain remuneration.

Temperature:

At Escondido a record of twenty-four years gives the annual mean temperature as 60.5°, the maximum temperatures ever obtained are about 113°, and, while a record of the Weather Bureau over a long period of time shows that a temperature as low as 13° has been recorded, such low temperatures are quite unusual. The climate is in general quite uniform and well suited to the growth of orchards or truck gardens.

Seasons:

While it is true that most of the annual

precipitation is recorded from November to March, the climate is characterized by a total absence of distinct seasons. With irrigation, crops can be grown almost continuously throughout the year.

CROPS.

The ability of the lands within the proposed District to successfully produce good crops is already well demonstrated. Instances are the excellent citrus orchards about Vista, grown with even an inadequate water supply, and the prosperous farms in the San Marcos region.

All of the tillable lands are capable of intensive farming and will, when thus farmed, produce the most valuable crops. A large percentage of the District will finally be planted to citrus orchards. Other lands, some of which are now producing bean crops without irrigation, will with irrigation produce truck garden crops throughout the year. A portion of the District is also well suited to growing olives.

SOILS.

Within the boundaries of San Luis Rey Irrigation District there is a considerable variation of soils. Much of the land is rolling. Hilly land is often gravelly and is generally well drained. With very few exceptions,

these hilly lands have a soil covering of ample depth and are well suited for orchard culture.

Many of the swales are partially filled with alluvial deposits. These lands are better suited for gardening or other non-orchard crops. Their soils are rich and, in many places, sufficiently moist to grow crops with more or less success without irrigation. With general irrigation of the District, some of these lands will probably soon show tendencies of water-logging and will then need drainage.

The Bureau of Soils of the U. S. Department of Agriculture has classified the soils within the District (Field Operations of the Bureau of Soils, 1915) as being principally of the following five classes: Montezuma adobe, Sierra sandy loam, Placentia loams, Olympic adobe soils and Las Flores and Kimball loams.

These several classes are described as follows:

Montezuma Adobe:

"The Montezuma clay adobe consists of a dark-gray to black clay with typical adobe structure. In drying the soil checks and cracks; the larger cracks, roughly dividing the surface into blocks a foot or more across, may extend to the subsoil. Smaller cracks, both vertical and horizontal, further break up the soil mass. The soil is untillable when wet or dry, but can be pulverized fairly well if cultivated when in an intermediate stage of moisture. When cultivated the excessive cracking is prevented and both the surface soil and subsoil store and retain a large supply of moisture. In places the dark-colored soil extends to a depth of 4 or 5 feet without change, but usually a light-brown, yellowish-brown, or grayish-brown subsoil, similar in texture to or lighter than the surface soil, is developed at any depth from 12 to 35 inches. The subsoil layers are subject to considerable variation in structure, but usually they are quite compact and include occasional semi-cemented layers. A grayish stratum often underlies the surface soil. Both surface soil and subsoil are apparently calcareous. The deeper underlying material of

the type often consists of gray, clayey beds with a peculiar bleached appearance.

"The Montezuma clay loam adobe consists of a dark-gray to black clay loam which upon drying assumes a little less pronounced adobe structure than the clay adobe, but is otherwise quite similar."

Sierra Sandy Loams:

"The Sierra sandy loam consists of a friable, micaceous, light-red or pronounced reddish brown sandy loam, varying greatly in depth. The soil is rather free from stone fragments even in the midst of rock outcrop, owing to the rather thorough disintegration of the parent rock. Rock outcrop is in places abundant, and in few instances are there large areas without some exposures. Bowlders occur occasionally, but it is not usually necessary to remove many stones to put the land in condition for cultivation, as areas that are suitable for tillage in respect to soil depth and topography are usually also rather stone free. In places the red sandy loam surface soil grades rather sharply at any depth from 10 to 36 inches into a redder subsoil which is typically much heavier in texture, practically a clay loam. The subsoil becomes hard and flinty when dry and cracks upon exposure. Below the subsoil the material becomes a little more friable in structure and passes through zones of disintegrating granite into the parent rock, which is usually encountered within 6 feet of the surface. A variation in the type occurs where the surface sandy loam extends to the underlying rock with little change except that the material is usually somewhat lighter colored near the bedrock, and varying thicknesses of rotten granite are encountered before the unaltered rock is reached. The parent rock here is encountered at any depth below a few inches, its average depth perhaps being about 3 or 4 feet.

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"Topography and drainage. - The Sierra sandy loams occupy the smoother, rather rock free, and more deeply weathered parts of the excessively rough and mountainous areas in which they occur. The surface is rolling or hilly. Nearly all the land is tilled or tillable, and the included unarable bodies are usually nonagricultural by reason of their stone content rather than on account of steep surface. Drainage over these soils is typically excellent; the runoff is not often too rapid or damaging, owing to the ease with which the rainfall is absorbed.

"Utilization. - The Sierra sandy loams are the principal agricultural soils in the central part of the San Diego area from the northcentral part southeastward to the southern boundary. They are recognized as valuable soils for a wide range of fruit and other intensive crops, but they can be fully utilized along these lines only in exceptional cases, owing to a general lack of water for irrigation. As a consequence, their principal use is for growing grain and grain hay. In some places, where the soil is deep and moister than usual, the land is utilized without irrigation for producing fruits, including grapes. Very good results have been obtained, careful cultivation assisting to overcome the disadvantage due to the normally low rainfall. Irrigation has been supplied for some of the soils of this group around Escondido and elsewhere, and where the local climatic conditions are favorable some citrus orchards and many deciduous orchards are in bearing, with more extensive plantings under way. Olives are a prominent crop in some localities. There are many home orchards, vineyards, and gardens on these soils."

Placentia Loams:

"The Placentia loam typically consists of a reddish-brown or red, light to medium textured loam, nearly always free from gravel or rock fragments, underlain at 10 to 18 inches by a more compact red or reddish clay loam subsoil, which usually continues to a depth of 72 inches or more. Under the most favorable conditions the subsoil is only fairly compact and is permeable to both roots and water, but in places it is hard and semicemented. Normally there is no distinct hardpan, but lenses or intermittent layers are developed locally, in which case the soil profile very closely resembles that of the San Joaquin series, extensively mapped in other parts of the State. The dense subsoils are in places almost as unfavorable to plant growth as a true hardpan.

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"Topography and drainage. - The group occupies sloping or very gently rolling areas, with surface features fairly distinct from those of the recent-alluvial soils and from the higher lying residual soils. Much of the area near San Marcos has a hummocky surface. In general the topography favors good drainage, but the dense subsoil retards underdrainage, and locally the depressions between the mounds retain much water during or shortly after the rainy season. These soils in the Escondido and El-

cajon Valleys have a smoother surface and a somewhat higher agricultural value than over most of their extent.

"Utilization. - In the better areas in the Escondido and Elcajon Valleys the Placentia loams are valuable soils, utilized for the production of citrus fruits, grapes, and other intensive crops. Irrigation is used for some of the crops, and conservation of moisture by thorough tillage is relied upon for others. The greater part of the area near San Marcos is used either as pasture land or for the production of dry-farmed grain hay."

Olympic Adobe Soil:

"The Olympic clay adobe consists of a brown or dark-brown clay with marked adobe structure. The soil is refractory, being sticky when wet and hard when dry, but it is fairly easy to till under certain moisture conditions. It is normally rather free from stone, but rock outcrops are numerous. The soil material may extend to the parent rock with little change, but usually it becomes lighter colored at a depth of 8 to 14 inches and grades below this depth through layers of partially disintegrated rock of considerable thickness before the lower limit of root penetration is reached. The subsoil is sometimes slightly reddish in color, and it is typically more friable than the surface soil. The depth of the soil material is in places 6 feet, but it usually is much less, averaging probably about 3 feet.

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"Utilization. - About 50 per cent of the land is used for the production of dry-farmed grain and hay. The soil is capable of storing large supplies of moisture, and good yields are obtained. Over part of the group, however, the soil is shallow. The heavy texture, which hinders cultivation, will probably limit the use of these soils to the production of the present crops. As is true of the other residual types, the Olympic adobe soils can not be as widely used for intensive crops under the normal rainfall as can the deeper, moister, recent-alluvial soils."

Las Flores and Kimball Loams (undifferentiated):

"The Las Flores sandy loam consists of a light-gray or light brownish gray, nonmicaceous sandy loam, which is nearly everywhere free from gravel or rock fragments. Typically an exceedingly compact brown, grayish-brown, or reddish-brown clay loam or clay, sub-

Fig. 1. Warner Reservoir Site where principal Storage Reservoir for District is to be constructed.

Fig. 2. An Orchard Near Vista.

Fig. 1. Grazing land in Warner Ranch comprising portion of Warner Reservoir Site.

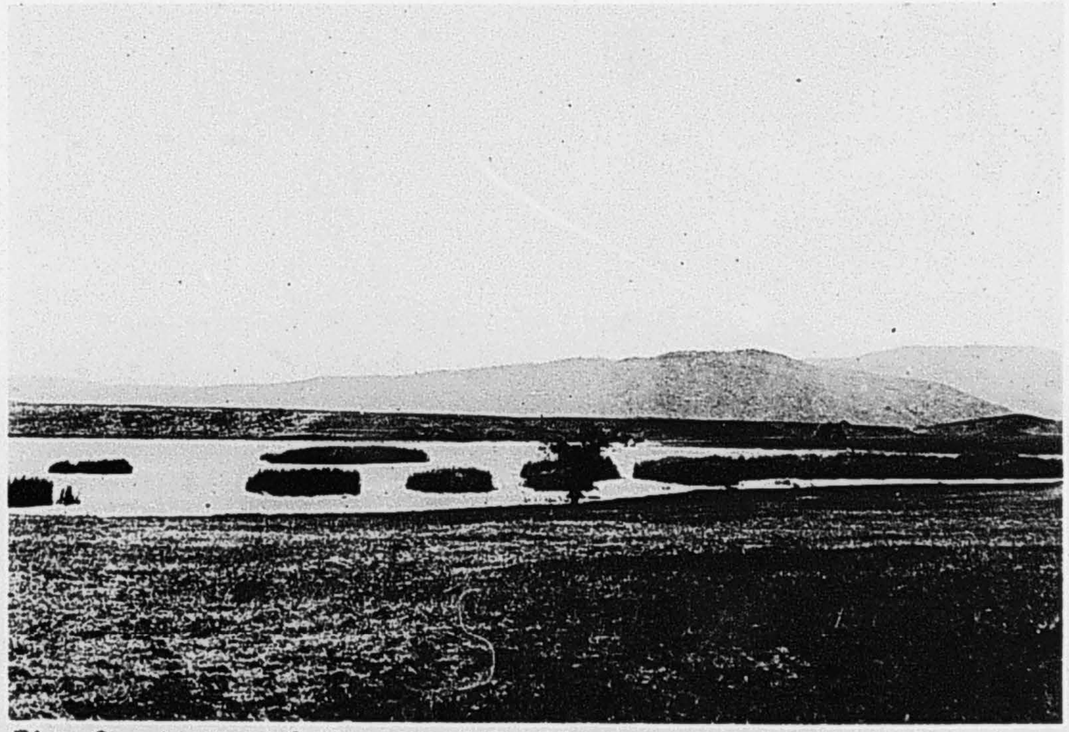

Fig. 2. One of the many lakes in Warner Reservoir Site.

soil is developed at depths of 10 to 24 inches and continues without much variation to a depth of 6 feet or more. The subsoil becomes hard and flinty when dry and cracks upon exposure. It is usually unfavorable for root development and rather impervious. Distinct hardpan layers or gravelly substrata are normally lacking. The soil is friable when moist, but hard and compact when dry.

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"The Kimball sandy loam typically consists of a reddish-brown or brown, nonmicaceous sandy loam. It is usually free from gravel and is easily tilled when moist, but like the other types of the group becomes very hard when dry. At any depth from 12 to 36 inches, the surface grades sharply into a compact, heavy-textured subsoil which normally extends to a depth of 6 feet or more. The subsoil becomes flinty and cracked when dry, and is too compact to be easily permeated by water or penetrated by roots. It ranges in color from brown to reddish brown or even red in a few places, and quite commonly is mottled."

WATER SUPPLY.

General Conditions:

San Luis Rey Irrigation District will receive its water supply from the San Luis Rey River, almost entirely from storage afforded by Warner Reservoir. This reservoir is some 25 miles east of the District upon the well known Warner Ranch (Plate 2, Fig. 1). At the lower end of this broad level ranch, the San Luis Rey River enters a gorge and drops more rapidly. At the head of this gorge an earth fill dam will impound the storage upon which the District will depend largely for its water supply.

The ultimate storage capacity contemplated for

Warner Reservoir is 200,000 acre feet which will have a flood line 107 feet above the stream bed at the dam site. It is proposed that the first construction be such as to raise the flood line to only 100 feet above the stream bed, thus storing 164,000 acre feet. Studies of water supply will, of course, be based upon the ultimate storage capacity.

In addition to the reservoir site, its present owners also own approximately 98% of all riparian rights on San Luis Rey River from the dam site to the Pacific Ocean. Unfortunately for the District, allowance must be made for the rights by appropriation of Escondido Mutual Water Company. In releasing sufficient flow from Warner Dam to satisfy the rights of Escondido Mutual Water Company at the intake of its ditch, a considerable quantity of water is wasted by percolation into the sands of the San Luis Rey River between Warner Dam Site and the Escondido intake, a distance of approximately nine miles. Certain rights of the Indians along San Luis Rey River must also be recognized, but these rights are for small amounts and their recognition does not impose any particular burden.

Throughout that part of the channel of the San Luis Rey River between Warner Dam Site and the Pacific Ocean, many important underground reservoirs are afforded by extensive gravel beds which remain charged from the flow of the river and many large side canyons which join the river in this part of its course. One of the most reliable of these underground reservoirs adjoins the District on the north a

short distance above San Luis Rey Mission and the District is, indeed, fortunate in having here a reserve supply; available only by pumping, but, nevertheless, available even during successive years of drought when most needed. A heavy draft upon this supply may, if necessary, be made by San Luis Rey Irrigation District without depleting the reserve supply of Cardiff Irrigation District, which is now acquiring the system of Oceanside Mutual Water Company including its pumping plant located a short distance below.

Run-Off:

To determine the stream flow available from Warner Reservoir for San Luis Rey District, reference is made to the existing records of stream flow for stations on San Luis Rey River (See Table 1). It will be noted that none of these records extend back of the year 1903. Periods of drought more severe than any during the period of record have occurred in the past and it is reasonable to assume will again occur. The period from 1897 to 1904 is that of the greatest drought authentically recorded for this region, but for even this period there are no complete records of the flow of the San Luis Rey River. It is, therefore, necessary to estimate the flows which would have been available during these years. This is best accomplished by determining a relation between the flow of San Luis Rey River and other streams of Southern California with somewhat similar watersheds and for which records were made during the period of drought. Such relation can be determined for years when sim-

ultaneous records exist and with this relation approximate estimates of the flow of San Luis Rey River can be made for years for which records of the other stream are available. In making such estimates it is found that many complex conditions have an effect. Naturally, a season of heavy precipitation following a like season will supply a far greater seasonal run-off than one following a season of drought. The distribution of precipitation throughout the season also has a marked effect upon the total seasonal run-off.

An estimate of the net safe yield of Warner Reservoir was prepared in February, 1917, by a board of engineers consisting of J. B. Lippincott, H. Hawgood, Francis L. Sellew and William S. Post. This estimate is based upon an estimate by Mr. H. Hawgood of the annual run-off for the years preceding those for which stream flow records are available as far as 1888-89. In preparing this estimate, Mr. Hawgood has platted and has utilized relations between the flow of San Luis Rey River and Sweetwater River, San Diego River, Cuyamaca Reservoir, Hemet and San Gabriel River, respectively. In utilizing the relations thus established, Mr. Hawgood has weighed the values obtained in proportion to the similarity of stream regimen and accuracy of records. After critically reviewing Mr. Hawgood's estimates, I will utilize his results. In doing so I wish to point out that, while they are the best results obtainable, they are approximate estimates. Errors are undoubtedly included because of the questionable accuracy of some of the records utilized and

because of the lack of a fixed relation between the streams compared. Notwithstanding the inclusion of some inaccuracies, the results are close enough to justify their use in this report and as the basis for the formation of the District as outlined.

The estimated annual discharges for these seasons preceding 1903-04 are:

Season	Acre feet
1887-88	23,000
88-89	27,950
89-90	48,000
1890-91	51,000
91-92	21,400
92-93	32,500
93-94	12,810
94-95	98,000
1895-96	7,270
96-97	23,100
97-98	3,950
98-99	2,910
99-00	1,950
1900-01	13,920
01-02	8,840
02-03	16,020

A study of the monthly records of run-off for those years for which records are available shows that approximately 70% of the total annual run-off occurs between October 1 and March 31, and 30% during the remainder of the season (See Table No. 2). Making this allowance for those years for which monthly records of run-off are not available and making a minor correction for a subterranean flow which was not brought to the surface and included in measurements until the construction of Warner cut-off wall, Table 3 has

been compiled to show the run-off for the winter and summer periods of each season.

Evaporation:

Fortunately the Volcan Land and Water Company has for several years and at considerable expense secured quite accurate records of evaporation, not only for Warner Reservoir, but for several other points in San Diego County. These records are given in Table 4.

The report of the board of consulting engineers upon the safe yield from Warner Reservoir, previously mentioned, utilizes a figure for gross evaporation which was derived by Mr. Hawgood. In deriving this figure, Mr. Hawgood utilizes a diagram of relation between elevation, temperature and evaporation, which diagram is an amplification of a similar diagram by Mr. Post, and with this diagram computes the evaporation at Warner Reservoir. His computation begins with a figure by Mr. Post for so called "Actual Net Evaporation" at Cuyamaca Reservoir. The accuracy of Mr. Post's figure for actual net evaporation, in which an endeavor is made to account for so called "make-up" from reservoir and other conditions, is subject to some question. From this figure, by means of a theoretical diagram, Mr. Hawgood derives his figure for Warner Reservoir. Comparison of this figure with the measured evaporation shows a ratio of 76% of the measured or pan evaporation. Mr. Hawgood points out that this ratio is on the safe side as compared with figures of 58.8% to 64.6% by Grunsky, and 62% to 67.5% by Duryea for other lakes. However, the relation of

floating pan observations to actual evaporation is a much disputed point among engineers. Personally I am inclined to agree with Mr. Chas. H. Lee that "for all practical engineering purposes, floating pan observations give the true depth of evaporation from a large body of water." (Transactions American Society of Civil Engineers, Vol. LXXX, page 1925). Consequently I am unwilling to subordinate the results of pans placed to measure evaporation directly at Warner Reservoir to theoretical determinations based first, on so called actual determinations elsewhere and, secondly, on corrections for elevation and temperature. I will utilize the records obtained for the pan in water at Warner Dam (See Table 4) because I believe this record more nearly represents the conditions which will obtain on the proposed reservoir than does the record for Big Lake.

Unfortunately, records for only four years, 1913 to 1916, inclusive, are available for Warner Dam Site. However, even this record, taken directly at the site, is a better one than usually exists for such studies. Probably the mean of these four years is slightly different from the result which would be obtained for a very long period of years, but this difference is not important and I will utilize the available record. The mean of the four years of record is as follows:

	Inches	Per cent.
January	2.59	4.76
February	3.33	6.14
March	4.38	8.08
April	4.81	8.85

	Inches	Per cent.
May	5.05	9.30
June	6.06	11.15
July	7.32	13.45
August	6.84	12.60
September	5.11	9.40
October	3.94	7.25
November	2.77	5.10
December	2.13	3.92
Yearly	54.33	100.00

35% of the total yearly evaporation (average 19.14 inches) occurs between October 1 and March 31, and 65% (average 35.19 inches) between April 1 and September 30.

The losses by evaporation are partially, often entirely, compensated by direct rainfall upon the surface of the reservoir, hence this effect must be studied. There are seven years of recorded rainfall for five stations near Warner Reservoir, three of which are within the flooded area. Table No. 5 shows the record for these stations divided into winter and summer seasons. The observed total average annual rainfall for these five stations is 23.73 inches, 83% of which occurs in the winter season and 17% in the summer season. I have utilized a ratio of 80% - 20% in my calculations. The board of consulting engineers, previously mentioned, in reporting upon the safe yield of Warner Reservoir, have utilized this record and have, by utilizing the average per cent rainfall years for nine base stations in San Diego County, extending over a period of 44 years, estimated the rainfall upon the water surface of the proposed reservoir (See Table 6). It is assumed that 10% of the direct rainfall upon the surface of the reservoir is already accounted for in stream flow, and that but 90%

can be considered as counteracting the effect of evaporation. In compiling Table 6 I have utilized the estimated values for rainfall computed by the board of consulting engineers and have simply added the observed values for the years 1916-17 and 1917-18 without modifying the estimated values, a modification which would add nothing to the accuracy of the final report. A combination of the evaporation losses and gains from rainfall gives the net additions or deductions from the stored supply (See Table 7).

Priorities:

As previously noted, the Volcan Land and Water Company has acquired practically all of the riparian rights on the San Luis Rey River from Warner Dam Site to the Pacific Ocean. The only priorities on the stream which need consideration are those of the Pala Indians, the Rincon Indians and the Escondido Mutual Water Company. The City of Oceanside, at the mouth of the San Luis Rey River, has at various times protested against the construction of a dam at Warner Dam Site, but I will not make any allowance for its claims because, from my knowledge of the stream, it is inconceivable to me that the City of Oceanside should suffer any damage by the construction of such dam. The Pala Indians claim a perennial flow of 6 second feet. Their diversion is just below the Pala gage. Above this diversion a large porous gravel area acts as a regulating reservoir, storing a portion of the winter flood waters and yielding a quite constant flow. Pauma Creek, with a drainage area of twelve square miles, is a perennial stream

which joins the main river above the Pala diversion. This creek and the tributary drainage below the Escondido diversion will, without question, provide the diversion of the Pala Indians. Their claim, therefore, does not require special consideration in studying the safe yield from Warner Reservoir.

The United States Indian Service has a contract with the Escondido Mutual Water Company to supply a stipulated amount of water to the Rincon Indian Reservation. The practice in the past has been for the Escondido Mutual Water Company to stop its diversion in the summer time and for the Indians to take the entire summer flow of the San Luis Rey River, which ordinarily amounts to about 1½ second feet. Warner Dam is about nine miles above the Escondido diversion. The stream goes dry during the summer months about three miles below the dam site and it is not probable that the water passing Warner Dam Site during the summer is the water diverted by the Indians during the summer season since this summer flow goes down stream as an underflow and probably would not travel to the point of diversion in two or three months. Several perennial streams flowing from Pala Mountain probably sustain the flow of the river at the Escondido diversion point. I do not believe that in future operation it will be necessary to release any water from Warner Reservoir to provide for the Rincon Indian Reservation and I have made my safe yield study accordingly.

The Volcan Land and Water Company entered into

a contract with the Escondido Mutual Water Company under date of June 21, 1912. This contract provides that the Escondido Mutual Water Company is entitled to an annual diversion of 4,140 acre feet, that the water may be diverted between November 1 and July 1, that the maximum rate of diversion shall be 40 second feet and that whenever this amount of water is available at the river between the dates mentioned, it shall be considered as contributed to the requirements of the Escondido Mutual Water Company irrespective of whether it is actually diverted by that company or not. It is also provided that if at any time between November 1 and July 1 after the first of July, 1917, the water flowing in the river shall not exceed 100 miners inches (2 second feet) plus the amount required by the Indians, then the said 100 miners inches shall not be considered as included in making up the total diversion to which the Escondido Mutual Water Company is entitled. It is also provided that the Escondido Mutual Water Company shall not be entitled to more water in any year than the actual run-off of the river at the company's point of diversion during such year or, in other words, to more water than would be available for diversion by the company if Warner Dam were not constructed.

There are 33 square miles of drainage area above the Escondido diversion point not tributary to Warner Reservoir. In preparing their report of May 8, 1915, to the City Council of San Diego upon the Volcan Land and Water Company's project, Messrs. M. M. O'Shaughnessy and J. B. Lippin-

cott made a careful study of the run-off from this area tributary to the Escondido diversion point and not to the Warner Reservoir. In making this study, a record of the flow of the West Fork of the San Luis Rey River at a point where it has a tributary area of 24.4 square miles was utilized. A study of the rainfall records led Messrs. O'Shaughnessy and Lippincott to conclude that the rate of runoff per square mile from the area under consideration is approximately equal to that from the West Fork. Thus an estimate was made of the run-off from the area tributary to the Escondido diversion and not to Warner Reservoir Site.

Messrs. O'Shaughnessy and Lippincott then made a further study to determine the amount of water which could have been diverted each season by the Escondido ditch from the San Luis Rey River without regulation, also the amount which could have been diverted each season from the run-off from the 33 square miles below Warner Dam Site and above the Escondido diversion point. When this latter quantity is not equal to 4,140 acre feet, it is necessary, under the provisions of the contract, to release from Warner Reservoir a quantity sufficient to bring the Escondido diversion up to this amount or to the amount which could have been diverted if the dam had not been constructed. Table No. 8 shows the quantities which it is necessary to release from Warner Reservoir each season to meet this requirement. It will be noted that it is necessary to release the greatest quantities during years of drought when the run-off for

Warner Reservoir is least.

Draft:

Irrigation service on the Cuyamaca Water Company's system for the years 1915 and 1916 was as follows:

Month	1915 Acre Feet	1915 Per Cent. of Total	1916 Acre Feet	1916 Per Cent. of Total
January	107.3	3.4	84.5	2.5
February	97.9	3.1	53.1	1.6
March	143.6	4.6	116.2	3.5
April	271.3	8.7	270.0	8.0
May	241.1	7.7	362.4	10.8
June	362.4	11.5	369.3	11.0
July	393.9	12.6	466.1	13.9
August	372.7	11.8	401.9	12.0
September	349.2	11.1	359.5	10.7
October	358.2	11.4	278.5	8.3
November	262.6	8.4	323.1	9.6
December	177.3	5.7	271.7	8.1

For the year 1915, 63.4% of the irrigation supply was delivered between April 1 and September 30, and 36.6% during the remaining or winter months. For 1916 these percentages were 66.4 and 33.6, respectively. The requirements for the area to be included in the San Luis Rey District will probably be quite similar. I will, therefore, assume, in my calculations of safe yield, that two thirds of the delivery must be made between April 1 and September 30, and one third during the winter months.

Conserved Evaporation:

A total area of 1740 acres of swampy land lies within Warner Reservoir Site. Most of this land becomes charged with water during the rainy season and the water thus retarded evaporates to a depth of probably six feet during the dry season. The water which is now lost from these lands by evaporation will be conserved when the area is submerged. Messrs. O'Shaughnessy and Lippincott have estimated that the evaporation losses occurring on these lands are equal to a depth of water of 19 inches per annum over the moist area. On this basis Plate 4 has been prepared to show the quantity of water conserved for any given amount of water impounded in the reservoir. It will be noted that the filling of the upper portion of the reservoir adds nothing to the quantity conserved.

Storage Study:

In studying the draft which could have been supplied from Warner Reservoir, the board of consulting engineers, previously mentioned, made an estimate of the water supply which would have been available for some twenty-eight years previous to the date of their report, then assumed that the use of this supply for irrigation as beginning at the beginning of the estimated record of run-off. The board further assumed that but one tenth of the irrigation draft would exist the first year and that an additional 10% of the total draft would be added each year until the total draft was finally required. I cannot agree with these assumptions.

WALTER LEROY HUBER
CIVIL ENGINEER

Conserved Evaporation:

A total area of 1740 acres of swampy land lies within Warner Reservoir Site. Most of this land becomes charged with water during the rainy season and the water thus retarded evaporates to a depth of probably six feet during the dry season. The water which is now lost from these lands by evaporation will be conserved when the area is submerged. Messrs. O'Shaughnessy and Hippinoott have estimated that the evaporation losses occurring on these lands are equal to a depth of water of 19 inches per annum over the moist area. On this basis Plate 4 has been prepared to show the quantity of water conserved for any given amount of water impounded in the reservoir. It will be noted that the filling of the upper portion of the reservoir adds nothing to the quantity conserved.

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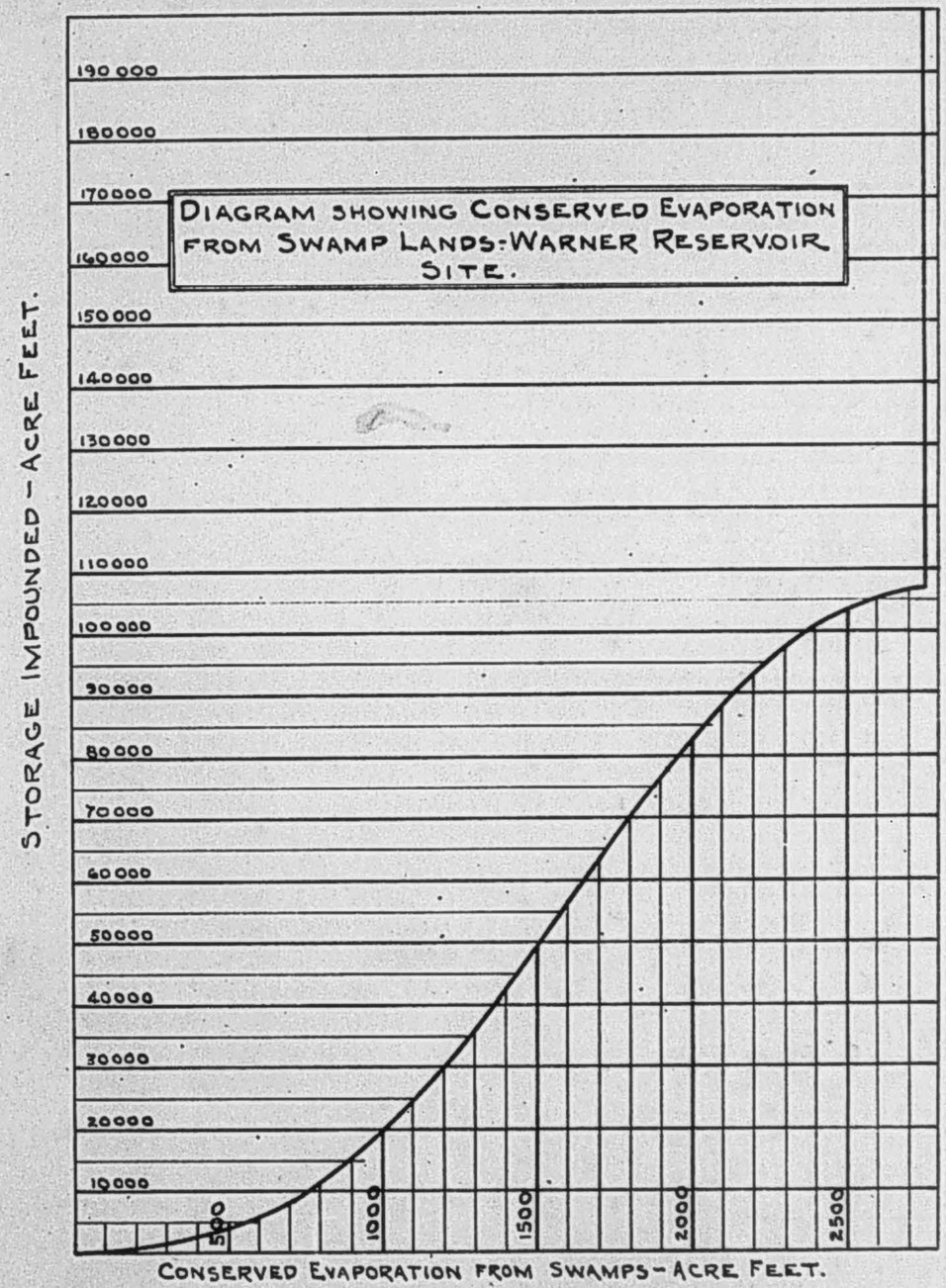
DIAGRAM SHOWING CONSERVED EVAPORATION FROM SWAMP LANDS: WARNER RESERVOIR SITE.
STORAGE IMPOUNDED – ACRE FEET.
190 000
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
500
1000
1500
2000
2500
CONSERVED EVAPORATION FROM SWAMPS – ACRE FEET.

MASS DIAGRAM FOR WARNER RESERVOIR

Draft October 1 to March 31 — 9 300 acre feet.
Draft April 1 to September 30 — 18700 acre feet.

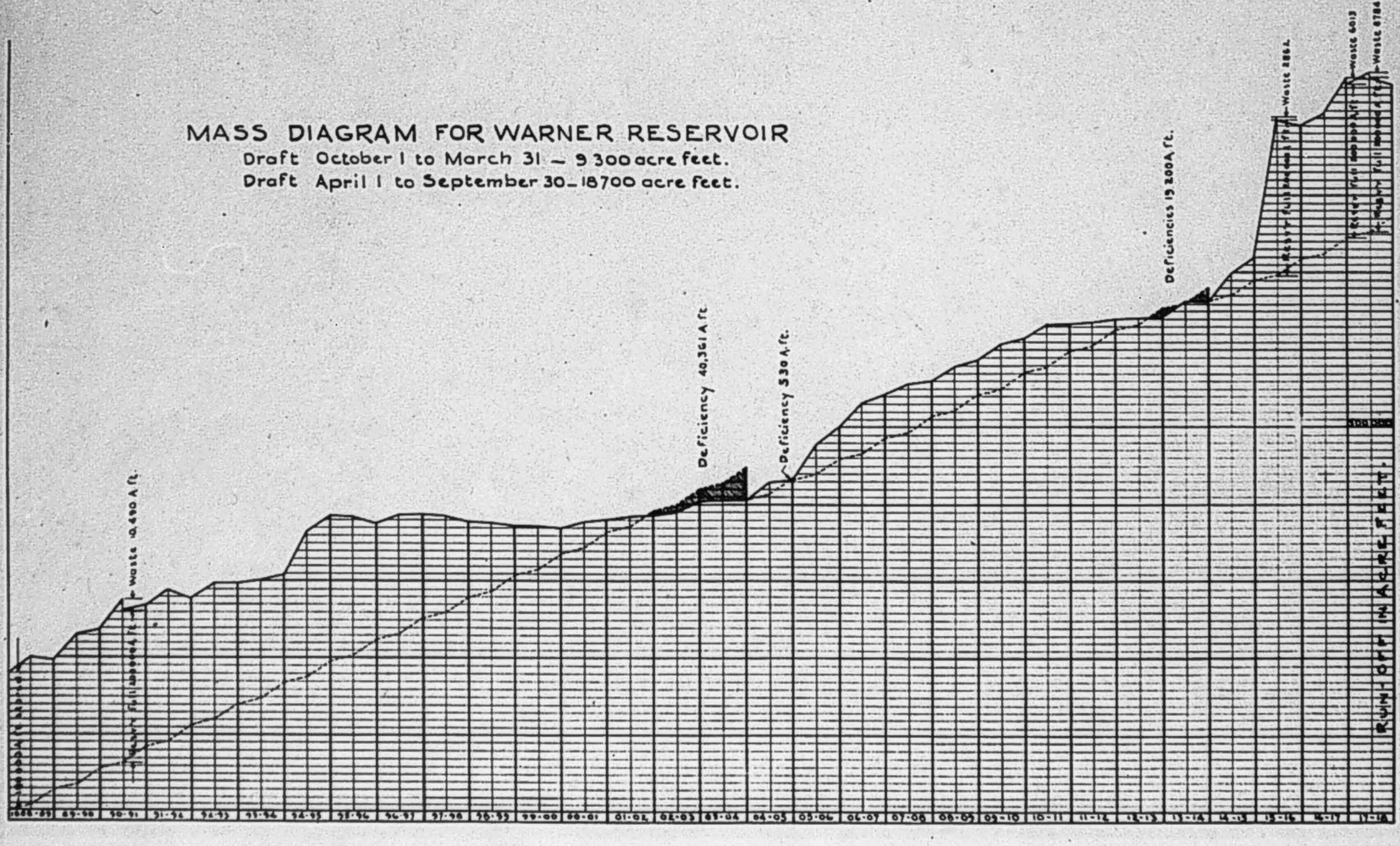

PLATE 5.

We are concerned only with the future. Records of the past are utilized simply to predict the conditions of stream flow which may again occur - probably will again occur. Having a record of the flow of San Luis Rey River for thirty years past, it is reasonable to assume that a period of thirty years will again occur during which the stream flow will be quite similar and that such future period of thirty years will occur after the full irrigation demand has been developed. There is, therefore, no justification for making a study for less than the complete demand during the first ten years.

It is problematical whether such thirty year period will be begun with the reservoir full. Years of low flow recur in cycles. It is, therefore, probable that the years of low flow in the nineties were preceded by years of more abundant run-off. I have, therefore, assumed the reservoir ninety per cent filled on October 1, 1888.

A study of conditions as they would have occurred from October 1, 1888 to September 30, 1918 if Warner Reservoir had been operated to supply, when available, 28,000 acre feet per annum - 9300 acre feet being drawn between October 1 and March 31, and 18,700 acre feet between April 1 and September 30 - is shown in Table 9. The results of this study are also graphically shown by the mass diagram of Plate 5.

It will be noted that during the seasons 1902-03 and 1903-04 rather serious deficiencies occurred. During certain other seasons (1901-02, 1912-13 and 1913-14) lesser deficiencies occurred, but during all of these the partial supply which was

available would have insured partial crops and would have protected all orchards, etc., the available supplies amounting to 80%, 59% and 73%, respectively, of full seasonal supplies.

The more serious deficiency of 1902-03 and 1903-04 is the only serious deficiency which occurred in a period of thirty years and was occasioned by the unprecedented succession of years of drought from 1897 to 1904. Fortunately, San Luis Rey Irrigation District has insurance against even such adverse conditions of stream flow by having available a pumping reserve on San Luis Rey River. The plans of the District include the acquisition of certain lands at the western corner of the Guajome grant, which lands are underlain by one of the most reliable underground reservoirs along San Luis Rey River, and the installation at this point of an adequate pumping plant. During such infrequent occasions as the single period of drought under consideration, it is believed that provision need not be made for more than a 50% supply. To furnish this supply it would have been necessary to pump approximately 3,000 acre feet during the summer of 1903 and approximately 14,000 acre feet during the summer of 1904. This quantity is available from the District's pumping site without injury to the pumping rights of the proposed Cardiff Irrigation District or the City of Oceanside located at lower points along the San Luis Rey River. The irrigation of approximately 7,000 acres of the western portion of the District by pumping can be accomplished quite economically. To irrigate the

higher areas will require the addition of booster pumps and some additional expense. In actual operation it is improbable that these will ever be required because, by operating the reserve pump system, the lower lands could be supplied during the earlier years of a succession of years of drought, thus leaving sufficient water from the gravity supply for the higher lands.

DUTY.

Records of the duty of water for quite similar irrigated areas in San Diego County are available.

At my request Mr. F. M. Faude has prepared a statement of the duty for the area irrigated by Cuyamaca Water Company, this being an area similar to that which will be included in San Luis Rey Irrigation District and one which is planted in mixed crops similar to those which will be grown in the proposed District. The following is quoted from Mr. Faude's statement:

> "On the Cuyamaca Water System the areas irrigated and various crops raised were determined by actual field surveys in 1913 and 1914. This survey covered several months and cost the Company nearly $5,000 for surveys, computations and platting. The net areas irrigated and crops raised were as follows:

	Area Irrigated in Acres			
Crop	Low Service	High Service	Flume Service	Total
Olives ----------	3	198	153	354
Deciduous Fruits ---	22	56	138	216
Grapes ----------	0	1	604	605
Citrus Fruits ------	196	926	1092	2214
Alfalfa ----------	0	12	40	52

Vegetables ---------	52	82	71	205
Ornamental, etc. ---	20	21	38	79
Total -------------	293	1296	2136	3725

The Low Service Area includes lands lying between the limits of the City of San Diego and Old La Mesa. The two Mansur 5 acre tracts are on the easterly edge of the Low Service Area.

The High Service Area includes lands lying between Old La Mesa and Eucalyptus Reservoir. The La Mesa, Lemon Grove and Spring Valley districts are included within the High Service Area.

The Flume Service Area includes all lands east of the Eucalyptus Reservoir and are all served direct from the Company's flume.

While the surveys referred to above were made in 1913-1914 conditions have changed but little since that time and the total areas irrigated will not be materially affected. The areas in citrus fruits, deciduous fruits, olives and grapes are practically the same and practically the only changes will be found in the other crops whose total areas are small.

Owing to the mixed character of crops on lands under irrigation under the system, it will be impossible to give duties of water for any particular crop, such as oranges, lemons, olives, etc., except in isolated cases. The duty of water for the system will therefore have to be worked out as an average one covering all crops.

The duty of water for 1915 was as follows:

	Low Service	High Service	Flume Service	Total
Water delivered acre feet -------	260	1235	1642	3137
Acres Irrigated ---	293	1296	2136	3725
Depth of Water applied acre feet per acre --------	0.89	0.95	0.77	0.84

A full supply of water was furnished in 1915.

The duty of water for 1916 was as follows:

	Low Service	High Service	Flume Service	Total
Water delivered acre feet -------	277	1297	1782	3356
Acres Irrigated ---	293	1296	2136	3725

Depth of Water applied acre feet per acre --------	0.95	1.0	0.83	0.90

A full supply of water was furnished in 1916 except for a short interruption after the floods of January 1916. This interruption was, however, for so short a period and came at a time when the ground was so saturated that the total supply for the year was not appreciably affected.

From an inspection of the computations for duty of water in 1915 and in 1916, it is seen that the use on the flume line is less per acre than on either the high or low service areas. This is explained by the fact that some of the flume line consumers have pumping plants which are operated occasionally. Such operation in 1916 was almost negligible. No definite figures are available to show the actual quantities pumped as the owners of the plants keep no reliable records.

The duty on the high service area in 1915 was 0.18 acre feet more than on the flume service area and in 1916 was 0.17 acre feet less.

If 0.18 acre feet is added to the flume service use to compensate for pumped water from private plants, the 1916 figures become:

Low Service Area ----------	1.00	acre	feet	per	acre.		
High " " ----------	0.95	"	"	"	"		
Flume " " ----------	1.01	"	"	"	"		
Average for entire system -	1.00	"	"	"	"		

On April 1st, 1917, a new schedule of rates went into effect. Under the old rates the irrigator paid at the rate of $65 per year per miner's inch (630,720 cubic feet) for water delivered on the flume and $70 per year per miner's inch for water delivered on the low and high service districts. Each consumer had a certain allowance each month which he could use but not exceed and for which he paid whether he used the water or not. Under the new rates the irrigator pays $4.00 for the first 2,000 cubic feet and for all additional water used, 2-1/2 cents per 100 cubic feet with no restrictions as to minimum or maximum use.

The result has been that use has decreased 27% for the first eight months of operation under the new rates as compared with the corresponding months of the previous year. The table below shows the comparative records:

Month	Use Under Old Rates Year 1916 Irrigation use in Thousand Cu. Ft.	Use Under New Rates Year 1917 Irrigation use in Thousand Cu. Ft.	Percent of Decrease
April	16,649	6,883	59
May	17,896	7,386	58
June	16,087	12,806	20
July	20,304	17,969	12
August	17,507	15,380	12
September	15,659	12,930	17
October	12,133	12,945	# 7
November	14,075	8,356	41
	130,310	94,655	27

= Increase

The decrease shown above is in spite of the fact that the year 1917 has been one of considerably less rainfall than 1916. It is expected by the Company officials that the winter use under the new rates will be considerably less than in 1916.

It is unquestionably true that the new rates will operate to decrease the use of water for irrigation and that the average compensated use for 1916 of 1 acre foot per irrigated acre over the entire system will in 1917 show a substantial decrease, which will undoubtedly amount to at least 20%, giving an average annual use of water on the entire system of approximately 0.80 acre feet per irrigated acre."

Mr. Faude's statement includes the net irrigated area and does not, therefore, include rough, broken or waste lands or dedicated streets or roads.

In reporting upon the probable duty of water for Cardiff Irrigation District Mr. Frank Adams recently stated:

"The Escondido Mutual Water Company, in the irrigation census of 1909, reported a gross project duty of 0.99 acre foot per acre. Mr. J. E. Boal, manager of the Sweetwater Water Company, stated to both Mr. Tait and Mr. Veihmeyer, that his company has found 350,000 gallons per acre (1.07 acre feet) sufficient for citrus orchards, although the amount used by the different irrigators varies somewhat from the usual averages."

TABULATION OF DUTY OF WATER FOR CROPS IN SAN DIEGO COUNTY.

GROWER	LOCATION	WATER SYSTEM SUPPLIED BY	CROPS	NUMBER OF CROPS	ACRES	WATER USED - 1917 CU. FT. TOTAL	WATER USED - 1917 ACRE FEET PER ACRE	WATER USED - 1917 MONTHS IRRIGATED	AVERAGE ACRE FEET PER ACRE TO MATURE ONE CROP
E. HOWELL	GROSSMONT	COYAMACA	TOMATOES, PEPPERS, CUCUMBERS, ETC.	1	18	331580	0.42	5+	0.45
E. GROUND	NORTH LA MESA	"	CITRUS 20 AC. GARDEN 10 AC.	1+	30	1026200	0.79	12	0.70
MANSUR	OLD LA MESA	"	MILO MAIZE	1	25	883590	0.82	4	0.82
MANSUR	"	"	TOMATOES, PEPPERS, CABBAGE, ETC.	1+	5	168310	0.77	12	0.45
W. FISH	TECOLATE VALLEY	CITY SAN DIEGO	"	2	3	79500	0.60	12	0.30
A GUCHI	PACIFIC BEACH	"	"	1	7	34900	0.11	7	0.11
RIAMOTO	"	"	"	½	3.5	46600	0.30	3	0.60
MATSUMOTA	"	"	"	1	6.7	137600	0.47	6	0.47
I & WADA	LA JOLLA	"	"	2	23.1	567200	0.56	12	0.28
AKAMURA	BIRD ROCK	"	FLOWERS	?	15	229300	0.35	8	?
ONYA	"	"	TOMATOES, PEPPERS, PEAS, ETC.	2	5	140100	0.64	12	0.32
				1	12.5	256800	0.47	6	0.47
TERADA	"	"	"	1+	2.4	51300	0.50	8	0.35
AKADA	"	"	"	1+	10.3	157910	0.35	7	0.35
. DICKENS	SWEETWATER VALLEY	SWEETWATER	"	2	5.3	237365	0.98	12	0.49
. BOAL	NATIONAL CITY	"	"	2	5	360406	1.65	12	0.83
YVEYNE	"	"	TOMATOES, CELERY, LETTUCE, ETC.	2	4.9	320696	1.50	12	0.75
MILLER	CHULA VISTA	"	CELERY	2	4.1	294842	1.65	12	0.83
SOUTH COAST LAND CO.	CARLSBAD	OCEANSIDE MUTUAL WATER CO.	VEPARY BEANS	1	30	160000	0.12	4½	0.12
			STRING BEANS	1	1.5	168000	2.57	3	2.57
			HUBBARD SQUASH	1	5	NONE	0.00	0	0.00
OCHI BROTHERS	"	"	PEAS	1	15	300000	0.46	3	0.46
			STRING BEANS	1	5	60000	0.27	3	0.27
			PEAS	1	10	260000	0.60	4	0.60
			STRING BEANS	1	7	NONE	0.00	0	0.00
			" "	1	5	"	0.00	0	0.00
S. TAKEDA	"	"	CHILI PEPPERS	1	2	168000	1.93	6	1.93
			PEAS	1	11	160000	0.33	4	0.33
			STRING BEANS	1	7	224000	0.73	4	0.73
			DRY BEANS	1	9	144000	0.37	5	0.37
			POTATOES	1	5	120000	0.55	4	0.55
M. L. YOUNG	"	"	DRY BEANS	1	6	72000	0.27	4	0.27
			LIMA BEANS	1	1	16000	0.37	?	0.37
			DRY BEANS	1	8	NONE	0.00	0	0.00
F. J. RAMSEY	"	"	STRING BEANS	1	6	120000	0.46	3	0.46
			POTATOES	1	2	72000	0.83	2½	0.83
S. NAWAMURA	"	"	PEAS	1	15	280000	0.43	3	0.43
			GREEN BEANS	1	5	80000	0.37	3	0.37
			DRY BEANS	1	8	128000	0.37	5	0.37
			CHILI PEPPERS	1	2	112000	1.29	7	1.29

AVERAGE DUTY OF WATER FOR MATURING ONE CROP OF VEGETABLES, AS COMPUTED FROM THE ABOVE TABULATION, IS 0.96 ACRE FEET PER ACRE, FOR IRRIGATED AREA.

COMPILED BY
F. M. Faude
HYDRAULIC ENGINEER.
DECEMBER 31, 1917.

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May	17,896	7,386	58
June	16,087	12,806	20
July	20,304	17,969	12
August	17,807	15,280	12
September	15,659	13,930	12
October	13,122	12,948	7
November	14,079	8,886	41
	150,810	96,808	37

⅓ = Increase

The decrease shown above is in spite of the fact that the year 1917 has been one of considerably less rainfall than 1916. It is expected by the Company officials that the winter use under the new rates will be considerably less than in 1916.

It is unquestionably true that the new rates will operate to decrease the use of water for irrigation and that the average compensated use for 1916 of 1 acre foot per irrigated acre over the entire system will in 1917 show a substantial decrease, which will undoubtedly amount to at least 20%, giving an average annual use of water on the entire system of approximately 0.80 acre feet per irrigated acre."

Mr. Maude's statement includes the net irrigated area and does not, therefore, include roads, broken or waste lands or dedicated streets or roads.

In reporting upon the probable duty of water for Cardiff Irrigation District Mr. Frank Adams recently stated:

"The Escondido Mutual Water Company, in the irrigation season of 1909, reported a gross project duty of 0.99 acre foot per acre. Mr. J. M. Boal, manager of the Sweetwater Water Company, stated to both Mr. Tait and Mr. Veihmeyer, that his company has found 350,000 gallons per acre (1.07 acre feet) sufficient for citrus orchards, although the amount used by the different irrigators varies somewhat from the usual average."

The data so far enumerated applies to areas of mixed crops located some distance back from the coast and comparable to the larger part of San Luis Rey Irrigation District. However, an area of approximately 5,500 acres near the coast and in the valleys is more nearly comparable to the lands within the Cardiff District. For these lands quite complete investigations were made, including an investigation and report by Mr. Frank Adams of the U. S. Department of Agriculture, Irrigation Investigations, from which investigations it was finally decided to assume a duty for net irrigated area of 0.8 acre foot per acre. The data collected by Mr. Faude and shown on Plate 6 is of interest in this connection. For these 5,500 acres near the coast and in the valleys, I consider 0.8 acre foot per acre sufficient, but for the remainder of the District, I am of the opinion that 1.0 acre foot per acre per annum, net area, is necessary to produce the best results.

AREA AND BOUNDARIES.

As previously shown, an annual supply of water amounting to 28,000 acre feet will ordinarily be available for San Luis Rey Irrigation District, deficiencies being so infrequent and of such nature that a District based upon this annual supply is perfectly safe.

This supply is, however, available at Warner Dam, more than 25 miles from the nearest portion of

the District. The construction proposed for the conduit which will conduct the water throughout this distance is of an excellent type and should reduce all losses to a minimum, but, with the long distance of transmission, even with the best type of construction, I am of the opinion that the losses will amount to 10% of the available supply, leaving 25,200 acre feet per annum available for actual irrigation. The net area which can be supplied within San Luis Rey Irrigation District is then as follows:

5,500 acres @ 0.8 acre foot -------	4,400 acre feet.
20,800 acres @ 1.0 acre foot -------	20,800 acre feet.
Total ----------	25,200 acre feet.

A tentative boundary has been drawn to include the lands best suited for inclusion within the District (See Plate 1). This boundary, which is shown on Plate 7, is subject to minor modifications to suit the wishes of individual property owners. It includes a gross area of approximately 43,000 acres, but a net area of only 25,200 acres is to be irrigated in any one year, derived as follows:

Gross area ----------	43,000 acres.
Deductions:	
(1) For County Roads and Public Streets, 10% ---	4,300
(2) For land too rough or rocky to be irrigated (determined by inspection and land classification), 16% -------	6,880
(3) For lands which in any year, even under complete development, will not be irrigated, 15.4%	6,620

Total Deductions ---------- 17,800 acres.

Maximum irrigated area ---------- 25,200 acres.

The ratio of net area to be irrigated in any one year to the gross area (60%), compares favorably with that for other San Diego County irrigated areas and, in fact, it is not higher for even some of the Districts in the San Joaquin Valley where only level unbroken valley lands are included.

The tentative boundaries of the District, together with main lines of the distribution system and supply line, are shown on Plate 1.

WATER RIGHTS.

It is proposed to secure from Volcan Land and Water Company the Warner Reservoir Site and all of the company's water rights on San Luis Rey River. This company posted notices of appropriation of the waters of San Luis Rey River at Warner Dam Site before the enactment of the law requiring the initiation of such rights by application to the State Water Commission. It has since that time proceeded with development, not only by actual construction, but by the acquisition, at great expense, of lower riparian rights along San Luis Rey River. While no formal proceeding has been brought before the State Water Commission, the Commission has informally reviewed the diligence of the company in proceeding with development and has offered no

complaint. The right by appropriation of the company is unquestioned and is believed to be fully established to date.

In addition to its right by appropriation, the company has acquired practically all of the riparian rights along San Luis Rey River. It is now willing to assume the responsibility of acquiring the remaining rights in order to transfer to the District all riparian rights complete. To acquire these rights the company has found it necessary to buy between three hundred and four hundred different properties and to sell some of them reserving riparian rights. Included in the properties which have been thus purchased are Pauma Ranch of 13,000 acres, Monserrate Ranch of over 5,000 acres and other ranches ranging in size up to 1,000 acres. Some of these properties are said to have cost as much as $250 per acre.

The rights which the District will acquire from Volcan Land and Water Company are secondary to certain priorities which must be recognized - the rights of the City of Oceanside, the Indian Reservations and the Escondido Mutual Water Company.

From my knowledge of the San Luis Rey River and the underground reservoirs along its course, I have no hesitancy in pronouncing any claim of damage by the City of Oceanside as not well founded and as deserving no further consideration.

Damage to Pala Indian Reservation is similarly quite impossible. Rincon Indian Reservation is more sus-

ceptible to influence, but, as pointed out in the previous section on Water Supply, the possibility of its suffering damage is very remote. An agreement in behalf of this reservation has been entered into between the U. S. Indian Service and the Escondido Mutual Water Company and the possible claims of the reservation are included in the allowance for Escondido Mutual Water Company in this report.

Escondido Mutual Water Company and Volcan Land and Water Company have entered into an agreement which was described in the previous section on Water Supply. In estimating the water supply available for San Luis Rey Irrigation District, an allowance was made for the priority of Escondido Mutual Water Company as defined by this agreement.

There is no question as to the ability of San Luis Rey Irrigation District to secure a right to the use of the quantity of water estimated in this report as necessary for its successful irrigation.

DRAINAGE.

The lands within the District are generally rolling. Rather restricted areas in some of the principal valleys, particularly near San Marcos, will, when the entire District is under irrigation, need drainage. In fact, at the present time, and with practically no irrigation, these lands are moist and will produce crops which in Southern California generally require irrigation. However, physical

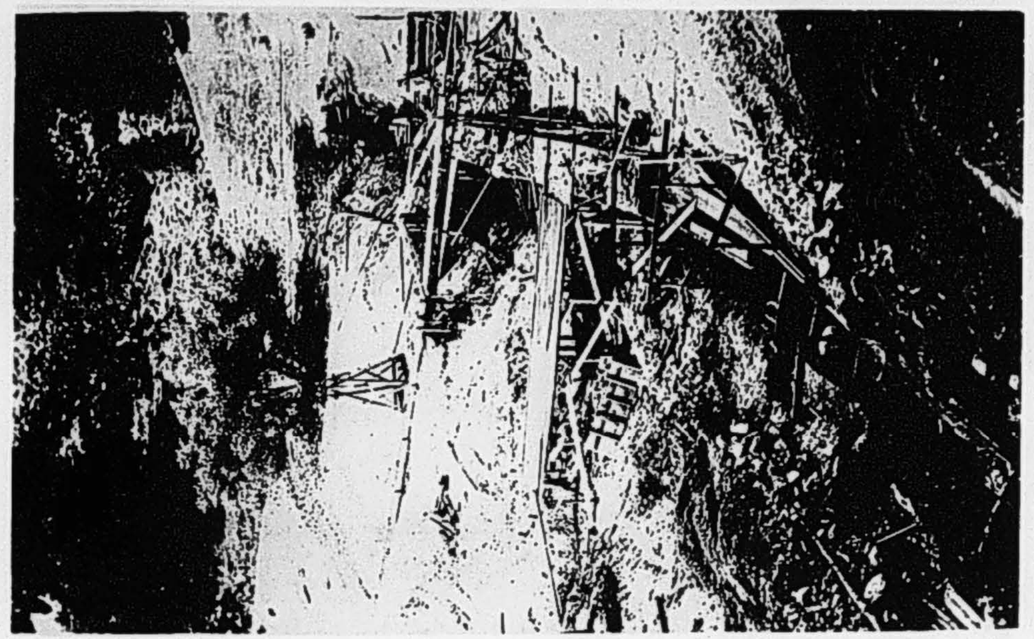


Fig. 1. Progress View of Construction of Cut-Off Wall, Warner Dam Site.

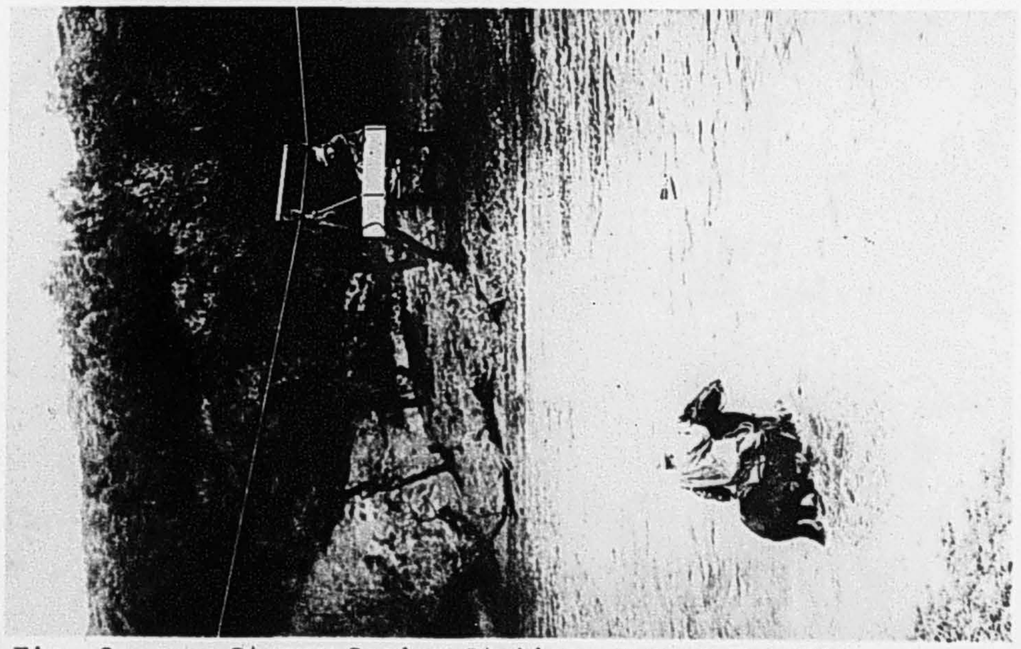


Fig. 2. Stream Gaging Station, Warner Dam Site.

conditions make the drainage which will be necessary for the relief of these restricted areas very simple and economical. It is a minor problem which needs no further consideration in this report.

IRRIGATION WORKS.

On Plate 1 the location of the principal features of the system which is to irrigate San Luis Rey Irrigation District is shown.

Warner Reservoir:

Warner Reservoir will have its maximum flood line 107 feet above the stream bed at the dam site, will have a capacity of 200,000 acre feet and will flood 6,050 acres. Its capacity and area curves are shown on Plate 3. The reservoir site is well shown in Figure 1, Plate 2. The dam site is well suited for the construction of an earth fill dam, and Volcan Land and Water Company has had plans for a dam of this type prepared and has completed some construction work. Figure 1, Plate 7, is a progress view of the construction of a cut-off wall which has been completed across the dam site. Figure 1 of Plate 8 shows the portal of the outlet tunnel, approximately 1,000 feet long, which has been driven through the hillside at the south abutment of the dam site, and Figure 2 of Plate 8 shows the settling basin which has been constructed at the lower end of this tunnel. Work has been temporarily discontinued on the dam

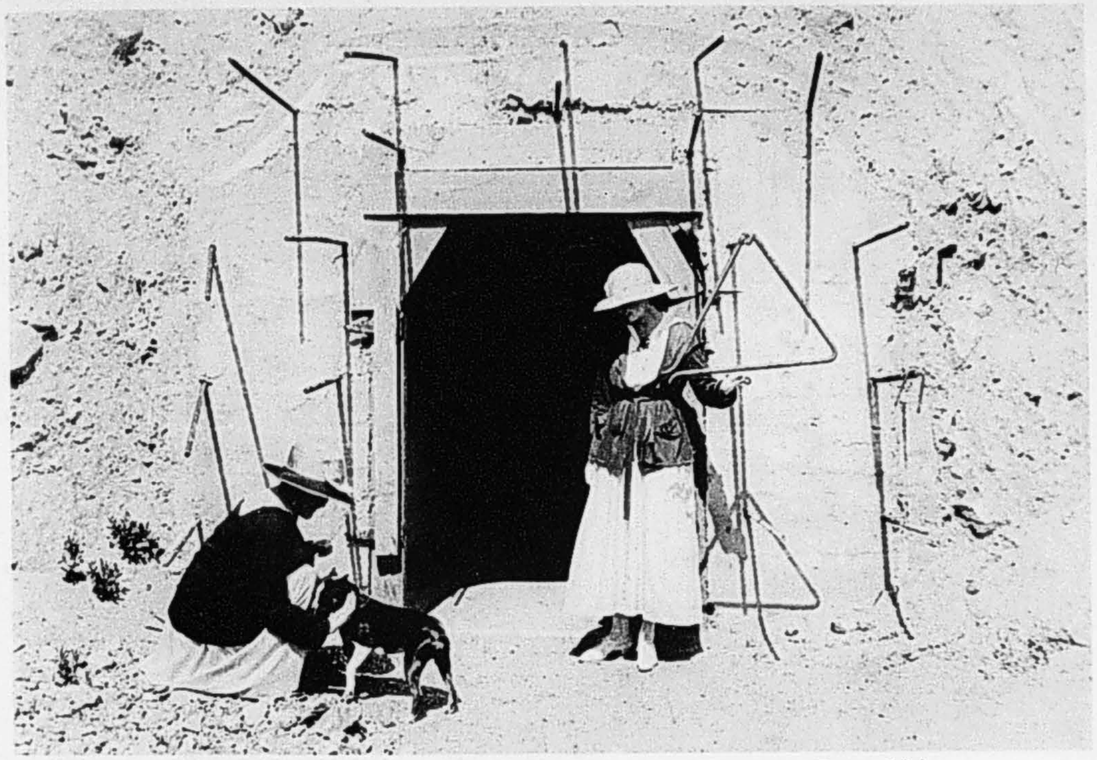


Fig. 1. Upper Portal of Outlet Tunnel, Warner Dam Site.

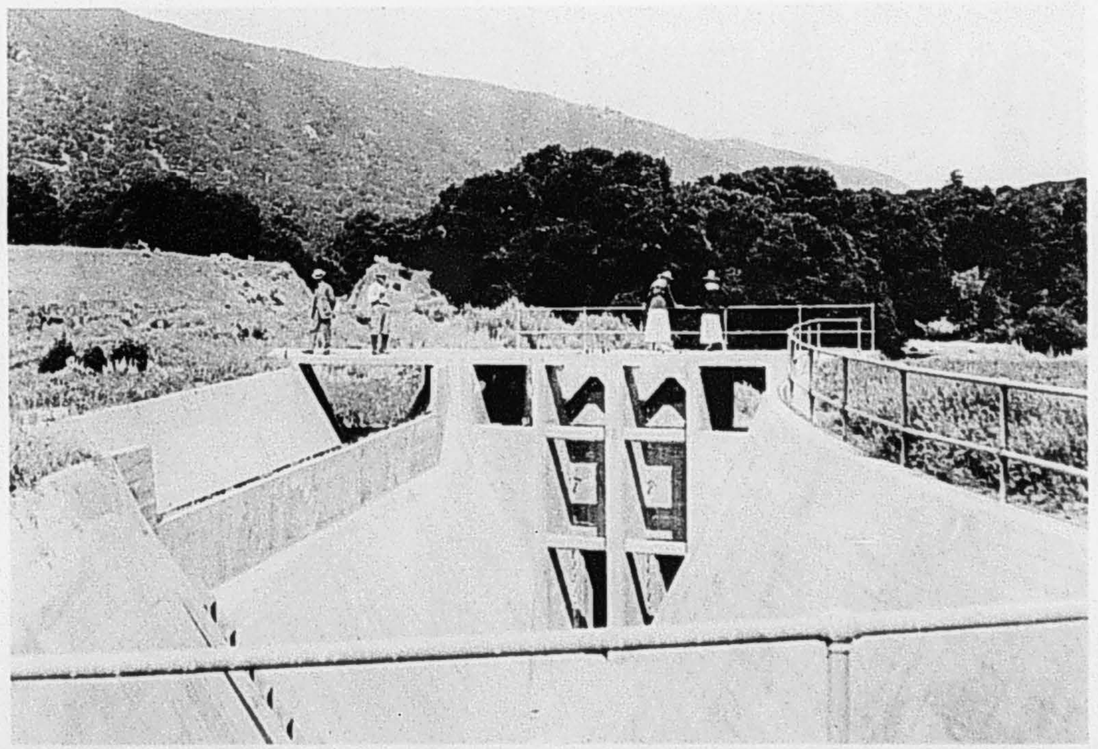


Fig. 2. Settling Basin at Lower End of Outlet Tunnel, Warner Dam Site.

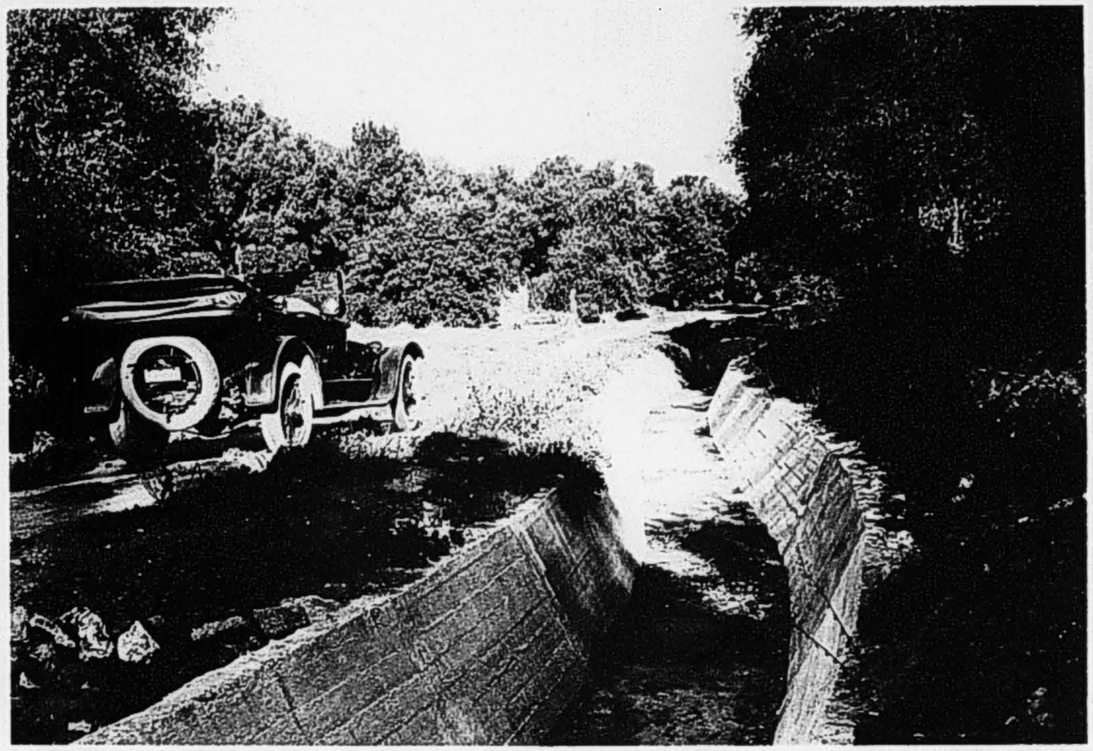
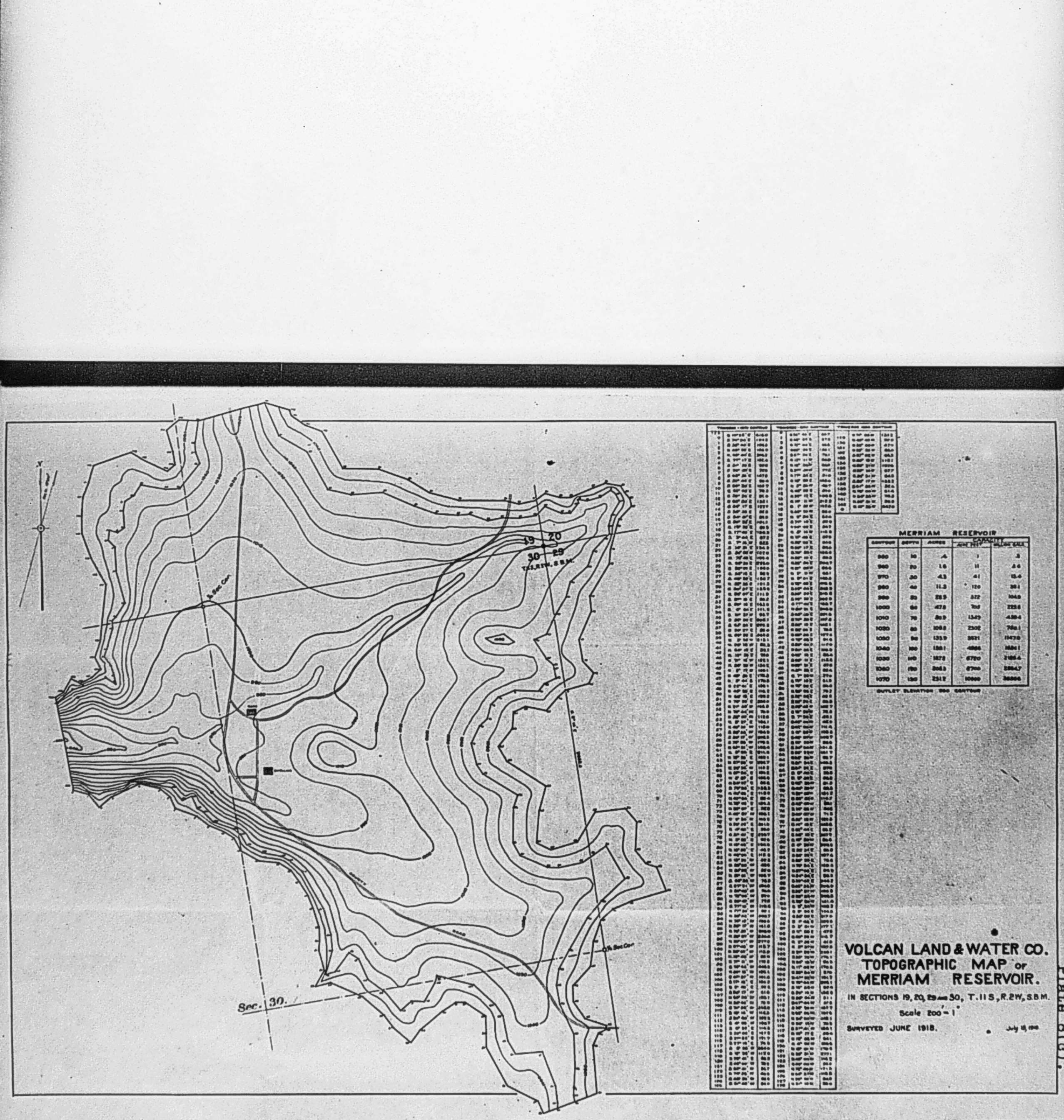


Fig. 1. Concrete lined canal completed by Volcan Land and Water Company, part of Warner Hellhole Conduit Line.

Fig. 2. Same as above.

Fig. 1. Merriam Dam Site from the Reservoir Site.

Fig. 2. A Street in Vista.



MERRIAM RESERVOIR

CONTOUR	DEPTH	ACRES	CAPACITY ACRE FEET	CAPACITY MILLION GALS.
950	10	.4	1	.3
960	20	1.6	11	3.6
970	30	4.3	41	13.4
980	40	11.3	120	39.1
990	50	28.9	322	104.9
1000	60	67.8	709	223.8
1010	70	139.9	1349	439.4
1020	80	258.8	2502	786.1
1030	90	435.9	3821	1247.8
1040	100	558.1	4886	1592.1
1050	110	767.2	6780	2185.6
1060	120	906.3	8700	2834.7
1070	130	1311.2	10900	3550.6

OUTLET ELEVATION 960 CONTOUR

VOLCAN LAND & WATER CO.
TOPOGRAPHIC MAP OF MERRIAM RESERVOIR.

IN SECTIONS 19, 20, 29 AND 30, T. 11 S., R. 2 W., S.B.M.

Scale 200' = 1"

SURVEYED JUNE 1918. July 15, 1918

Plate 8(a).

Plate 8.

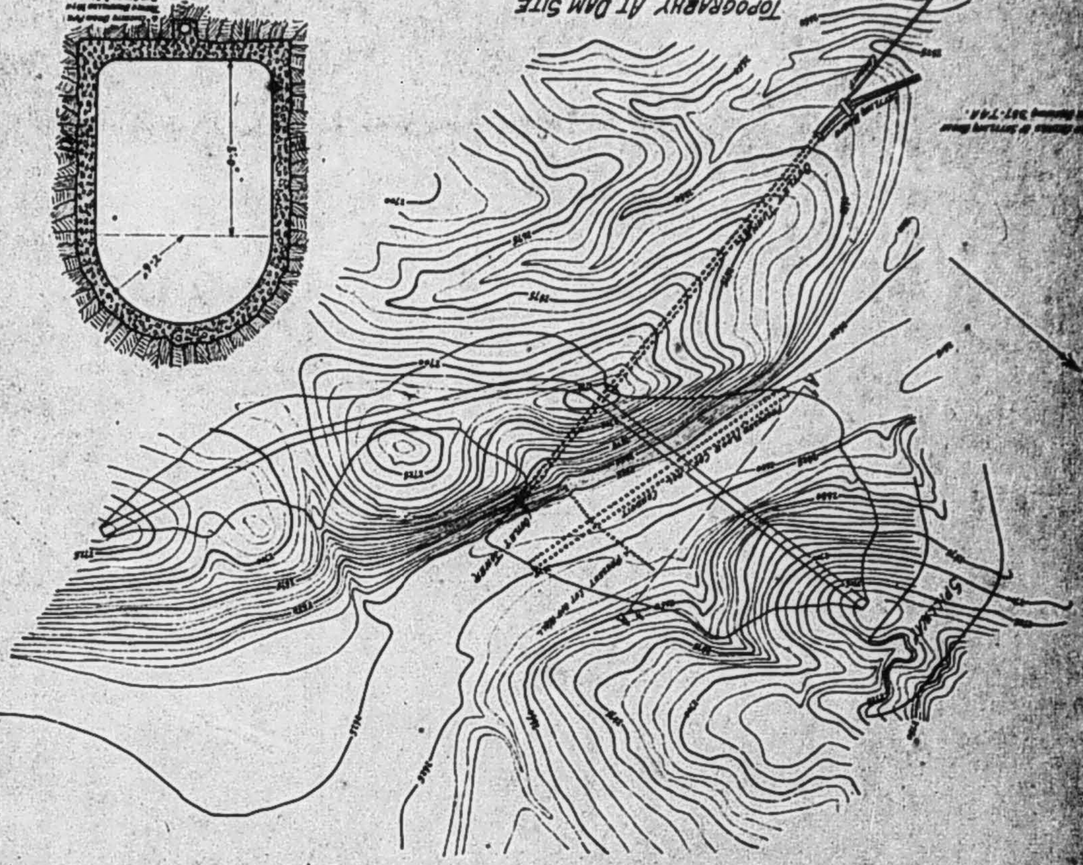
PROPOSED WARNER DAM

SCALES AS INDICATED.

SEPT. 25, 1918.

TOPOGRAPHY AT DAM SITE

SCALE - 1" = 100'.



OUTLET TUNNEL

SCALE - ¾" = 1'.

FLOOD CONTROL CONDUIT

SCALE - ¾" = 1'.

325 LBS. STEEL PER FT.

SECTION A-A'

SCALE - 1" = 60'.

and in the interim some discussion has ensued as to the exact design of the final structure. This is a secondary matter which may be determined at any time before actual construction. For the basis of estimates which follow, I have utilized the design shown on Plate 9. While this design may be modified, no material change in the total yardage will be possible. It will be desirable to carry the construction to only a portion of the total ultimate height until the District approaches complete development, thus avoiding an economic waste occasioned by placing the greatly increased yardage long before it is necessary.

Some discussion of the possibility of constructing a masonry dam, probably of the multiple-arch type, at a site some distance below has been occasioned but there are at present no indications of a foundation suitable for such dam and I will not consider it in this report.

Conduit:

From Warner Dam it is proposed to run a conduit along the south side of San Luis Rey River, with only sufficient slope to insure an economic section, to a point some twelve miles below where the point of a hill is reached and where a power drop of 924 feet can be utilized at what is known at Hellhole power drop (See Plate 10, Figure 2). From the lower end of this power drop, the conduit will continue for approximately twelve miles to a point where a power drop of 473.77 feet is available and where the entire flow can be

Fig. 1. Metal Flume Section, Escondido Mutual Water Company's Supply Conduit.

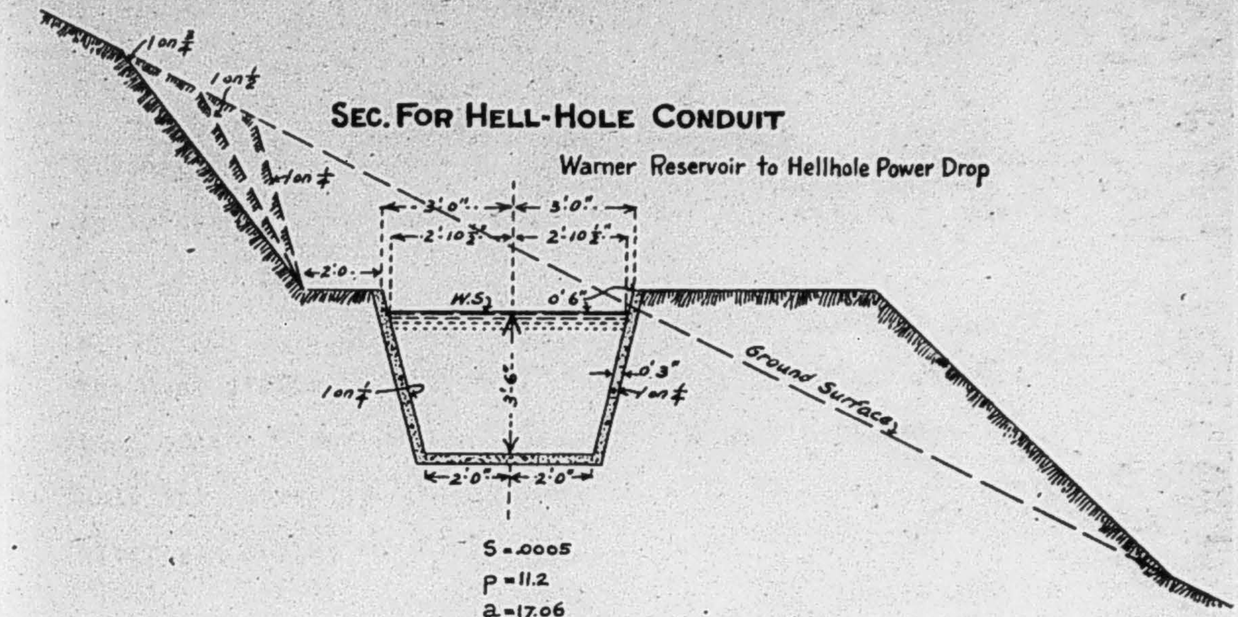
Fig. 2. Hellhole Power Drop, Proposed Conduit of San Luis Rey Irrigation District.

Fig. 1. Escondido Mutual Water Company's Supply Ditch.

Fig. 2. Storage Dam, Escondido Mutual Water Company's Bear Valley Reservoir.

SEC. FOR HELL-HOLE CONDUIT

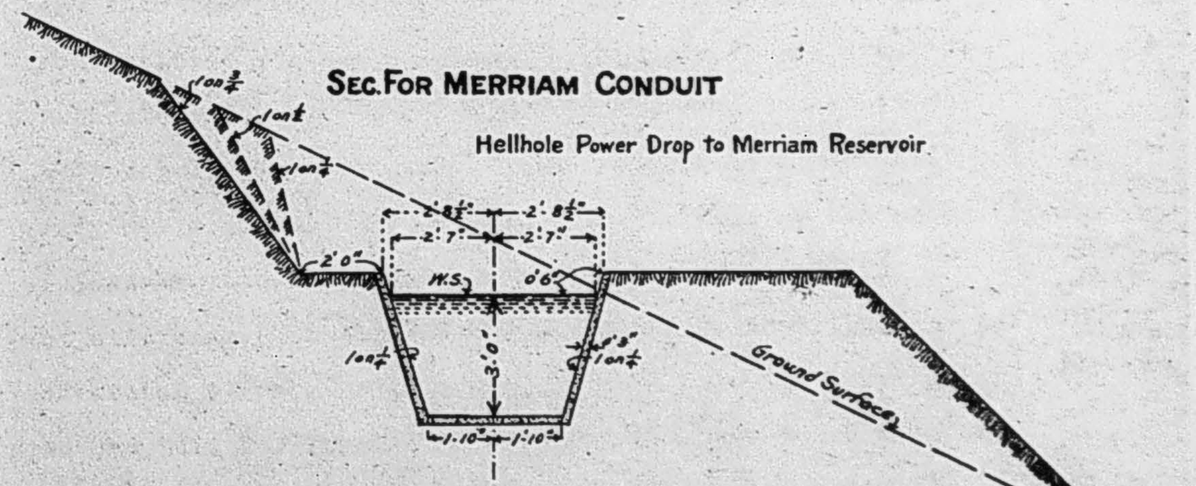
Warner Reservoir to Hellhole Power Drop



S = .0005
P = 11.2
a = 17.06
r = 1.52
n = .015
v = 2.94
q = 50.15

SEC. FOR MERRIAM CONDUIT

Hellhole Power Drop to Merriam Reservoir



S = .001
P = 9.85
a = 13.23
r = 1.34
n = .015
v = 3.85
q = 50.94

discharged into Merriam Reservoir which is very advantageously located directly above the District with outlet at elevation 860.0 feet.

The location of this conduit has been one of the most difficult problems in connection with the preparation of the plans for San Luis Rey Irrigation District. Not only the survey of the line, but its actual advantages over alternate routes have been studied.

A project which has long been contemplated by Volcan Land and Water Company included conducting the line along the south side of San Luis Rey River for only a few miles, then into a tributary canyon from which a single tunnel reached a tributary of the Santa Ysabel River and where a single power drop of 1,500 feet is available before discharging into the proposed Pamo Reservoir. This project also contemplated storage of waters from Santa Ysabel Creek at Sutherland Reservoir, its diversion to Pamo Reservoir and additional storage in the latter. Volcan Land and Water Company has acquired many of the lands controlling the necessary reservoir sites. I have investigated the possibility of utilizing that part of the project here described and the diversion of both Santa Ysabel and San Luis Rey River waters to San Luis Rey Irrigation District but have found that the cost of constructing a conduit from this point makes the

project impractical - furthermore, the District would be reached at such a low elevation that much pumping would be necessary, which would make the project still more impractical economically.

Another alternate route which at first appeared to have some economic merit was one to utilize the existing ditch of Escondido Mutual Water Company after enlarging and reconstructing it. Careful study of this proposal showed many disadvantages. It would necessitate releasing water from Warner Dam Site and recapturing it at the Escondido intake some nine miles below. Because of the sandy nature of this part of the bed of San Luis Rey River, the losses would be entirely unreasonable. To construct a flow line along the hillside with power drop to the Escondido intake would prevent these losses, but to place a power drop here would not permit the utilization of a higher head which may be obtained by continuing the line as it was finally surveyed to Hellhole power drop. The line as actually surveyed from a point above Escondido intake to Hellhole power drop is shorter than the Escondido ditch on the hillside below and passes through much more suitable ground. In fact, the reconstruction of Escondido ditch presents some quite costly problems. Thus it is seen that there are no economic advantages in utilizing this portion of the Escondido ditch. It was also proposed that San Luis Rey Irrigation District combine with Escondido Mutual Water Company in the enlargement of the latter's Bear Valley Storage Reservoir or that it construct a second reservoir

immediately above. The enlargement of Bear Valley Dam, which is shown on Plate 11, Figure 2, would involve a large expenditure as the present dam is a very cheaply constructed rock fill dam which, in order to permit raising to greater height, must have some very substantial additions. Another dam site was considered immediately above Bear Valley Reservoir. Although surveys are not available, it was at once apparent that a dam at this point would involve a large expenditure for a comparatively small storage capacity. A further and very important factor is that any storage at this site is not well located for serving San Luis Rey Irrigation District. The difficulties so far enumerated in combining the works of San Luis Rey Irrigation District with those of Escondido Mutual Water Company are only those of economics. In addition, many conflicts would continue to arise in the operation of such joint works. It has, therefore, been decided to make the works of San Luis Rey Irrigation District entirely independent of those of Escondido Mutual Water Company.

The sections proposed for the conduit of San Luis Rey Irrigation District are shown on Plate 12. Although some tunnel sections and some siphons are included, the sections shown are used throughout most of the length.

Merriam Reservoir:

Merriam Reservoir is located below both power drops in the main conduit. It will have sufficient capacity (approximately 6,500 acre feet) to regulate the

flow to irrigation needs after it has been used for power development. The location of Merriam Reservoir is unique. It is located in a saddle where water can easily be made to flow down any one of three watersheds. Thus, in addition to the main dam on the west, it is necessary to construct earth dikes of lesser height on both the north and south. The main dam will be of masonry, probably of the multiple-arch type.

Distribution Lines:

From Merriam Reservoir a system of pipe lines, as indicated on Plate 1, will serve as the main distribution system. In addition to these, a number of smaller lines will finally be constructed to reach individual parcels of land. The main lines of the distribution system are the Vista Line, with Guajome branch; the Buena Line, with San Marcos branch; and the Richland Line, with Cerro branch. The system has been designed of reinforced concrete pipe ranging in size from 44 inches in diameter to 6 inches in diameter, with comparatively short lengths of steel pipe substituted where some of the heaviest pressures are imposed on siphons.

The system as a whole is well located and is suited to the purposes for which it was designed. Great care must be exercised in constructing reinforced concrete pipe to withstand pressures such as are here to be imposed in order to secure satisfactory joints. While this is not impossible, there is not an abundance of precedent for such construction. The policy of constructing the laterals of lesser importance as the District develops is a sound one economically and one which will lead to the best design.

VALUE OF IRRIGATION SYSTEM.

Before giving any estimates of cost, I wish to very clearly show the difficulty of making estimates under present abnormal conditions. Prices for both materials and labor are now higher than ever before. The period of these high prices is indefinite but it will probably not continue during the entire period of construction of San Luis Rey Irrigation District. However, it is probable that the more stable prices of pre-war times will not again be reached for a long period. Thus it is evident that an estimate of cost of constructing the works of San Luis Rey Irrigation District cannot be made at the present time with even an approach to accuracy because prices which will be effective when the work is actually contracted or performed cannot be foretold. Present prices are, however, a safe basis for the compilation of a report to the Irrigation District Bond Commission, which is concerned with the security of a bond issue by the District sufficient to supply funds for completing its system. On the other hand, lack of agreement between unit prices here used and those which have been used for similar estimates in previous reports should be understood. It is also hoped that interested land owners will appreciate present conditions and the possibility of constructing the system, by the time the organization of the District has been completed, for a somewhat reduced cost.

Total Cost:

Item No.	Structure	Cost
1.	Lands	$ 972,575
2.	Warner Reservoir	614,762
3.	Hellhole Conduit	637,160
4.	Merriam Conduit	469,771
5.	Merriam Reservoir	214,715
6.	Distribution System	1,310,546
7.	Water Rights	1,075,000
		$5,294,529

The following explanation of the several items included in this appraisal is offered.

Item 1. Lands:

Most of the lands which it is necessary to purchase in order to complete and operate the proposed irrigation system of San Luis Rey Irrigation District are within the Warner Reservoir Site and within the well-known Warner Ranch which comprises the Spanish grants Valle de San Jose and San Jose de Valle. This reservoir site is very well-known and has long been recognized as the key to any storage development for either water power development or irrigation on the San Luis Rey River. Many years ago it was purcahsed by parties planning to utilize it for reservoir purposes and it has since changed hands always with this same potentiality in mind. The entire Warner Ranch includes some 49,000 acres and the reservoir, with the maximum flood line

Total Cost:

Item No.	Structure	Cost
1.	Lands	$ 372,575
2.	Warner Reservoir	614,758
3.	Wellhole Conduit	637,160
4.	Merriam Conduit	469,771
5.	Merriam Reservoir	234,718
6.	Distribution System	1,810,546
7.	Water Rights	1,078,000
		$5,294,829

The following explanation of the several items included in this appraisal is offered.

Item 1. Lands:

Most of the lands which it is necessary to purchase in order to complete and operate the proposed irrigation system of San Luis Rey Irrigation District are within the Warner Reservoir Site and within the well-known Warner Ranch which comprises the Spanish grants Valle de San Jose and San Jose de Valle. This reservoir site is very well-known and has long been recognized as the key to any storage development for either water power development or irrigation on the San Luis Rey River. Many years ago it was purchased by parties planning to utilize it for reservoir purposes and it has since changed hands always with this same potentiality in mind. The entire Warner Ranch includes some 49,000 acres and the reservoir, with the maximum flood line

contemplated will flood but 6,050 acres. While the reservoir site has always been considered one of the principal elements of value of the ranch, it is true that the lands outside of the reservoir site are valuable for farming and grazing purposes and on this account a large severance value should not be allowed for these lands as in the case of lands made inaccessible or practically useless by the utilization of other lands of the same holding for reservoir purposes.

The lands within Warner Reservoir Site are valuable for both agricultural and grazing purposes. They have not been developed for farming purposes to the extent that certain other parts of the Warner Ranch have been and partly for the reason that expenditures for irrigation or drainage would be ill advised for an area which it has always been believed would soon be flooded. The agricultural value of these lands is thus hard to fix but I am of the opinion that it does not exceed $100 per acre. As previously noted, this reservoir site has long been recognized as the key to water storage on San Luis Rey River and it must be borne in mind that land valuable for reservoir purposes must be valued for that particular purpose, not necessarily for some other less important use. This principle was established as early as 1879 by a decision of the U. S. Supreme Court in the case of Boom Company vs. Patterson, (98 U.S. 403). This was a case in eminent domain for the condemnation of certain small islands in the Mississippi River peculiarly adapted for the construction of a boom. The jury rendered a general verdict assessing the value of the land at $9,358.33, but accompanied it with

a special verdict assessing its value aside from any consideration of its value for boom purposes at $300, and, in view of its adaptability for this purpose, a further and additional value of $9,058.33. The court reduced the verdict to $5,500. The plaintiff brought the case on writ of error to the Supreme Court of the United States where the judgment was affirmed. The following is quoted from the decision of the United States Supreme Court:

> "In determining the value of land appropriated for public purposes, the same considerations are to be regarded as in a sale of property between private parties. The inquiry in such cases must be what is the property worth in the market, viewed not merely with reference to the uses to which it is at the time applied, but with reference to the uses to which it is plainly adapted; that is to say, what is it worth from its availability for valuable uses? Property is not to be deemed worthless because the owner allows it to go to waste, or to be regarded as valueless because he is unable to put it to any use. Others may be able to use it, and make it subserve the necessities or conveniences of life. Its capability of being made thus available gives it a market value which can be readily estimated.
>
> "So many and varied are the circumstances to be taken into account in determining the value of property condemned for public purposes, that it is, perhaps, impossible to formulate a rule to govern its appraisement in all cases. Exceptional circumstances will modify the most carefully guarded rule; but, as a general thing, we should say that the compensation to the owner is to be estimated by reference to the uses for which the property is suitable, having regard to the existing business and wants of the community, or such as may be reasonably expected in the immediate future."

There are numerous later decisions of the courts which uphold all of the principles of law stated in this leading case (Minnesota Rate Cases, 232 U.S. 352, etc.). With the principal therein enumerated in mind, after carefully considering the value of the lands in Warner Reservoir Site for other than reservoir purposes and after considering the effect upon the remainder of the Warner

Ranch including certain minor areas of side hill lands not easily accessible after the construction of the reservoir, I have decided that a fair appraisal for those lands actually within the flooded area, and which are to be owned in fee by the District, is $150.00 per acre. So far as I have been apprised, it is the intention of the present owners to sell and of the District to purchase the entire flooded area - 6,050 acres or thereabouts.

A study of Table 9 shows that if the reservoir had been operated by San Luis Rey District during the past thirty years, during nineteen of those years areas not in excess of 5,000 acres would have been flooded, or, in other words, during nineteen years the remaining area of 1,050 might have been used for other purposes providing the purity of the water supply be not thus jeopardized or be not a necessary consideration. Possibly under these conditions an arrangement to secure floodage rights only for this area of 1,050 acres, and to secure these at a reduced cost, might be arranged. This is merely offered as a Suggestion, and, since it is not included in the plans of the District as outlined to me, and since it might be objectionable for sanitary reasons, I have not given it further consideration in estimating the value of lands to be acquired.

In addition to the lands included in Warner Reservoir Site, certain other rights of way will be necessary, particularly for the main supply conduit from Warner Reservoir to Merriam Reservoir. For this conduit a right of way approximately fifty feet in width will be necessary, and for that part of the conduit from Warner Reservoir down to Hellhole power drop

approximately eighty-eight acres will be utilized. Much of this right of way lies on vacant public land, and for it only the expense incidental to securing an easement, including the preparation of necessary filing maps, etc., need be incurred. This expense will be moderate, but, where patented lands are crossed, a greater expense will be incurred. I have used a figure of $25.00 per acre as an average cost for the right of way for the main supply conduit across both private and publicly owned lands between Warner Reservoir and Merriam Reservoir. The larger percentage of privately owned lands will be crossed by that section of the conduit between Hellhole power plant and Merriam Reservoir. This section of the conduit below Hellhole, excluding Merriam forebay, penstock and power plant, will occupy ninety-three acres, for which again I have used a value of $25.00 per acre.

Merriam Reservoir will flood the greater portion of a productive farm now being successfully cultivated by dry farming methods. It will also flood the farm buildings, including an attractive stone residence. This land, like Warner Reservoir Site, should be considered, in addition to its value for farming purposes, as a reservoir site. For this purpose it has a particular value to San Luis Rey Irrigation District because of its unique location and proximity to that District. However, it does not, like Warner Reservoir Site, constitute the key to storage development - it is made favorable as a reservoir only by a very long conduit which brings its water supply.

Approximately 200 acres are involved in this reservoir site, and, after considering all factors involved, I have made an allowance of $100 per acre for the site.

A pumping site on San Luis Rey River is to be acquired and for it I have allowed a value, exclusive of its value for pumping purposes, of $35,550 (177.75 acres @ $200).

Finally, certain rights of way will be necessary for the distribution system, but, as most of these lie within the District itself and as practically the entire distribution system consists of pipes buried in the ground and not particularly objectionable, I believe most of the rights of way will be donated by the land owners. Probably some expense will be incurred in securing all of the necessary rights of way, but to estimate this expense with accuracy is at present impossible. I have simply made a total allowance of $5,000.

Item 1 is, therefore, made up as follows:

Warner Reservoir Site, 6,050 acres @ $150	$907,500
Hellhole conduit, ex cluding forebay and power house site, 88 acres @ $25	2,200
Merriam conduit, 93 acres @ $25	2,325
Merriam Reservoir Site, 200 acres @ $100	20,000
Pumping site on San Luis Rey River	35,550
Rights of way for distribution system	5,000
Total	$972,575

Item 2. Warner Reservoir:

Core drilling and exploration excavations	$ 5,000
Stripping:	
40,000 cu. yds. earth @ 0.25	10,000

Grouting foundations ----------		$ 10,000
Cut-off Wall:		
Excavation:		
Earth and Loose Rock, 15,000 yds. @ .50 ----------	$ 7,500	
Disintegrated granite and rock 15,000 yds. @ 2.00 ----------	30,000	
Reinforced concrete, 2,230 cu. yds. @ 15.00 ----------	33,450	
Pumping and shoring ----------	4,500	75,450
Flood Control Conduit:		
4,225 cu. yds. reinforced concrete, including necessary excavation and shoring, @ 20.00 ----------		84,500
Outlet Tunnel:		
Excavation at east and west portals -	$ 2,200	
Excavation in tunnel ----------	6,130	
Lining ----------	12,620	
Drain pipe ----------	520	21,470
Gate tower and bridge ----------		10,000
Settling Basin ----------		8,990
Earth Fill:		
738,000 cu. yds. @ 0.30 ----------		221,400
Rip rap:		
34,500 cu. yds. @ 1.75 ----------		60,375
Spillway excavation and lining:		
Earth, 2,000 cu. yds. @ 0.25 --------	$ 500	
Disintegrated rock, 5,000 cu. yds. @ 1.50 ----------	7,500	
Concrete lining, 100,000 sq. ft. @ 0.50 ----------	10,000	18,000
Engineering and Incidentals (approximately 15%) --------		78,777
Total Cost of Warner Dam ----------		$603,962
Keeper's house and buildings ----------		3,000
Clearing reservoir ----------		3,000

Fencing reservoir (approximately) 24 miles @ $200 ----- $ 4,800

Total Cost of Warner Reservoir, exclusive of lands, --- $614,762

Item 3. Conduit Warner Dam to Hellhole Forebay:

Description:

Concrete Conduit (open) ------ 56,510 feet		
Concrete Conduit (covered) --- 5,300 feet		
Total Concrete Conduit ----------	61,810	feet
Tunnels ----------	2,990	"
Siphons ----------	4,900	"
Metal Flume on Concrete Trestle ----------	6,800	"
Total Length ----------	76,500	feet

Clearing:

Total length 76,500 feet; assume a cleared width of 20 feet; cleared area 35 acres. Heavy brush, therefore an allowance of $30 per acre ---------- $ 1,050

Excavation:

To Station 220+00 = 24,700 cu. yds.

14,820 cu. yds. Earth
4,940 cu. yds. Loose Rock
4,940 cu. yds. Solid Rock

From Station 220+00 to Station 525+00 = 29,900 cu. yds.

17,940 cu. yds. Earth
7,475 cu. yds. Loose Rock
4,485 cu. yds. Solid Rock

From Station 525+00 to Station 606+00 = 9,100 cu. yds.

5,005 cu. yds. Earth
2,730 cu. yds. Loose Rock
1,365 cu. yds. Solid Rock

From Station 606+00 to Station End = 14,800 cu. yds.

7,400 cu. yds. Earth
5,180 cu. yds. Loose Rock
2,220 cu. yds. Solid Rock

Total Excavation (except siphons and tunnels):

45,165 cu. yds. Earth @ $0.50 --------	$22,582	
20,325 cu. yds. Loose Rock @ $2.00 ---	40,650	
13,010 cu. yds. Solid Rock @ $4.00 ---	52,040	$115,272

Tunnels:

Size of tunnels 5 feet by 7 feet. Assume all tunnels in hard rock. At the present time men skilled in hard rock work are scarce and the cost of both labor and powder is high. It is, therefore, believed that tunnels cannot be driven on this conduit for less than $22.00 per lin. ft. To this must be added the cost of lining to a height of four feet on the walls. A six inch lining on floor and lower four feet of walls will require 0.35 cu. yds. per lin. ft. which at $20 per cu. yd. will amount to $7.00 per lin. ft. or a total cost of tunnel section, lined as required, of $29.00 per lin. ft.

List of Tunnels:

Tunnel No. 1 ----------	300	feet long
Tunnel No. 2 ----------	140	" "
Tunnel No. 3 ----------	320	" "
Tunnel No. 4 ----------	2,230	" "
Total length ----------	2,990	feet

2990 feet @ $29.00 ---------- $ 86,710

Lining for Ditch Section:

61,810 lin. ft. lined with gunite and wire mesh (3" thickness) @ $0.18 per sq. ft. or $2.43 per lin. ft. of conduit ---------- $150,000

Concrete Cover Slab:

5,300 lin. ft.; width inside 6' 0"; width of slab 7' 0"; depth of slab 4 inches. At $0.32 per sq. ft. of slab - $2.25 per lin. ft., 5,300 lin. ft. @ $2.25 ---------- $ 11,925

Culverts:

Total number, 101.

Estimate of cost of single culvert:

Excavation, 10 cu. yds. @ $1.00 -----	$ 10.00	
Backfill, 6 cu. yds. @ $0.50 --------	3.00	
Dry rock wall, 9 cu. yds. @ $5.00 ---	45.00	
#16 gage steel pipe 12" diameter, 28 feet @ $1.50 ----------	42.00	$100.00 each

101 culverts @ $100.00 ---------- $10,100

Siphons:

Siphon No. 1:

Horizontal Length 210' - Slope Length 280'.

Maximum Head 100 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

90' @	30'	head @	$3.53	erected	----------	$ 317.70
42' "	40'	" "	3.81	"	----------	160.02
34' "	50'	" "	4.10	"	----------	129.40
29' "	60'	" "	4.34	"	----------	125.86
24' "	70'	" "	4.64	"	----------	111.36
25' "	80'	" "	4.93	"	----------	123.25
25' "	90'	" "	5.26	"	----------	131.50
11' "	100'	" "	5.59	"	----------	61.49

Total Cost of pipe erected except haul to job and trenching ---------- $1,160.58

Leveling and Benching 100 cu. yds. @ $1.00 ------- 100.00

Haul and distribution from Escondido to job - 36 miles - 12 tons @ $0.20 ton mile ---------- 86.40

Inlet Structure with sand trap ---------- 725.00

Outlet Structure ---------- 275.00

Blow-off Valve and Tee ---------- 150.00

Concrete Anchor ---------- 150.00

Total Cost of Siphon ---------- $2,646.98

Cost per foot of Horizontal Length ---------- $ 12.60

Siphon No. 2:

Horizontal Length 910' - Slope Length 960'.

Maximum Head 140 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

182'	@	30'	head	@	$3.53	erected	$ 642.46
91'	"	40'	"	"	3.81	"	346.71
74'	"	50'	"	"	4.10	"	303.40
75'	"	60'	"	"	4.34	"	325.50
73'	"	70'	"	"	4.64	"	338.72
71'	"	80'	"	"	4.93	"	350.03
67'	"	90'	"	"	5.26	"	352.42
71'	"	100'	"	"	5.59	"	396.89
67'	"	110'	"	"	5.92	"	396.64
66'	"	120'	"	"	6.25	"	412.50
73'	"	130'	"	"	6.58	"	480.34
50'	"	140'	"	"	6.91	"	345.50

Total Cost of pipe erected except haul to job and trenching ---------- $4,691.11

Benching and Leveling 400 cu. yds @ $1.00 ------- 400.00

Haul from Escondido to job, 35 miles, 39 tons @ $0.20 ton mile ---------- 273.00

Inlet Structure with sand trap ---------- 725.00

Outlet Structure ---------- 275.00
Manhole ---------- 100.00

Blow-off Valve and Tee ---------- 150.00

Concrete Anchor ---------- 200.00

Total Cost of Siphon ---------- $6,814.11

Cost per foot of Horizontal Length ---------- $ 7.48

Siphon No. 3:

Horizontal Length 1230 feet. Slope Length 1340 feet.

Maximum Head 200 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

190'	@	30'	head	@	$3.53	erected	$ 670.70
70'	"	40'	"	"	3.81	"	266.70
65'	"	50'	"	"	4.10	"	266.50
70'	"	60'	"	"	4.34	"	303.80
65'	"	70'	"	"	4.64	"	301.60
70'	"	80'	"	"	4.93	"	345.10
65'	"	90'	"	"	5.26	"	341.90
70'	"	100'	"	"	5.59	"	391.30
65'	"	110'	"	"	5.92	"	384.80
70'	"	120'	"	"	6.25	"	437.50
65'	"	130'	"	"	6.58	"	427.70

70'	@	140'	head	@	$6.91	erected	$ 483.70
65'	"	150'	"	"	7.24	"	470.60
70'	"	160'	"	"	7.57	"	529.90
65'	"	170'	"	"	7.90	"	513.50
70'	"	180'	"	"	8.23	"	576.10
65'	"	190'	"	"	8.56	"	556.40
70'	"	200'	"	"	8.89	"	622.30

Total Cost of pipe in place except trenching and haul	$ 7,890.10
Leveling and Benching, 500 cu. yds @ $1.00	500.00
Haul from Escondido, 34 miles - 54 tons @ $0.20 ton mile	367.20
Inlet Structure with sand trap	725.00
Outlet Structure	275.00
Blow-off Valve and Tee	150.00
Manhole	100.00
Concrete Anchor	200.00
Total Cost of Siphon	$10,207.30
Cost per foot of Horizontal Length	$ 8.31

Siphon No. 4:

Horizontal Length 240 feet. Slope Length 252 feet.

Maximum Head 50 feet.

46 inch wood stave pipe.

Capacity 50 second feet (n = .014).

145'	@	30'	head	@	$3.53	erected	$ 511.85
71'	"	40'	"	"	3.81	"	270.51
36'	"	50'	"	"	4.10	"	147.60

Total Cost of pipe in place except haul and trenching	$ 929.96
Leveling and Benching 100 cu. yds. @ $1.00	100.00
Haul from Escondido to job, 33 miles, 11 tons @ $0.20 ton mile	72.60
Inlet Structure with sand trap	725.00

Outlet Structure										$ 275.00
Blow-off Valve and Tee										150.00
Concrete Anchor										150.00
Total Cost of Siphon										$2,402.56
Cost per foot of horizontal length										$ 10.01

Siphon No. 5:

Horizontal Length 1580 feet. Slope Length 1775 feet.

Maximum Head 380 feet.

46 inch wood stave and steel pipe.

Capacity 50 second feet.

75'	Wood Stave	Pipe	@	30'	head	@	$ 3.53	erected	$	264.75
35'	"	"	"	40'	"	"	3.81	"		133.35
35'	"	"	"	50'	"	"	4.10	"		143.50
35'	"	"	"	60'	"	"	4.34	"		151.90
30'	"	"	"	70'	"	"	4.64	"		139.20
35'	"	"	"	80'	"	"	4.93	"		172.55
30'	"	"	"	90'	"	"	5.26	"		157.80
35'	"	"	"	100'	"	"	5.59	"		195.65
25'	"	"	"	110'	"	"	5.92	"		148.00
35'	"	"	"	120'	"	"	6.25	"		218.75
30'	"	"	"	130'	"	"	6.58	"		197.40
40'	"	"	"	140'	"	"	6.91	"		276.40
40'	"	"	"	150'	"	"	7.24	"		289.60
40'	"	"	"	160'	"	"	7.57	"		302.80
40'	"	"	"	170'	"	"	7.90	"		316.00
40'	"	"	"	180'	"	"	8.23	"		329.20
50'	"	"	"	190'	"	"	8.56	"		428.00
50'	"	"	"	200'	"	"	8.89	"		444.50
250'	Steel Pipe			250'	"	"	26.60	"		6,650.00
385'	"	"		315'	"	"	34.20	"		13,167.00
440'	"	"		380'	"	"	41.80	"		18,392.00

Total Cost of Pipe in place except trenching and haul	$42,518.35
Haul from Escondido to job, 30 miles, 131 tons @ $0.20 ton mile	786.00
Leveling and Benching, 700 cu. yds @ $1.00	700.00
Inlet Structure with sand trap	725.00
Outlet Structure	275.00

Blow-off Valve and Tee	$ 150.00
Manhole	100.00
Concrete Anchors	1,750.00
Special Fittings (anchor straps, etc.)	750.00
Total Cost of Siphon	$47,754.35
Cost per foot of horizontal length	$ 30.22

Siphon No. 6:

Horizontal Length 730 feet. Slope Length 855 feet.

Maximum Head 220 feet.

46 inch wood stave pipe.

Capacity 50 second feet (n = .014).

90' pipe at	30' head at	$3.53	erected	$	317.70
40' " "	40' " "	3.81	"		152.40
45' " "	50' " "	4.10	"		184.50
40' " "	60' " "	4.34	"		173.60
45' " "	70' " "	4.64	"		208.80
40' " "	80' " "	4.93	"		197.20
45' " "	90' " "	5.26	"		236.70
40' " "	100' " "	5.59	"		223.60
45' " "	110' " "	5.92	"		266.40
45' " "	120' " "	6.25	"		281.25
30' " "	130' " "	6.58	"		197.40
30' " "	140' " "	6.91	"		207.30
30' " "	150' " "	7.24	"		217.20
30' " "	160' " "	7.57	"		227.10
85' " "	170' " "	7.90	"		671.50
35' " "	180' " "	8.23	"		288.05
35' " "	190' " "	8.56	"		299.60
35' " "	200' " "	8.89	"		311.15
35' " "	210' " "	9.22	"		322.70
35' " "	220' " "	9.55	"		334.25

Total Cost of Pipe in place except trenching and haul	$5,318.40
Haul from Escondido, 29 miles, 36 tons @ $0.20 ton mile	208.80
Trenching, 400 cu. yds. @ $1.00	400.00
Inlet Structure	275.00
Outlet Structure	275.00

Blow-off Valve and Tee	$ 150.00
Manhole	100.00
Concrete Anchors	1,750.00
Special fittings (anchor straps, etc.)	780.00
Total Cost of Siphon	$47,754.35
Cost per foot of horizontal length	$ 30.22

Siphon No. 6:

Horizontal length 730 feet. Slope length 855 feet.

Maximum Head 250 feet.

46 inch wood stave pipe.

Capacity 50 second feet (n = .014).

90' pipe at	30' head at	$3.83 erected	$ 317.70
40' " "	40' " "	3.81 "	152.40
45' " "	50' " "	4.10 "	184.80
40' " "	60' " "	4.34 "	173.60
45' " "	70' " "	4.64 "	208.80
40' " "	80' " "	4.93 "	197.20
45' " "	90' " "	5.26 "	236.70
40' " "	100' " "	5.59 "	223.60
45' " "	110' " "	5.92 "	266.40
45' " "	120' " "	6.28 "	282.60
30' " "	130' " "	6.58 "	197.40
30' " "	140' " "	6.91 "	207.30
30' " "	150' " "	7.24 "	217.20
30' " "	160' " "	7.57 "	227.10
85' " "	170' " "	7.90 "	671.50
35' " "	180' " "	8.23 "	288.05
35' " "	190' " "	8.56 "	299.60
35' " "	200' " "	8.89 "	311.15
35' " "	210' " "	9.22 "	322.70
35' " "	220' " "	9.55 "	334.25

Total Cost of Pipe in place except trenching and haul	$5,318.40
Haul from Escondido, 29 miles, 56 tons @ $0.20 ton mile	208.80
Trenching, 400 cu. yds. @ $1.00	400.00
Inlet Structure	275.00
Outlet Structure	275.00

Blow-off Valve and Tee	$ 150.00
Manhole	100.00
Concrete Anchor	200.00
Total Cost of Siphon	$6,927.20
Cost per foot of horizontal length	$ 9.48

Summary of Siphon Lengths and Costs:

Siphon No.	Length	Size	Cost
1	210'	46"	$ 2,646.98
2	910'	46"	6,814.11
3	1,230'	46"	10,207.30
4	240'	46"	2,402.56
5	1,580'	46"	47,754.35
6	730'	46"	6,927.20
Totals	4,900'		$76,752.50

Average Cost per foot of horizontal length ------- $ 15.66

Flumes:

Quantities based upon San Dieguito Mutual Water Company's Standard Plan of Trestles, increased 50% for larger flume and changes in plans. These quantities were then applied to Trestle No. 6 on Hellhole Conduit, length 190 feet, as follows:

Excavation, 10 cu. yds. @ $2.00	$ 20.00
Reinforced concrete, 25 cu. yds. @ $30.00	750.00
Plain concrete, 9 cu. yds. @ $20.00	180.00
Metal flume in place, 190 lin. ft. @ $4.00	760.00
Total cost	$1,710.00
Cost per foot	$ 9.00

A price of $9.00 per lin. ft. was then applied to all trestle supported flumes. It is believed that this is a safe basis for purposes of estimates, but in actually executing the work it is very probable that a different design from that used by San Dieguito Mutual Water Company would be used.

As there is a total length of 6,800 feet of flume on Hellhole Conduit, the total cost will be $61,200.00.

Finally, the total cost of Hellhole Conduit from Warner Dam to Hellhole Forebay is:

Clearing	$ 1,050
Excavation	115,272
Tunnels	86,710
Lining for Ditch Section	150,000
Concrete Cover Slab	11,925
Culverts	10,100
Siphons	76,752
Flumes	61,200
Road for construction and maintenance, 80,000 lin. ft. @ $0.50	40,000
Engineering and contingencies	82,951
12 bridges @ $100 each	1,200
Total Cost	$637,160

Item 4. Conduit from Hellhole to Merriam Forebay:

Description:

Concrete Conduit (open)	57,690	feet
Concrete Conduit (covered)	1,500	"
Total Concrete Conduit	59,190	feet
Tunnels	300	"
Siphons	17,760	"
Metal Flume on Concrete Trestle	3,640	"
Total length	80,890	feet

Clearing:

Total length 80,890 feet; assume average cleared width of 20 feet; cleared area 37 acres. 37 acres @ $30 per acre ---------- $ 1,110

Excavation:

To Station 108-00 - 7,260 cu. yds.

5,810 cu. yds. Earth
0 cu. yds. Loose Rock
1,450 cu. yds. Solid Rock

From Station 108+00 to Station 170+00 = 8,350 cu. yds.

7,930 cu. yds. Earth
0 cu. yds. Loose Rock
420 cu. yds. Solid Rock

From Station 170+00 to Station 360+00 = 18,280 cu. yds.

10,970 cu. yds. Earth
3,660 cu. yds. Loose Rock
3,650 cu. yds. Solid Rock

From Station 360+00 to End = 31,000 cu. yds.

23,250 cu. yds. Earth
4,650 cu. yds. Loose Rock
3,100 cu. yds. Solid Rock

Total Excavation (except siphons and tunnels):

47,960 cu. yds. Earth @ $0.50	$23,980	
8,310 cu. yds. Loose Rock @ $2.00	16,620	
8,620 cu. yds. Solid Rock @ $4.00	34,480	$75,080

Tunnels:

One tunnel 300 feet long; 5 feet by 7 feet; assume hard rock. As explained in detail for Warner-Hellhole Conduit (page 48) price to be $29.00 per lineal foot. 300 lin. ft. @ $29.00 ------- $8,700

Lining for Ditch Section:

59,190 lin. ft. lined with gunite and wire mesh (3" thickness) @ $0.18 per sq. ft. or $1.95 per lin. ft. of conduit ---------- $115,000

Concrete Cover Slab:

1,500 lin. ft; width inside 5.42 feet; width of slab 6.4 feet; depth of slab 4 inches. At $0.32 per sq. ft. of slab, $2.00 per lin. ft., 1,500 lin. ft. @ $2.00 ---------- $3,000

Culverts:

94 culverts @ $100 each as explained in detail for Warner-Hellhole Conduit (page 48) ---------- $9,400

Siphons:

Siphon No. 1:

Horizontal length 1570 feet. Slope length 1655 feet.

Maximum Head 230 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

140'	pipe	@	30'	head	@	$3.53	erected	----------	$ 494.20
70'	"	"	40'	"	"	3.81	"	----------	266.70
70'	"	"	50'	"	"	4.10	"	----------	287.00
90'	"	"	60'	"	"	4.34	"	----------	390.60
85'	"	"	70'	"	"	4.64	"	----------	394.40
85'	"	"	80'	"	"	4.93	"	----------	419.05
95'	"	"	90'	"	"	5.26	"	----------	499.70
55'	"	"	100'	"	"	5.59	"	----------	307.45
65'	"	"	110'	"	"	5.92	"	----------	384.80
50'	"	"	120'	"	"	6.25	"	----------	312.50
50'	"	"	130'	"	"	6.58	"	----------	329.00
65'	"	"	140'	"	"	6.91	"	----------	449.15
65'	"	"	150'	"	"	7.24	"	----------	470.60
65'	"	"	160'	"	"	7.57	"	----------	492.05
65'	"	"	170'	"	"	7.90	"	----------	513.50
65'	"	"	180'	"	"	8.23	"	----------	534.95
90'	"	"	190'	"	"	8.56	"	----------	770.40
80'	"	"	200'	"	"	8.89	"	----------	711.20
95'	"	"	210'	"	"	9.22	"	----------	875.90
85'	"	"	220'	"	"	9.55	"	----------	811.75
125'	"	"	230'	"	"	9.88	"	----------	1,235.00

Total Cost of pipe erected except haul and trenching ----------	$10,949.90
Leveling and benching, 700 cu. yds. @ $1.00 -----	700.00
Inlet Structure ----------	275.00
Outlet Structure ----------	275.00
Haul from Escondido to job, 22 miles, 75 tons @ $0.20 ton mile ----------	330.00
Blow-off Valve and Tee ----------	150.00
Manhole ----------	100.00
Concrete Anchor ----------	200.00
Total Cost of Siphon ----------	$12,979.90
Cost per foot of Horizontal Length ----------	$ 8.27

Siphon No. 2:

Horizontal Length 450 feet. Slope Length 510 feet.

Maximum Head 95 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

225'	pipe	@	30'	head	@	$3.53	erected	$ 794.25
50'	"	"	40'	"	"	3.81	"	190.50
115'	"	"	50'	"	"	4.10	"	471.50
30'	"	"	60'	"	"	4.34	"	130.20
30'	"	"	70'	"	"	4.64	"	139.20
25'	"	"	80'	"	"	4.93	"	123.25
25'	"	"	90'	"	"	5.26	"	131.50
10'	"	"	100'	"	"	5.59	"	55.90

Total Cost of pipe erected except haul to job and trenching ---------- $2,036.30

Haul from Escondido to job, 20 miles, 16 tons @ $0.20 ton mile ---------- 64.00

Leveling and Benching, 200 cu. yds. @ $1.00 ------ 200.00

Inlet Structure with sand trap ---------- 725.00

Outlet Structure ---------- 275.00

2 Blow-off Valves and Tees ---------- 300.00

2 Manholes ---------- 200.00

Concrete Anchor ---------- 200.00

Air Valve ---------- 75.00

Total Cost of Siphon ---------- $4,075.50

Cost per foot of horizontal length ---------- $ 9.05

Siphon No. 3:

Horizontal Length 1210 feet. Slope Length 1275 feet.

Maximum Head 50 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

275'	pipe	@	30'	head	@	$3.53	erected	$ 970.75
375'	"	"	40'	"	"	3.81	"	1,428.75
625'	"	"	50'	"	"	4.10	"	2,562.50

Total Cost of pipe erected except haul to job and trenching ---------- $4,962.00

Haul from Escondido, 19 miles, 40 tons @ $0.20 ton mile							$ 152.00
Leveling and Benching, 500 cu. yds. @ $1.00							500.00
Inlet Structure							275.00
Outlet Structure							275.00
Blow-off Valve and Tee							150.00
Manhole							100.00
Concrete Anchor							200.00
Total Cost of Siphon							$6,614.00
Cost per foot of horizontal length							$ 5.48

Siphon No. 4:

Horizontal Length 1600 feet. Slope Length 1645 feet.

Maximum Head 135 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

525'	pipe	@	30'	head	@	$3.53	erected		$1,853.25
85'	"	"	40'	"	"	3.81	"		323.85
65'	"	"	50'	"	"	4.10	"		266.50
80'	"	"	60'	"	"	4.34	"		347.20
65'	"	"	70'	"	"	4.64	"		301.60
75'	"	"	80'	"	"	4.93	"		369.75
80'	"	"	90'	"	"	5.26	"		420.80
110'	"	"	100'	"	"	5.59	"		614.90
120'	"	"	110'	"	"	5.92	"		710.40
135'	"	"	120'	"	"	6.25	"		843.75
155'	"	"	130'	"	"	6.58	"		1,019.90
150'	"	"	140'	"	"	6.91	"		1,036.50

Total Cost of pipe in place except haul to job and trenching	$8,108.40
Haul from Escondido to job, 15 miles, 60 tons @ $0.20 ton mile	180.00
Leveling and Benching, 700 cu. yds. @ $1.00	700.00
Inlet Structure with sand trap	725.00
Outlet Structure	275.00

Blow-off Valve and Tee		$ 150.00
Manhole		100.00
Concrete Anchor		200.00
Total Cost of Siphon		$10,438.40
Cost per foot of horizontal length		$ 6.52

Siphon No. 5:

Horizontal Length 420 feet. Slope Length 430 feet.

Maximum Head 45 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

230'	pipe @	30'	head @	$3.53	erected		$ 811.90
100'	"	" 40'	"	" 3.81	"		381.00
100'	"	" 50'	"	" 4.10	"		410.00

Total Cost of pipe in place except haul and trenching	$1,602.90
Haul from Escondido, 14 miles, 14 tons @ $0.20 ton mile	39.20
Leveling and Benching, 200 cu. yds. @ $1.00	200.00
Inlet Structure with sand trap	725.00
Outlet Structure	275.00
Blow-off Valve and Tee	150.00
Manhole	100.00
Concrete Anchor	150.00
Total Cost of Siphon	$3,242.10
Cost per foot of horizontal length	$ 7.72

Siphon No. 6:

Horizontal Length 640 feet. Slope Length 655 feet.

Maximum Head 60 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

215'	pipe	@ 30'	head	@	$3.53	erected	$ 758.95
145'	"	" 40'	"	"	3.81	"	552.45
155'	"	" 50'	"	"	4.10	"	635.50
140'	"	" 60'	"	"	4.34	"	607.60

Total Cost of pipe in place except trenching and haul	$2,554.50
Haul from Escondido, 13 miles, 22 tons @ $0.20 ton mile	61.20
Leveling and Benching, 300 cu. yds. @ $1.00	300.00
Inlet Structure	275.00
Outlet Structure	275.00
Blow-off Valve and Tee	150.00
Manhole	100.00
Concrete Anchor	150.00
Total Cost of Siphon	$3,865.70
Cost per foot of horizontal length	$ 6.04

Siphon No. 7:

Horizontal Length 530 feet. Slope Length 535 feet.

Maximum Head 30 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

535' pipe @ 30' head @ $3.53 erected	$1,888.55
Haul from Escondido to job, 16 miles, 16 tons @ $0.20 ton mile	51.20
Leveling and Benching, 250 cu. yds. @ $1.00	250.00
Inlet Structure with sand trap	725.00
Outlet Structure	275.00
Blow-off Valve and Tee	150.00
Manhole	100.00

Concrete Anchor	$ 150.00
Total Cost of Siphon	$3,589.75
Cost per foot of horizontal length	$ 6.77

Siphon No. 8:

Horizontal Length 2000 feet. Slope Length 2055 feet.

Maximum Head 110 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

210' @ 30' head @ $3.53 erected	$ 741.30
85' " 40' " " 3.81 "	323.85
215' " 50' " " 4.10 "	881.50
450' " 60' " " 4.34 "	1,953.00
600' " 70' " " 4.64 "	2,784.00
220' " 80' " " 4.93 "	1,084.60
90' " 90' " " 5.26 "	473.40
155' " 100' " " 5.59 "	866.45
30' " 110' " " 5.92 "	177.60
Total Cost of pipe in place except trenching and haul	$9,285.70
Haul from Escondido to job, 16 miles, 56 tons @ $0.20 ton mile	179.20
Leveling and Benching, 900 cu. yds. @ $1.00	900.00
Inlet Structure	275.00
Outlet Structure	275.00
5 Blow-off Valves and Tees	750.00
3 Manholes	300.00
2 Concrete Anchors	400.00
4 Air Valves	300.00
Total Cost of Siphon	$12,664.90
Cost per foot of horizontal length	$ 6.33

Siphon No. 9:

Horizontal Length 820 feet. Slope Length 845 feet.

Maximum Head 110 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

240'	pipe	@	30'	head	@	$3.53	erected	----------	$ 847.20
60'	"	"	40'	"	"	3.81	"	----------	228.60
60'	"	"	50'	"	"	4.10	"	----------	246.00
65'	"	"	60'	"	"	4.34	"	----------	282.10
85'	"	"	70'	"	"	4.64	"	----------	394.40
105'	"	"	80'	"	"	4.93	"	----------	517.65
120'	"	"	90'	"	"	5.26	"	----------	631.20
90'	"	"	100'	"	"	5.59	"	----------	503.10
20'	"	"	110	"	"	5.92	"	----------	118.40

Total Cost of pipe in place except trenching and haul ---------- $3,768.65

Haul from Escondido to job, 16 miles, 29 tons @ $0.20 ton mile ---------- 92.80

Leveling and Benching, 400 cu. yds. @ $1.00 ------ 400.00

Inlet Structure ---------- 275.00

Outlet Structure ---------- 275.00

Blow-off valve and Tee ---------- 150.00

Manhole ---------- 100.00

Concrete Anchor ---------- 200.00

Total Cost of Siphon ---------- $5,261.45

Cost per foot of horizontal length ---------- $ 6.42

Siphon No. 10:

Horizontal Length 3890 feet. Slope Length 3945 feet.

Maximum Head 110 feet.

38 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

1100'	pipe	@	30'	head	@	$3.00	erected	----------	$ 3,300.00
255'	"	"	40'	"	"	3.10	"	----------	790.50
795'	"	"	50'	"	"	3.30	"	----------	2,623.50
950'	"	"	60'	"	"	3.55	"	----------	3,372.50
415'	"	"	70'	"	"	3.83	"	----------	1,589.45
175'	"	"	80'	"	"	4.10	"	----------	717.50

135'	pipe	@	90'	head	@	$4.38	erected	----------	$ 591.30
75'	"	"	100'	"	"	4.65	"	----------	348.75
45'	"	"	110'	"	"	4.93	"	----------	221.85

Total Cost of pipe in place except trenching and haul ---------- $13,555.35

Haul from Escondido, 10 miles, 110 tons @ $0.20 ton mile ---------- 220.00

Leveling and Benching, 1100 cu. yds. @ $1.00 ---- 3,360.00

Inlet Structure ---------- 275.00

Outlet Structure ---------- 275.00

2 Blow-off Valves and Tees ---------- 300.00

3 Manholes ---------- 300.00

Air Valve ---------- 75.00

Concrete Anchors ---------- 400.00

Total Cost of Siphon ---------- $18,760.00

Cost per foot of horizontal length ---------- $ 4.82

Siphon No. 11:

Horizontal Length 500 feet. Slope Length 515 feet.

Maximum Head 60 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

210'	pipe	at	30'	head	@	$3.53	erected	----------	$ 741.30
85'	"	"	40'	"	"	3.81	"	----------	323.85
90'	"	"	50'	"	"	4.10	"	----------	369.00
130'	"	"	60'	"	"	4.34	"	----------	564.20

Total Cost of pipe in place except trenching and haul ---------- $1,998.35

Haul from Escondido, 11 miles, 16 tons @ $0.20 ton mile ---------- 35.20

Trenching, 200 cu. yds. @ $1.00 ---------- 200.00

Inlet and Outlet Structure ---------- 550.00

Blow-off Valve and Tee ---------- 150.00

Manhole								$ 100.00
Concrete Anchor								150.00
Total Cost of Siphon								$3,183.55
Cost per foot of horizontal length								$ 6.37

Siphon No. 12:

Horizontal Length 3860 feet. Slope Length 4095 feet.

Maximum Head 160 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

125'	pipe @	30'	head @	$3.53	erected		$	441.25
50'	" "	40'	" "	3.81	"			190.50
40'	" "	50'	" "	4.10	"			164.00
50'	" "	60'	" "	4.34	"			217.00
285'	" "	70'	" "	4.64	"			1,322.40
345'	" "	80'	" "	4.93	"			1,700.85
530'	" "	90'	" "	5.26	"			2,787.80
660'	" "	100'	" "	5.59	"			3,689.40
560'	" "	110'	" "	5.92	"			3,315.20
510'	" "	120'	" "	6.25	"			3,187.50
330'	" "	130'	" "	6.58	"			2,171.40
125'	" "	140'	" "	6.91	"			863.75
280'	" "	150'	" "	7.24	"			2,027.20
205'	" "	160'	" "	7.57	"			1,551.85

Total Cost of pipe in place except trenching and haul	$23,630.10
Haul from Escondido, 10 miles, 118 tons @ $0.20 ton mile	236.00
Leveling and Benching, 1700 cu. yds. @ $1.00	1,700.00
Inlet and Outlet Structures	550.00
6 Blow-off Valves and Tees	900.00
3 Manholes	300.00
Concrete Anchors	600.00
6 Air Valves	450.00
Total Cost of Siphon	$28,366.10
Cost per foot of horizontal length	$ 7.34

Siphon No. 13:

Horizontal Length 270 feet. Slope Length 275 feet.

Maximum Head 30 feet.

46 inch diameter wood stave pipe.

Capacity 50 second feet (n = .014).

275' pipe @ 30' head @ $3.53 erected	$	970.75
Haul from Escondido, 8 miles, 9 tons @ $0.20 ton mile		14.40
Leveling and Benching, 120 cu. yds. @ $1.00		120.00
Inlet and Outlet Structures		550.00
Blow-off Valve and Tee		150.00
Concrete Anchor		100.00
Total Cost of Siphon		$1,905.15
Cost per foot of horizontal length	$	7.05

Summary of Siphon Lengths and Costs:

Siphon No.	Length	Size	Cost
1	1,570	46"	$12,979.90
2	450	46"	4,075.30
3	1,210	46"	6,614.00
4	1,600	46"	10,458.40
5	420	46"	3,242.10
6	640	46"	3,865.70
7	530	46"	3,589.75
8	2,000	46"	12,664.90
9	820	46"	5,261.45
10	3,890	38"	18,760.35
11	500	46"	3,183.55
12	3,860	46"	28,366.10
13	270	46"	1,905.15
Totals	17,760		$114,946.65

Average Cost per foot of horizontal length ------ $ 6.47

Flumes:

As previously explained (page 54) quantities are based upon San Dieguito Mutual Water Company's Standard Plan of Trestles, increased 50% for

larger flume and changes in plan, from which, by application to Trestle No. 6 on Warner-Hellhole Conduit, an average cost of $9.00 per lin. ft. was derived.

As the total length of flume on trestle is 3,640 lin. ft. in Merriam Conduit, the total cost will be 3,640 @ $9.00 ---------- $32,760

Finally the total cost of conduit from Hellhole to Merriam Forebay will be:

Clearing	$ 1,110
Excavation	75,080
Tunnels	8,700
Lining for Ditch Section	115,000
Concrete Cover Slab	3,000
Culverts	9,400
Siphons	114,947
Flumes	32,760
Road for construction and maintenance, 83,000 lin. ft. @ $0.50	41,500
Fencing 10 miles of conduit on both sides @ $200 per mile of fence	4,000
30 Bridges across Canal @ $100 each	3,000
Engineering and Contingencies	61,274
Total Cost	$469,771

Item 5. Merriam Reservoir:

Merriam Dam:

The site of the principal dam of Merriam Reservoir is well suited for the construction of a reinforced concrete multiple-arch dam. The extreme height of this dam from stream bed to maximum flood line will be approximately 120 feet. Its length at maximum flood line will be 550 feet. No exploration excavations have been made, but surface indications lead to the assumption that bed rock will be reached without costly excavation. I am informed that in February, 1918, Mr. John S.

Eastwood estimated the cost of a dam at this site complete to be $137,000. Mr. F. M. Faude on August 19th used a figure of $175.000. Without complete plans, and the preparation of them is beyond the scope of this report, it is not possible to make an exact estimate, but, from my study of the site and approximate estimates, I have decided to adopt Mr. Faude's figure. This is for the dam complete including exploration excavation, valves, fittings, engineering, etc. ---- $175,000

North Dike:

Crest width 20 feet; slopes 2:1 and 1½:1; riprap both sides 12 inches thick; crest elevation 1060 feet.

Clearing 1 acre	$ 30	
Cut-off wall 1 x 6 x 900 = 200 cu. yds. @ $15	3,000	
Earth embankment, 46,500 cu. yds. @ $.30	13,950	
Riprap, 74,000 sq. ft. @ $.08	5,920	
Engineering and contingencies	3,435	26,335

South Dike:

Clearing ½ acre	$ 15	
Cut-off wall 1 x 4 x 400 = 60 cu. yds. @ $15	900	
Earth embankment, 3,500 cu. yds. @ $.30	1,050	
Engineering and contingencies	415	
Riprap, 10,000 sq. ft. @ $.08	800	3,180

Clearing Reservoir Site:

About 40 acres to be cleared @ $30 ---------- 1,200

Moving County Road:

9,000 feet of new County road to be constructed @ $1.00 ---------- 9,000

Total Cost of Merriam Reservoir ---------- $214,715

Item 6. Distribution System:

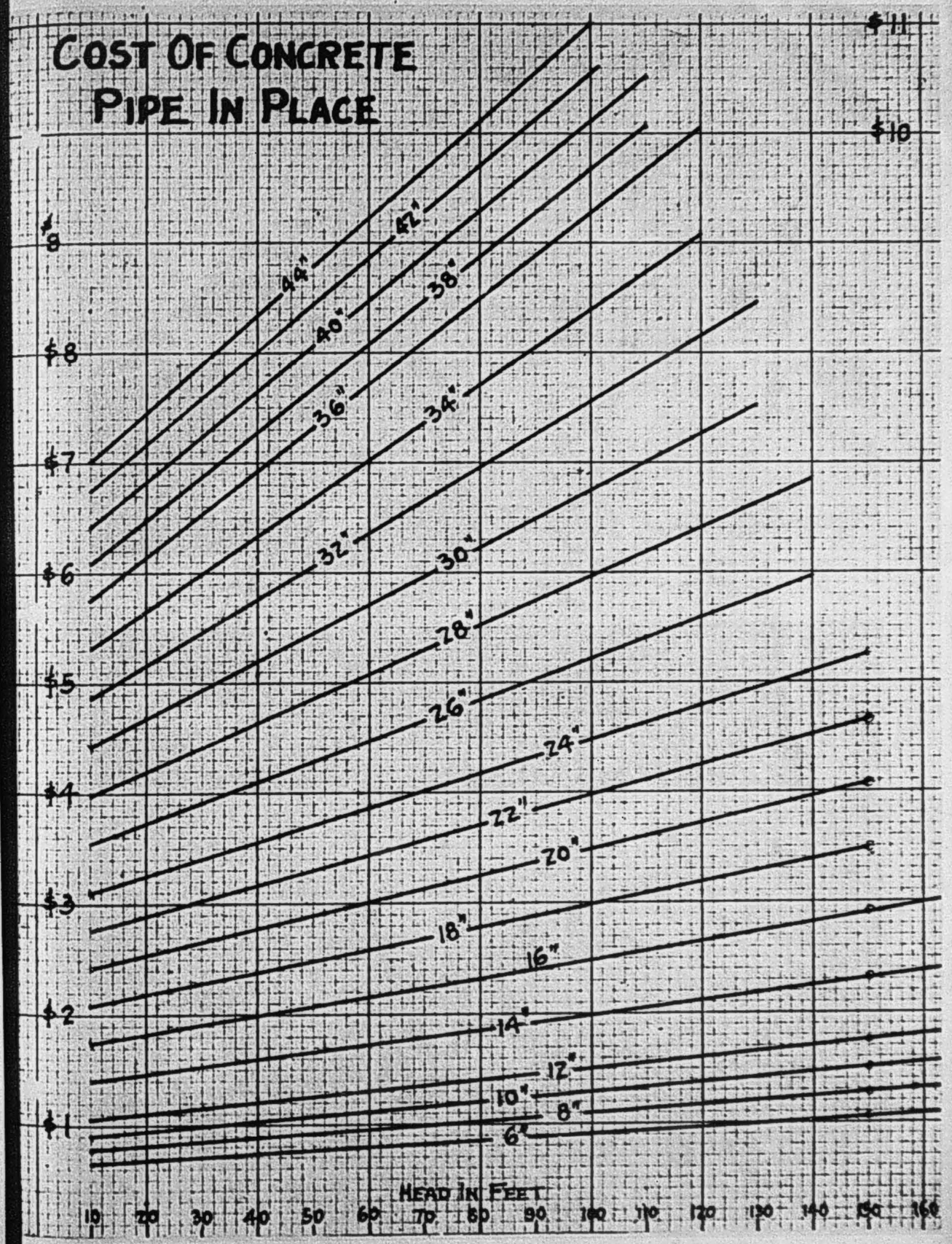
In computing the sizes of pipes to be used as a basis for estimating the cost of constructing the distribution system, the duty of water over the entire District was assumed as

one acre foot per acre per annum. It was also assumed that the use during the driest month would be 15% of the total yearly use or .15 acre foot per acre - .00252 second foot per acre of irrigable area, or, as the irrigable area is 64% of the gross area, .00161 second foot flow for each acre of gross area. The addition of 10% for safety gives a flow of .0018 second foot for each acre of gross area.

Under normal conditions I would hesitate to use concrete pipe for withstanding pressures as great as those imposed upon the distribution system of this District, but at the present time it is practically impossible to obtain steel pipe and where obtainable it is at prohibitive prices. Under these unusual conditions I believe the use of heavily reinforced concrete pipe with special reinforced collars at joints is warranted. The estimates which follow are based upon this class of construction, except as noted. The estimated cost at yard of concrete pipe of various diameters is given in Table 9(a). The estimated average cost for trenching is given in Table 10, the estimated cost of hauling and distributing in Table 11, and the total estimated cost of the pipe in place in Table 12. From the figures of Table 12, the diagram of Plate 13 has been constructed and it has been utilized as a basis of the estimates which follow. These figures are believed to be high enough to include engineering and contingencies.

Cost of Vista Pipe Line (Horizontal length 81,300 ft.):

44 inch Concrete Pipe:



WALTER LEROY HUBER
CIVIL ENGINEER

one acre foot per acre per annum. It was also assumed that the use during the driest month would be 15% of the total yearly use or .15 acre foot per acre - .00282 second foot per acre of irrigable area, or, as the irrigable area is 64% of the gross area, .0018 second foot flow for each acre of gross area. The addition of 10% for safety gives a flow of .0018 second foot for each acre of gross area.

Under normal conditions I would hesitate to use concrete pipe for withstanding pressures as great as those imposed upon the distribution system of this District, but at the present time it is practically impossible to obtain steel pipe and where obtainable it is at prohibitive prices. Under these unusual conditions I believe the use of heavily reinforced concrete pipe with special reinforced collars at joints is warranted. The estimates which follow are based upon this class of construction, except as noted. The estimated cost at yard of concrete pipe of various diameters is given in Table 9(a). The estimated average cost for trenching is given in Table 10, the estimated cost of hauling and distributing in Table 11, and the total estimated cost of the pipe in place in Table 12. From the figures of Table 12, the diagram of Plate 13 has been constructed and it has been utilized as a basis of the estimates which follow. These figures are believed to be high enough to include engineering and contingencies.

Cost of Vista Pipe Line (Horizontal length 81,300 ft.):

44 inch Concrete Pipe:

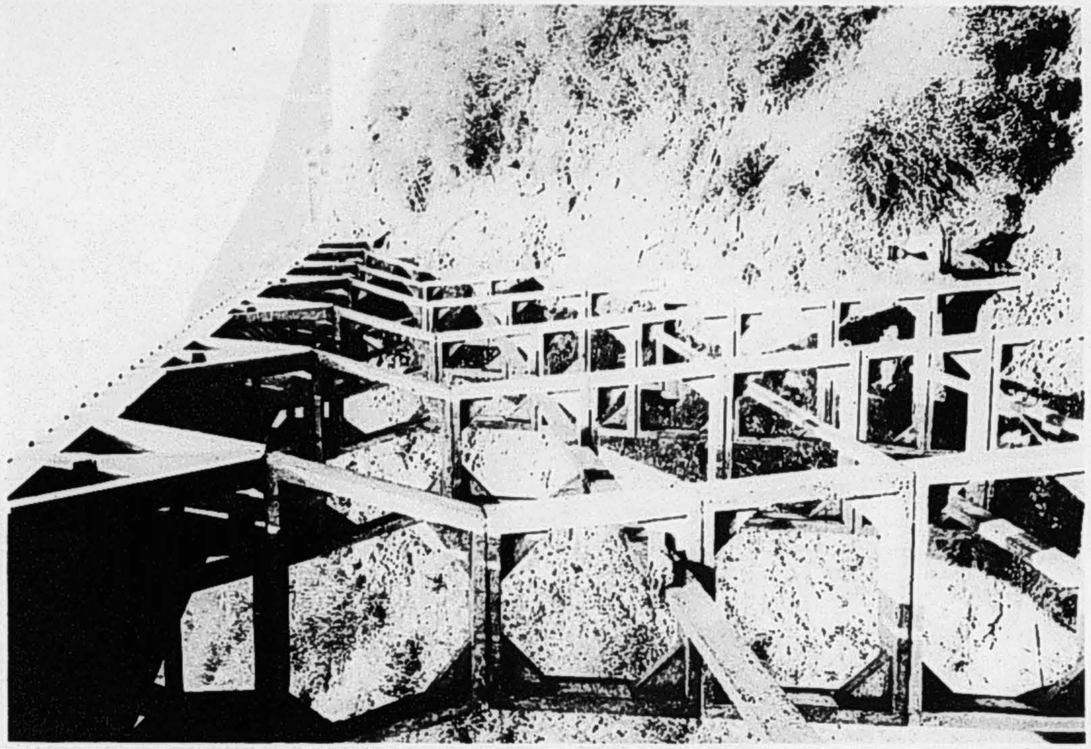


Fig. 1. Concrete trestle on San Dieguito Mutual Water Company's System - a type similar to that to be used by San Luis Rey Irrigation District.

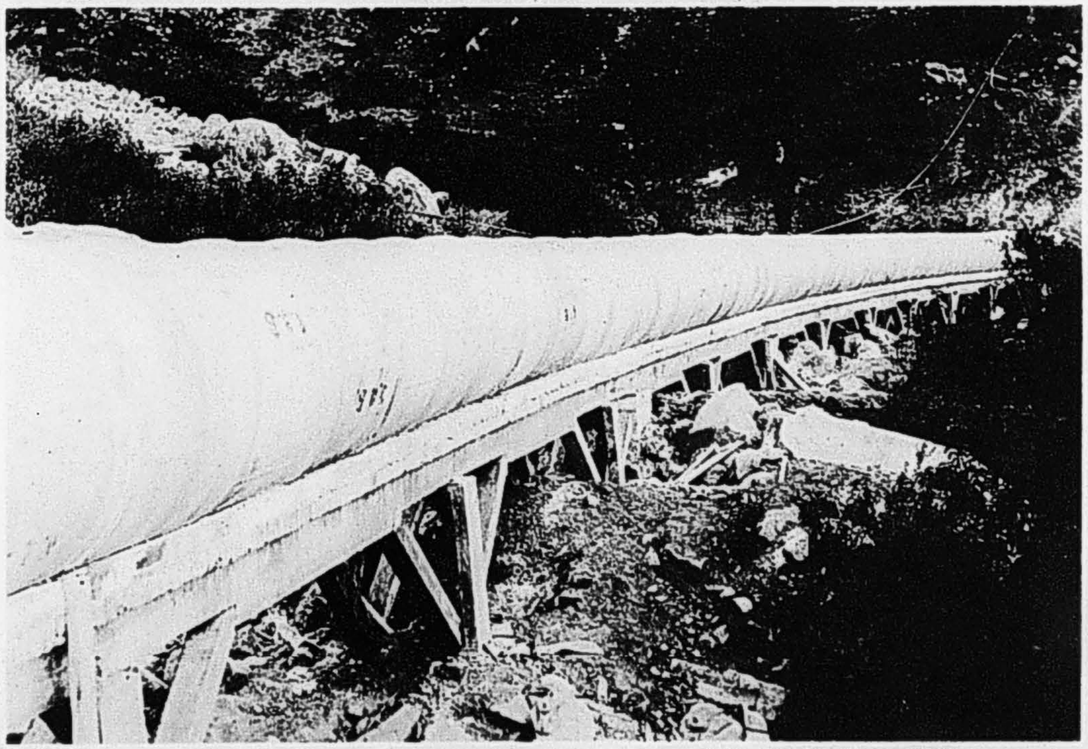


Fig. 2. 42" concrete siphon on San Dieguito Mutual Water Company's System.

310' - 40' head	@	$8.35	$ 2,588.00	
1730' - 50' "	"	8.80	15,224.00	
2450' - 60' "	"	9.20	22,540.00	
920' - 70' "	"	9.70	8,924.00	$49,276.00

42 Inch Concrete Pipe:

50' - 50' head	@	$ 8.45	$ 422.50	
50' - 60' "	"	8.95	447.50	
50' - 70' "	"	9.30	465.00	
30' - 80' "	"	9.70	291.00	
30' - 90' "	"	10.15	304.50	1,930.50

40 Inch Concrete Pipe:

940' - 30' head	@	$7.25	$ 6,815.00	
1940' - 40' "	"	7.65	14,841.00	
3160' - 50' "	"	8.05	25,438.00	
790' - 60' "	"	8.50	6,715.00	
700' - 70' "	"	8.90	890.00	
100' - 80' "	"	9.30	930.00	55,629.00

30 Inch Concrete Pipe:

660' - 20' head	@	$4.70	$ 3,102.00	
1020' - 30' "	"	4.95	5,049.00	
1990' - 40' "	"	5.20	10,348.00	
2600' - 50' "	"	5.50	14,300.00	
1480' - 60' "	"	5.75	8,510.00	
870' - 70' "	"	6.00	5,220.00	
870' - 80' "	"	6.25	5,437.50	
250' - 90' "	"	6.50	1,625.00	
50' - 100' "	"	6.75	337.50	53,929.00

28 Inch Concrete Pipe:

460' - 40' head	@	$4.65	$ 2,139.00	
1530' - 50' "	"	4.90	7,497.00	
50' - 60' "	"	5.10	255.00	9,891.00

26 Inch Concrete Pipe:

110' - 50' head	@	$4.30	$ 473.00	
110' - 60' "	"	4.50	495.00	
110' - 70' "	"	4.65	511.50	
220' - 80' "	"	4.85	1,067.00	
330' - 90' "	"	5.05	1,666.50	
610' - 100' "	"	5.20	3,172.00	
770' - 110' "	"	5.40	4,158.00	
170' - 120' "	"	5.60	952.00	
270' - 130' "	"	5.80	1,566.00	
110' - 140' "	"	5.95	654.50	
220' - 150' "	"	6.15	1,353.00	
280' - 160' "	"	6.35	1,778.00	17,846.50

24 Inch Concrete Pipe:

720' -	40'	head @ $3.55	$2,556.00	
330' -	50'	" " 3.70	1,221.00	
330' -	60'	" " 3.85	1,270.50	
270' -	70'	" " 4.05	1,093.50	
770' -	80'	" " 4.20	3,234.00	
880' -	90'	" " 4.35	3,828.00	
220' -	100'	" " 4.50	990.00	
50' -	110'	" " 4.65	232.50	
280' -	120'	" " 4.80	1,344.00	
270' -	130'	" " 4.95	1,336.50	
220' -	140'	" " 5.10	1,122.00	
390' -	150'	" " 5.25	2,047.50	$20,275.50

22 Inch Concrete Pipe:

320' -	20'	head @ $2.90	$ 928.00	
270' -	30'	" " 3.05	823.50	
430' -	40'	" " 3.20	1,376.00	
370' -	50'	" " 3.30	1,221.00	
860' -	60'	" " 3.45	2,967.00	
700' -	70'	" " 3.60	2,520.00	
670' -	80'	" " 3.70	2,479.00	
1040' -	90'	" " 3.85	4,004.00	
640' -	100'	" " 4.00	2,560.00	
1700' -	110'	" " 4.10	6,970.00	
430' -	120'	" " 4.25	1,827.50	
320' -	130'	" " 4.40	1,408.00	
370' -	140'	" " 4.50	1,665.00	
160' -	150'	" " 4.65	744.00	31,493.00

20 Inch Concrete Pipe:

220' -	20'	head @ $2.55	$ 561.00	
220' -	30'	" " 2.65	583.00	
270' -	40'	" " 2.80	756.00	
280' -	50'	" " 2.90	812.00	
220' -	60'	" " 3.00	660.00	
220' -	70'	" " 3.15	693.00	
160' -	80'	" " 3.25	520.00	
220' -	90'	" " 3.40	748.00	
170' -	100'	" " 3.50	595.00	
50' -	110'	" " 3.60	180.00	
60' -	120'	" " 3.75	225.00	
160' -	130'	" " 3.85	616.00	
170' -	140'	" " 3.95	671.50	
220' -	150'	" " 4.10	902.00	8,522.50

18 Inch Concrete Pipe:

160' -	20'	head @	$2.20	$ 352.00	
110' -	30'	" "	2.30	253.00	
100' -	40'	" "	2.40	240.00	
110' -	50'	" "	2.50	275.00	
480' -	60'	" "	2.60	1,248.00	
270' -	70'	" "	2.70	729.00	
320' -	80'	" "	2.80	896.00	
540' -	90'	" "	2.95	1,593.00	
270' -	100'	" "	3.00	810.00	
110' -	110'	" "	3.10	341.00	
160' -	120'	" "	3.20	512.00	
170' -	130'	" "	3.30	561.00	
210' -	140'	" "	3.40	714.00	
170' -	150'	" "	3.50	595.00	$ 9,119.00

14 Inch Concrete Pipe:

440' -	40'	head @	$1.60	$ 704.00	
500' -	50'	" "	1.70	850.00	
440' -	60'	" "	1.75	770.00	
160' -	70'	" "	1.80	288.00	
500' -	80'	" "	1.85	925.00	
1150' -	90'	" "	1.95	2,242.50	
1160' -	100'	" "	2.00	2,320.00	
880' -	110'	" "	2.05	1,804.00	
550' -	120'	" "	2.10	1,155.00	
660' -	130'	" "	2.20	1,452.00	
270' -	140'	" "	2.25	607.50	
280' -	150'	" "	2.30	644.00	
270' -	160'	" "	2.40	648.00	14,410.00

12 Inch Concrete Pipe:

60' -	100'	head @	$1.50	$ 90.00	
110' -	110'	" "	1.55	170.50	
710' -	120'	" "	1.60	1,136.00	
1600' -	130'	" "	1.65	2,640.00	
1650' -	140'	" "	1.70	2,805.00	
1100' -	150'	" "	1.75	1,925.00	
660' -	160'	" "	1.80	1,188.00	
220' -	170'	" "	1.85	407.00	
220' -	180'	" "	1.90	418.00	10,779.50

10 Inch Concrete Pipe:

170' -	40'	head @	$1.05	$ 178.50	
110' -	50'	" "	1.10	121.00	
160' -	60'	" "	1.15	184.00	
220' -	70'	" "	1.20	264.00	
280' -	80'	" "	1.20	336.00	
330' -	90'	" "	1.25	412.50	
1100' -	100'	" "	1.30	1,430.00	
1050' -	110'	" "	1.35	1,417.50	

990' - 120'	head @ $1.40	---------	$1,386.00	
1320' - 130'	" " 1.45	---------	1,914.00	$ 7,643.50

8 Inch Concrete Pipe:

50' - 90'	head @ $1.10	---------	$ 55.00	
60' - 100'	" " 1.10	---------	66.00	
50' - 110'	" " 1.10	---------	55.00	
60' - 120'	" " 1.15	---------	69.00	
170' - 130'	" " 1.15	---------	195.50	
220' - 140'	" " 1.20	---------	264.00	
550' - 150'	" " 1.20	---------	660.00	
600' - 160'	" " 1.25	---------	750.00	
1490' - 170'	" " 1.30	---------	1,937.00	
490' - 180'	" " 1.35	---------	661.50	
220' - 190'	" " 1.40	---------	308.00	5,021.00

6 Inch Concrete Pipe:

220' - 40'	head @ $0.75	----------	$ 165.00	
110' - 50'	" " 0.80	----------	88.00	
50' - 60'	" " 0.80	----------	40.00	
280' - 70'	" " 0.85	----------	238.00	
160' - 80'	" " 0.85	----------	136.00	
170' - 90'	" " 0.90	----------	153.00	
160' - 100'	" " 0.90	----------	144.00	
110' - 110'	" " 0.95	----------	104.50	
110' - 120'	" " 1.00	----------	110.00	
110' - 130'	" " 1.00	----------	110.00	
110' - 140'	" " 1.05	----------	115.50	
170' - 150'	" " 1.05	----------	178.50	
220' - 160'	" " 1.10	----------	242.00	1,824.50

42 Inch Steel Pipe:

150' - Steel Pipe 10 gauge - Weight per foot 72 lbs. @ $10.80 per foot in place (For heads up to 110 feet)	$1,612.50	
100' - Steel Pipe 3/16" Plate - Weight per foot 103 lbs. @ $14.80 per foot in place (For 120' to 140' heads) ----------	1,480.00	
390' - Steel Pipe ¼" Plate - Weight per foot 141 lbs. @ $19.80 per foot in place (For 150' to 190' heads) -	7,722.00	
2930' - Steel Pipe 5/16" Plate - Weight per foot 175 lbs. @ $24.50 per foot in place (For heads from 200' to 230') ----------	71,785.00	82,599.50

26 Inch Steel Pipe:

1890' - Steel Pipe 10 gauge - Weight per foot 42 lbs. @ $6.15 per foot in place (For heads up to 170 feet) -----	$11,623.50	
1730' - Steel Pipe 3/16" Plate - Weight per foot 66 lbs. @ $9.35 per foot in place (For heads from 180' to 200') ----------	16,175.50	$27,799.00

24 Inch Steel Pipe:

360' - Steel Pipe 10 gauge - Weight per foot 40 lbs. @ $5.80 per foot in place (For heads up to 190') ---------	$ 2,088.00	
1480' - Steel Pipe 3/16" Plate - Weight per foot 62 lbs. @ $8.70 per foot in place (For heads from 200' to 250') ----------	12,876.00	14,964.00

22 Inch Steel Pipe:

2910' - Steel Pipe 10 gauge - Weight per foot 35 lbs. @ $5.10 per foot in place (For heads up to 200 feet) -----	$14,841.00	14,841.00

20 Inch Steel Pipe:

1930' - Steel Pipe 10 gauge - Weight per foot 32 lbs. @ $4.65 per foot in place (For heads up to 220 feet) -----	8,974.50	8,974.50

12 Inch Steel Pipe:

820' - Steel Pipe 10 gauge - Weight per foot 16 lbs. @ $2.40 per foot in place (For heads up to 210 feet) -----	1,668.00	1,668.00

Specials and Angles for Steel Pipe ----------	4,500.00
1 - 44 Inch Gate Valve in place ----------	2,600.00
1 - 40 " " " " " ----------	2,400.00
1 - 26 " " " " " ----------	570.00
3 - 24 " " " " " @ $430.00 ----------	1,290.00
1 - 16 " " " " " ----------	260.00
1 - 14 " " " " " ----------	170.00
1 - 12 " " " " " ----------	135.00
1 - 10 " " " " " ----------	100.00
1 - 8 " " " " " ----------	85.00
1 - 44 Inch Standpipe with Float Valve Control -------	6,000.00
1 - 42 " " " " " " -------	5,500.00

1 - 30 Inch Standpipe with Float Valve Control ------		$	5,000.00
3 - 24 " " " " " " @ $3300-			9,900.00
1 - 18 " " " " " " ------			2,000.00
1 - 26 " " " " " " ------			4,500.00
1 - 14 " " " " " " ------			1,100.00
1 - 12 " " " " " " ------			1,050.00
1 - 10 " " " " " " ------			1,000.00
1 - 8 " " " " " " ------			900.00
70 - 6 Inch Gate Valves in place @ $75.00 ----------			5,250.00
3,000 Lin. H. Concrete Trestle @ $5.00 ----------			15,000.00
60 - 2 Inch Air Valves in place @ $75.00 ----------			4,500.00
930 Lin. H. Tunnel @ $20.00 ----------			18,600.00
Miscellaneous Items Not Included Above ----------			10,000.00
Total Cost of Vista Pipe Line ----------		$	550,847.00
Average Cost per foot ----------		$	6.77

Cost of San Marcos Pipe Line (Horizontal length 18,000 ft.):

32 Inch Concrete Pipe:

360' - 10' head @ $4.85 ---------	$ 1,746.00		
1630' - 20' " " 5.15 ---------	8,394.50		
1890' - 30' " " 5.50 ---------	10,395.00		
820' - 40' " " 5.75 ---------	4,715.00		
360' - 50' " " 6.05 ---------	2,178.00		
360' - 60' " " 6.35 ---------	2,268.00		
460' - 70' " " 6.65 ---------	3,059.00		
160' - 80' " " 6.95 ---------	1,112.00		
100' - 90' " " 7.25 ---------	725.00		
100' - 100' " " 7.55 ---------	755.00		
100' - 110' " " 7.85 ---------	785.00		
100' - 120' " " 8.15 ---------	815.00		
100' - 130' " " 8.45 ---------	845.00		$37,810.50

16 Inch Concrete Pipe:

100' - 30' head @ $1.90 ----------	$ 190.00		
970' - 40' " " 2.00 ----------	1,940.00		
560' - 50' " " 2.10 ----------	1,176.00		
410' - 60' " " 2.20 ----------	902.00		4,208.00

14 Inch Concrete Pipe:

260' - 40' head @ $1.60 ---------	$ 416.00		
1630' - 50' " " 1.70 ---------	2,771.00		
1380' - 60' " " 1.75 ---------	2,415.00		
1070' - 70' " " 1.80 ---------	1,926.00		

200' - 80'	head @	$1.85	----------	$ 370.00
200' - 90'	"	" 1.95	----------	390.00
150' - 100'	"	" 2.00	----------	300.00
100' - 110'	"	" 2.05	----------	205.00
				$ 8,793.00

12 Inch Concrete Pipe:

660' - 60'	head @	$1.30	----------	$ 858.00
110' - 70'	"	" 1.35	----------	148.50
110' - 80'	"	" 1.40	----------	154.00
220' - 90'	"	" 1.45	----------	319.00
170' - 100'	"	" 1.50	----------	255.00
280' - 110'	"	" 1.55	----------	454.00
				2,168.50

8 Inch Concrete Pipe:

110' - 40'	head @	$0.90	----------	$ 99.00
60' - 50'	"	" 0.95	----------	57.00
60' - 60'	"	" 0.95	----------	57.00
50' - 70'	"	" 1.00	----------	50.00
110' - 80'	"	" 1.05	----------	115.50
110' - 90'	"	" 1.10	----------	121.00
110' - 100'	"	" 1.10	----------	121.00
110' - 110'	"	" 1.15	----------	126.50
60' - 120'	"	" 1.20	----------	72.00
50' - 130'	"	" 1.20	----------	60.00
110' - 140'	"	" 1.25	----------	137.50
330' - 150'	"	" 1.30	----------	429.00
330' - 160'	"	" 1.30	----------	429.00
220' - 170'	"	" 1.35	----------	297.00
390' - 180'	"	" 1.40	----------	546.00
770' - 190'	"	" 1.45	----------	1,116.50
				3,834.00

32 Inch Steel Pipe:

610 lin. ft. - Steel Pipe No. 9 gauge - Weight per foot 55 lbs. @ $8.15 per foot in place (For 140' and 150' heads) ----------	4,971.50
Specials and Angles for Steel Pipe ----------	250.00
1 - 32 Inch Gate Valve in place ----------	2,100.00
1 - 16 " " " " " ----------	260.00
1 - 12 " " " " " ----------	135.00
1 - 8 " " " " " ----------	85.00
1 - 32 Inch Standpipe with Float Valve Control -----	5,000.00
1 - 8 " " " " " " -----	900.00
18 - 6 Inch Gate Valves in place @ $75 ----------	1,350.00
1500 Lin. H. Concrete Trestles @ $5.00 ----------	7,500.00
24 - 2 Inch Air Valves @ $75.00 ----------	1,800.00

Miscellaneous Items not included above ---------- $ 1,500.00

Total Cost of San Marcos Pipe Line ---------- $82,665.50

Average Cost per foot ---------- $ 4.59

Cost of Buena Pipe Line (Horizontal length 54,500 ft):

30 Inch Concrete Pipe:

60'	- 30'	head @ $4.95	$ 297.00	
1380'	- 40'	" " 5.20	7,176.00	
380'	- 50'	" " 5.50	2,090.00	
390'	- 60'	" " 5.75	2,242.00	
380'	- 70'	" " 6.00	2,280.00	
170'	- 80'	" " 6.25	1,062.50	
220'	- 90'	" " 6.50	1,430.00	
270'	- 100'	" " 6.75	1,822.50	
280'	- 110'	" " 7.00	1,960.00	
220'	- 120'	" " 7.30	1,606.00	
220'	- 130'	" " 7.50	1,650.00	$23,616.50

26 Inch Concrete Pipe:

440'	- 30'	head @ $3.90	$1,716.00	
330'	- 40'	" " 4.10	1,353.00	
170'	- 50'	" " 4.30	731.00	
610'	- 60'	" " 4.50	2,745.00	
270'	- 70'	" " 4.65	1,255.50	
830'	- 80'	" " 4.85	4,025.50	
550'	- 90'	" " 5.05	2,777.50	
440'	- 100'	" " 5.20	2288.00	
660'	- 110'	" " 5.40	3,564.00	
550'	- 120'	" " 5.60	3,080.00	
710'	- 130'	" " 5.80	4,118.00	
990'	- 140'	" " 6.00	5,940.00	33,593.50

22 Inch Concrete Pipe:

110'	- 20'	head @ $2.90	$ 319.00	
60'	- 30'	" " 3.05	183.00	
110'	- 40'	" " 3.20	352.00	
60'	- 50'	" " 3.30	198.00	
490'	- 60'	" " 3.45	1,690.50	
330'	- 70'	" " 3.60	1,188.00	
330'	- 80'	" " 3.70	1,221.00	
550'	- 90'	" " 3.85	2,117.50	
440'	- 100'	" " 4.00	1,760.00	
1210'	- 110'	" " 4.10	4,961.00	
440'	- 120'	" " 4.25	1,870.00	
500'	- 130'	" " 4.40	2,200.00	
110'	- 140'	" " 4.50	495.00	
110'	- 150'	" " 4.65	511.50	19,066.50

Cost of Buena Pipe Line (Horizontal length 84,600 Ft):

30 Inch Concrete Pipe:

880' - 130'	head @	$3.85	$3,388.00	
330' - 140'	" "	3.95	1,303.50	
110' - 150'	" "	4.10	451.00	$ 5,142.50

26 Inch Concrete Pipe:

550' - 20'	head @	$2.20	$1,210.00	
330' - 30'	" "	2.30	759.00	
220' - 40'	" "	2.40	528.00	
170' - 50'	" "	2.50	425.00	
710' - 60'	" "	2.60	1,846.00	
660' - 70'	" "	2.70	1,782.00	
440' - 80'	" "	2.80	1,232.00	
390' - 90'	" "	2.95	1,150.50	
330' - 100'	" "	3.00	990.00	
280' - 110'	" "	3.10	868.00	
550' - 120'	" "	3.20	1,760.00	
1270' - 130'	" "	3.30	4,191.00	
820' - 140'	" "	3.40	2,788.00	
550' - 150'	" "	3.50	1,925.00	21,454.50

22 Inch Concrete Pipe:

110' - 20'	head @	$2.20	$ 242.00	
60' - 30'	" "	2.30	138.00	
110' - 40'	" "	2.40	264.00	
60' - 50'	" "	2.50	150.00	
490' - 60'	" "	2.60	1,274.00	
330' - 70'	" "	2.70	891.00	
330' - 80'	" "	2.80	924.00	
550' - 90'	" "	2.90	1,595.00	
440' - 100'	" "	3.00	1,320.00	
1210' - 110'	" "	3.10	3,751.00	
440' - 120'	" "	3.20	1,408.00	
800' - 130'	" "	3.30	2,640.00	
110' - 140'	" "	3.40	374.00	
110' - 150'	" "	3.50	385.00	19,096.50

20 Inch Concrete Pipe:

880' - 130'	head @	$3.85	$3,388.00	
330' - 140'	" "	3.95	1,303.50	
110' - 150'	" "	4.10	451.00	$ 5,142.50

18 Inch Concrete Pipe:

550' - 20'	head @	$2.20	$1,210.00	
330' - 30'	" "	2.30	759.00	
220' - 40'	" "	2.40	528.00	
170' - 50'	" "	2.50	425.00	
710' - 60'	" "	2.60	1,846.00	
660' - 70'	" "	2.70	1,782.00	
440' - 80'	" "	2.80	1,232.00	
390' - 90'	" "	2.95	1,150.50	
330' - 100'	" "	3.00	990.00	
280' - 110'	" "	3.10	868.00	
550' - 120'	" "	3.20	1,760.00	
1270' - 130'	" "	3.30	4,191.00	
820' - 140'	" "	3.40	2,788.00	
550' - 150'	" "	3.50	1,925.00	21,454.50

16 Inch Concrete Pipe:

110' - 40'	head @	$2.00	$ 220.00	
110' - 50'	" "	2.10	231.00	
110' - 60'	" "	2.20	242.00	
110' - 70'	" "	2.25	247.50	
170' - 80'	" "	2.30	391.00	
50' - 90'	" "	2.40	120.00	
60' - 100'	" "	2.50	150.00	
50' - 110'	" "	2.60	130.00	
60' - 120'	" "	2.65	159.00	1,890.50

16 Inch Concrete Pipe:

50' - 130'	head @	$2.75	$ 137.50	
60' - 140'	" "	2.80	168.00	
50' - 150'	" "	2.90	145.00	
60' - 160'	" "	3.00	180.00	
50' - 170'	" "	3.10	155.00	785.50

14 Inch Concrete Pipe:

600' - 30'	head @	$1.50	$ 900.00	
390' - 40'	" "	1.60	624.00	
1050' - 50'	" "	1.70	1,785.00	
500' - 60'	" "	1.75	875.00	
380' - 70'	" "	1.80	684.00	
220' - 80'	" "	1.85	407.00	
110' - 90'	" "	1.95	214.50	
170' - 100'	" "	2.00	340.00	
220' - 110'	" "	2.05	451.00	6,280.50

12 Inch Concrete Pipe:

330'	-	70'	head	@	$1.35	$ 445.50	
160'	-	80'	"	"	1.40	224.00	
170'	-	90'	"	"	1.45	246.50	
160'	-	100'	"	"	1.50	240.00	
1430'	-	110'	"	"	1.55	2,216.50	
830'	-	120'	"	"	1.60	1,328.00	$ 4,700.50

10 Inch Concrete Pipe:

330'	-	50'	head	@	$1.10	$ 363.00	
330'	-	60'	"	"	1.15	379.50	
440'	-	70'	"	"	1.20	528.00	
50'	-	80'	"	"	1.20	60.00	
60'	-	90'	"	"	1.25	75.00	
50'	-	100'	"	"	1.30	65.00	
60'	-	110'	"	"	1.35	81.00	
660'	-	120'	"	"	1.40	924.00	
600'	-	130'	"	"	1.45	870.00	
110'	-	140'	"	"	1.50	165.00	
170'	-	150'	"	"	1.50	255.00	
330'	-	160'	"	"	1.55	511.50	4,277.00

8 Inch Concrete Pipe:

160'	-	30'	head	@	$0.85	$ 136.00	
220'	-	40'	"	"	0.90	198.00	
60'	-	50'	"	"	0.95	57.00	
50'	-	60'	"	"	0.95	47.50	
110'	-	70'	"	"	1.00	110.00	
60'	-	80'	"	"	1.05	63.00	
50'	-	90'	"	"	1.10	55.00	
110'	-	100'	"	"	1.10	121.00	
170'	-	110'	"	"	1.15	195.50	983.00

6 Inch Concrete Pipe:

220'	-	10'	head	@	$0.65	$ 143.00	
220'	-	20'	"	"	0.70	154.00	
160'	-	30'	"	"	0.70	112.00	
330'	-	40'	"	"	0.75	247.50	
170'	-	50'	"	"	0.80	136.00	
330'	-	60'	"	"	0.80	264.00	
220'	-	70'	"	"	0.85	187.00	
380'	-	80'	"	"	0.85	323.00	
500'	-	90'	"	"	0.90	450.00	
220'	-	100'	"	"	0.90	198.00	
270'	-	110'	"	"	0.95	256.50	
330'	-	120'	"	"	1.00	330.00	
270'	-	130'	"	"	1.00	270.00	
280'	-	140'	"	"	1.05	294.00	
270'	-	150'	"	"	1.05	283.50	
390'	-	160'	"	"	1.10	429.00	
330'	-	170'	"	"	1.10	363.00	

220' - 180' head @ $1.15 ---------	$ 253.00	
170' - 190' " " 1.20 ---------	204.00	$ 4,897.50

30 Inch Steel Pipe:

440' - Steel Pipe 10 gauge - Weight per foot 50 lbs. @ $7.40 per foot in place (For 140' and 150' heads) ----------		3,256.00

28 Inch Steel Pipe:

3800' - Steel Pipe 10 gauge - Weight per foot 45 lbs. @ $6.70 per foot in place (For heads from 150' to 190') ----------	$25,460.00	
1920' - Steel Pipe 3/16" Plate - Weight per foot 71 lbs. @ $10.15 per foot in place (For heads from 200' to 220') ----------	19,488.00	
820' - Steel Pipe ¼" Plate - Weight per foot 98 lbs. @ $13.80 per foot in place (For heads of 230' and 240') ----------	11,316.00	56,264.00

22 Inch Steel Pipe:

2310' - Steel Pipe 10 gauge - Weight per foot 36 lbs. @ $5.30 per foot in place (For heads from 160' to 200') ----------	$12,243.00	
550' - Steel Pipe 3/16" Plate - Weight per foot 57 lbs. @ $8.05 per foot in place (For heads of 210', 220' and 230') ----------	4,427.50	16,670.50

20 Inch Steel Pipe:

3460' - Steel Pipe 10 gauge - Weight per foot 33 lbs. @ $4.90 per foot in place (For heads from 160' to 220') ----------	$16,954.00	
2690' - Steel Pipe 3/16" Plate - Weight per foot 52 lbs. @ $7.50 per foot in place (For heads from 230' to 290') ----------	20,175.00	
2300' - Steel Pipe ¼" Plate - Weight per foot 73 lbs. @ $10.30 per foot in place (For 290', 300' and 310' heads) ----------	23,690.00	60,819.00

Specials and Angles for Steel Pipe ----------	$	5,000.00
1 - 30 Inch Gate Valve in place ----------		2,000.00
1 - 26 " " " " " ----------		570.00
1 - 22 " " " " " ----------		500.00
3 - 18 " " " " " @ $250 ----------		750.00
1 - 16 " " " " " ----------		210.00
1 - 12 " " " " " ----------		135.00
1 - 10 " " " " " ----------		100.00
3 - 18 Inch Standpipes with Float Valve Control @ $2000		6,000.00
1 - 16 " " " " " "		1,500.00
1 - 14 " " " " " "		1,100.00
1 - 8 " " " " " "		900.00
2 - 6 " " " " " " @ $750		1,500.00
50 - 6 Inch Gate Valves in place @ $75.00 --------		3,750.00
1200 Lin. H. Concrete Trestles @ $5.00 ----------		6,000.00
30 - 2 Inch Air Valves @ $75.00 ----------		2,250.00
Miscellaneous Items not included above ----------		5,000.00
Total Cost of Buena Pipe Line ----------		$300,962.50
Average Cost per foot ----------	$	5.50

Cost of Richland Pipe Line (Horizontal length 45,000 ft.):

26 Inch Concrete Pipe:

2140' - 10' head @ $3.55 --------	$ 7,597.00		
2040' - 20' " " 3.70 --------	7,548.00		
1530' - 30' " " 3.90 --------	5,467.00		
2250' - 40' " " 4.10 --------	9,225.00		
970' - 50' " " 4.30 --------	3,977.00		
1680' - 60' " " 4.50 --------	7,560.00		
3060' - 70' " " 4.65 --------	14,229.00		
1940' - 80' " " 4.85 --------	9,409.00		
610' - 90' " " 5.05 --------	3,080.50		
410' - 100' " " 5.20 --------	2,132.00		
210' - 110' " " 5.40 --------	1,134.00		$71,358.50

24 Inch Concrete Pipe:

50' - 20' head @ $3.25 ---------	$ 162.50	
60' - 30' " " 3.40 ---------	204.00	
50' - 40' " " 3.55 ---------	177.50	
60' - 50' " " 3.70 ---------	222.00	
280' - 60' " " 3.85 ---------	1,078.00	
390' - 70' " " 4.05 ---------	1,579.50	
330' - 80' " " 4.20 ---------	1,386.00	
330' - 90' " " 4.35 ---------	1,435.50	

220' - 100' head @ $4.50 ---------	$ 990.00	
220' - 110' " " 4.65 ---------	1,023.00	
220' - 120' " " 4.80 ---------	1,056.00	
330' - 130' " " 4.95 ---------	1,633.50	
330' - 140' " " 5.10 ---------	1,683.00	
330' - 150' " " 5.25 ---------	1,732.50	
130' - 160' " " 5.40 ---------	702.00	$15,065.00
18 Inch Concrete Pipe:		
220' - 110' head @ $3.10 ---------	$ 682.00	
220' - 120' " " 3.20 ---------	704.00	
170' - 130' " " 3.30 ---------	561.00	
170' - 140' " " 3.40 ---------	578.00	
220' - 150' " " 3.50 ---------	770.00	3,295.00
16 Inch Concrete Pipe:		
110' - 150' head @ $2.90 ---------	$ 319.00	
940' - 180' " " 3.00 ---------	2,820.00	3,139.00
14 Inch Concrete Pipe:		
1100' - 20' head @ $1.45 --------	$1,595.00	
880' - 30' " " 1.50 --------	1,320.00	
550' - 40' " " 1.60 --------	880.00	
110' - 70' " " 1.80 --------	198.00	
110' - 80' " " 1.85 --------	203.50	
110' - 90' " " 1.95 --------	214.50	
50' - 100' " " 2.00 --------	100.00	
60' - 110' " " 2.05 --------	123.00	
50' - 120' " " 2.10 --------	105.00	
60' - 130' " " 2.20 --------	132.00	
110' - 140' " " 2.25 --------	247.50	
110' - 150' " " 2.30 --------	253.00	
110' - 160' " " 2.40 --------	264.00	
330' - 170' " " 2.45 --------	808.50	
1100' - 180' " " 2.50 --------	2,750.00	9,194.00
12 Inch Concrete Pipe:		
1430' - 40' head @ $1.20 ---------	$1,716.00	
880' - 50' " " 1.25 ---------	1,100.00	
550' - 60' " " 1.30 ---------	715.00	
660' - 70' " " 1.35 ---------	891.00	
660' - 80' " " 1.40 ---------	704.00	
440' - 90' " " 1.45 ---------	638.00	5,764.00
10 Inch Concrete Pipe:		
990' - 50' head @ $1.10 ---------	$1,089.00	
1430' - 60' " " 1.15 ---------	1,644.50	
220' - 70' " " 1.20 ---------	484.00	
330' - 80' " " 1.20 ---------	396.00	
330' - 90' " " 1.25 ---------	412.50	4,026.00

Specials and Angles for Steel Pipe ---------- $ 5,000.00

1 - 30 Inch Gate Valve in place ---------- 2,000.00
1 - 26 " " " " " ---------- 870.00
1 - 22 " " " " " ---------- 800.00
3 - 18 " " " " " @ $280 ---------- 780.00
1 - 16 " " " " " ---------- 210.00
1 - 12 " " " " " ---------- 180.00
1 - 10 " " " " " ---------- 100.00

3 - 18 Inch Standpipes with Float Valve Control
@ $2000 6,000.00
1 - 16 " " " " " " 1,800.00
1 - 14 " " " " " " 1,400.00
1 - 8 " " " " " " 300.00
2 - 6 " " " " " " @ $760 1,800.00

80 - 6 Inch Gate Valves in place @ $78.00 -------- 3,780.00

1200 Lin. ft. Concrete Trestles @ $5.00 ---------- 6,000.00

30 - 2 Inch Air Valves @ $78.00 ---------- 2,280.00

Miscellaneous Items not included above ---------- 5,000.00

Total Cost of Buena Pipe Line ---------- $300,982.80

Average Cost per foot ---------- $ 5.80

Cost of Richland Pipe Line (Horizontal length 46,000 ft.):

26 Inch Concrete Pipe:

2140' - 10' head @ $3.55 --------	$ 7,597.00	
2040' - 20' " " 3.70 --------	7,548.00	
1330' - 30' " " 3.90 --------	5,187.00	
2250' - 40' " " 4.10 --------	9,225.00	
970' - 50' " " 4.30 --------	3,971.00	
1680' - 60' " " 4.50 --------	7,560.00	
3060' - 70' " " 4.65 --------	14,229.00	
1940' - 80' " " 4.85 --------	9,409.00	
610' - 90' " " 5.05 --------	3,080.80	
410' - 100' " " 5.20 --------	2,132.00	
210' - 110' " " 5.40 --------	1,134.00	$71,388.80

24 Inch Concrete Pipe:

50' - 20' head @ $3.25 ---------	$ 162.50	
80' - 30' " " 3.40 ---------	204.00	
50' - 40' " " 3.55 ---------	177.50	
80' - 50' " " 3.70 ---------	222.00	
280' - 60' " " 3.85 ---------	1,078.00	
390' - 70' " " 4.05 ---------	1,579.50	
330' - 80' " " 4.20 ---------	1,386.00	
330' - 90' " " 4.35 ---------	1,435.50	

8 Inch Concrete Pipe:

550' -	30'	head @	$0.85	$ 467.50	
330' -	40'	" "	0.90	297.00	
660' -	50'	" "	0.95	627.00	
660' -	60'	" "	0.95	627.00	
1100' -	70'	" "	1.00	1,100.00	
220' -	80'	" "	1.05	231.00	
390' -	90'	" "	1.10	429.00	
50' -	100'	" "	1.10	55.00	
50' -	110'	" "	1.10	55.00	
60' -	120'	" "	1.15	69.00	
60' -	140'	" "	1.20	72.00	
110' -	150'	" "	1.20	132.00	
110' -	160'	" "	1.25	137.50	
170' -	170'	" "	1.30	221.00	
330' -	180'	" "	1.35	445.50	$ 4,965.50

6 Inch Concrete Pipe:

550' -	70'	head @	$0.85	$ 467.50	
440' -	80'	" "	0.85	374.00	
220' -	90'	" "	0.90	198.00	
550' -	100'	" "	0.90	495.00	1,534.50

26 Inch Steel Pipe:

800' - Steel Pipe 10 gauge -
Weight per foot 42 lbs. @ $6.45
in place ---------- 5,160.00

24 Inch Steel Pipe:

660' - Steel Pipe 10 gauge -
Weight per foot 40 lbs. @ $6.10
in place ---------- $ 4,026.00

2420' - Steel Pipe 9 gauge -
Weight per foot 47 lbs. @ $6.95
in place ---------- 16,819.00 20,845.00

18 Inch Steel Pipe:

660'- Steel Pipe 10 gauge - Weight
foot 30 lbs. @ $4.70 in place ---------- 3,102.00

16 Inch Steel Pipe:

2150' - Steel Pipe 10 gauge - Weight
per foot 28 lbs. @ $4.40 in place ---------- 9,460.00

Angles and Specials for Steel Pipe ---------- 1,000.00

2 - 26 Inch Gate Valves in place @ $570.00 ------- 1,140.00

1 - 24 Inch Gate Valve in place ----------	$	430.00
1 - 14 " " " " " ----------		170.00
1 - 10 " " " " " ----------		100.00
1 - 6 " " " " " ----------		65.00
1 - 26 Inch Standpipe with Float Valve Control ---		4,500.00
1 - 24 " " " " " " ---		3,300.00
1 - 14 " " " " " " ---		1,100.00
1 - 8 " " " " " " ---		900.00
45 - 6 Inch Gate Valves, with Saddles @ $75.00 ---		3,375.00
2000 Lin. H. Concrete Trestle @ $5.00 ----------		10,000.00
50 - 2 Inch Air Valves in place @ $75.00 ---------		3,750.00
Miscellaneous Items not included above ----------		5,000.00
Total Cost of Richland Pipe Line ----------		$191,738.50
Average Cost per foot ----------	$	4.26

Cost of Guajome Pipe Line (Horizontal length 30,600 ft.):

20 Inch Concrete Pipe:

1620' -	10' head	@ $2.45	---------	$3,969.00	
1730' -	20' "	"	2.55	---------	4,411.50
2340' -	30' "	"	2.65	---------	6,201.00
840' -	40' "	"	2.80	---------	2,352.00
1020' -	50' "	"	2.90	---------	2,958.00
1020' -	60' "	"	3.00	---------	3,060.00
1020' -	70' "	"	3.15	---------	3,213.00
820' -	80' "	"	3.25	---------	2,665.00
1730' -	90' "	"	3.40	---------	5,882.00
700' -	100' "	"	3.50	---------	2,450.00
810' -	110' "	"	3.60	---------	2,916.00
830' -	120' "	"	3.75	---------	3,112.50
950' -	130' "	"	3.85	---------	3,657.50
570' -	140' "	"	3.95	---------	2,251.50
610' -	150' "	"	4.10	---------	2,501.00
170' -	160' "	"	4.20	---------	714.00 $ 52,314.00

14 Inch Concrete Pipe:

170' -	10' head	@ $1.40	----------	$	238.00
80' -	20' "	"	1.45	----------	116.00
250' -	30' "	"	1.50	----------	375.00
300' -	40' "	"	1.60	----------	480.00
310' -	50' "	"	1.70	----------	527.00
360' -	60' "	"	1.75	----------	630.00
360' -	70' "	"	1.80	----------	648.00
720' -	80' "	"	1.85	----------	1,332.00
630' -	90' "	"	1.95	----------	1,228.50
520' -	100' "	"	2.00	----------	1,040.00

440' - 110'	head @	$2.05	----------	$ 902.00	
570' - 120'	"	" 2.10	----------	1,197.00	
630' - 130'	"	" 2.20	----------	1,386.00	
490' - 140'	"	" 2.25	----------	1,102.50	
690' - 150'	"	" 2.30	----------	1,587.00	
390' - 160'	"	" 2.40	----------	936.00	$13,725.00

12 Inch Concrete Pipe:

220' - 60'	head @	$1.30	----------	$ 286.00	
80' - 70'	"	" 1.35	----------	108.00	
60' - 80'	"	" 1.40	----------	84.00	
80' - 90'	"	" 1.45	----------	116.00	
90' - 100'	"	" 1.50	----------	135.00	
80' - 110'	"	" 1.55	----------	124.00	
170' - 120'	"	" 1.60	----------	272.00	
990' - 130'	"	" 1.65	----------	1,633.50	2,758.50

10 Inch Concrete Pipe:

60' - 10'	head @	$0.90	----------	$ 54.00	
170' - 20'	"	" 0.95	----------	161.50	
140' - 30'	"	" 1.00	----------	140.00	
90' - 40'	"	" 1.05	----------	94.50	
130' - 50'	"	" 1.10	----------	143.00	
120' - 60'	"	" 1.15	----------	138.00	
130' - 70'	"	" 1.20	----------	156.00	
150' - 80'	"	" 1.20	----------	180.00	
150' - 90'	"	" 1.25	----------	187.50	
180' - 100'	"	" 1.30	----------	234.00	
210' - 110'	"	" 1.35	----------	283.50	
170' - 120'	"	" 1.40	----------	238.00	
220' - 130'	"	" 1.45	----------	319.00	
280' - 140'	"	" 1.50	----------	420.00	
340' - 150'	"	" 1.50	----------	510.00	
360' - 160'	"	" 1.55	----------	558.00	
170' - 170'	"	" 1.60	----------	272.00	
70' - 180'	"	" 1.65	----------	115.50	4,204.50

8 Inch Concrete Pipe:

170' - 50'	head @	$0.95	----------	$ 161.50	
390' - 60'	"	" 0.95	----------	370.50	
170' - 70'	"	" 1.00	----------	170.00	
990' - 80'	"	" 1.05	----------	1,039.50	
610' - 90'	"	" 1.10	----------	671.00	
110' - 100'	"	" 1.10	----------	121.00	
60' - 110'	"	" 1.15	----------	69.00	
80' - 120'	"	" 1.20	----------	96.00	
140' - 130'	"	" 1.20	----------	168.00	
250' - 140'	"	" 1.25	----------	312.50	
300' - 150'	"	" 1.30	----------	390.00	
280' - 160'	"	" 1.35	----------	378.00	3,947.00

10 Inch Steel Pipe:

1620 lin. ft. - 10 gauge steel pipe - Weight per foot 17 lbs. @ $2.75 per foot in place		$ 4,455.00
Angles and Specials for Steel Pipe		400.00
2 - 20 Inch Gate Valves in place @ $300.00		600.00
1 - 14 " " " " "		170.00
1 - 10 " " " " "		100.00
1 - 8 " " " " "		80.00
2 - 20 Inch Standpipes with Float Valve Control @ $2150		4,300.00
1 - 14 " " " " " "		1,100.00
2 - 10 " " " " " " @ $1000		2,000.00
16 - 6 Inch Gate Valves with Saddles in place @ $75 -		1,200.00
500 Lin. H. Concrete Trestle @ $5.00		2,500.00
24 - 2 Inch Air Valves in place @ $75.00		1,800.00
Miscellaneous Items not included above		2,500.00
Total Cost of Guajome Pipe Line		$98,154.00
Average Cost per foot		$ 3.21

Cost of Cerro Pipe Line (Horizontal length 35,500 ft.):

18 Inch Concrete Pipe:

70' - 90'	head @ $2.95	$ 206.50	
80' - 100'	" " 3.00	240.00	
570' - 110'	" " 3.10	1,767.00	
190' - 120'	" " 3.20	608.00	
190' - 130'	" " 3.30	627.00	
180' - 140'	" " 3.40	612.00	
170' - 150'	" " 3.50	595.00	$ 4,655.50

16 Inch Concrete Pipe:

210' - 10'	head @ $1.75	$ 367.50	
210' - 20'	" " 1.80	378.00	
980' - 30'	" " 1.90	1,862.00	
1580' - 40'	" " 2.00	3,160.00	
1640' - 50'	" " 2.10	3,444.00	
1890' - 60'	" " 2.20	4,158.00	
950' - 70'	" " 2.25	2,137.50	
950' - 80'	" " 2.30	2,185.00	
950' - 90'	" " 2.40	2,280.00	

630' - 100'	head @	$2.50	----------	$1,575.00	
350' - 110'	"	" 2.60	----------	910.00	
360' - 120'	"	" 2.65	----------	954.00	
110' - 130'	"	" 2.75	----------	302.50	
520' - 140'	"	" 2.80	----------	1,456.00	
590' - 150'	"	" 2.90	----------	1,711.00	
180' - 160'	"	" 3.00	----------	540.00	$27,420.50

14 Inch Concrete Pipe:

660' - 10'	head @	$1.40	----------	$ 924.00	
1570' - 20'	"	" 1.45	----------	2,276.50	
730' - 30'	"	" 1.50	----------	1,095.00	
1670' - 40'	"	" 1.60	----------	2,672.00	
570' - 50'	"	" 1.70	----------	969.00	
1120' - 60'	"	" 1.75	----------	1,960.00	
1360' - 70'	"	" 1.80	----------	2,448.00	
470' - 80'	"	" 1.85	----------	869.50	13,214.00

12 Inch Concrete Pipe:

1820' - 40'	head @	$1.20	----------	$2,184.00	
1090' - 50'	"	" 1.25	----------	1,362.50	
920' - 60'	"	" 1.30	----------	1,196.00	
410' - 70'	"	" 1.35	----------	553.50	
410' - 80'	"	" 1.40	----------	574.00	
410' - 90'	"	" 1.45	----------	594.50	
110' - 100'	"	" 1.50	----------	165.00	
110' - 110'	"	" 1.55	----------	170.50	
110' - 120'	"	" 1.60	----------	176.00	6,976.00

10 Inch Concrete Pipe:

40' - 10'	head @	$0.90	----------	$ 36.00	
730' - 20'	"	" 0.95	----------	693.50	
220' - 30'	"	" 1.00	----------	220.00	
110' - 40'	"	" 1.05	----------	115.50	
550' - 50'	"	" 1.10	----------	605.00	
1270' - 60'	"	" 1.15	----------	1,460.50	
830' - 70'	"	" 1.20	----------	996.00	
340' - 80'	"	" 1.20	----------	408.00	
350' - 90'	"	" 1.25	----------	437.50	
140' - 100'	"	" 1.30	----------	182.00	
120' - 110'	"	" 1.35	----------	162.00	
160' - 120'	"	" 1.40	----------	224.00	
390' - 130'	"	" 1.45	----------	565.50	
140' - 140'	"	" 1.50	----------	210.00	
110' - 150'	"	" 1.50	----------	165.00	
70' - 160'	"	" 1.55	----------	108.50	
70' - 170'	"	" 1.60	----------	112.00	
70' - 180'	"	" 1.65	----------	115.50	6,816.50

8 Inch Concrete Pipe:

660' - 30'	head @	$0.85	----------	$ 561.00	

230' - 40'	head @ $0.90	$ 207.00	
450' - 50'	" " 0.95	427.50	
400' - 60'	" " 0.95	380.00	
390' - 70'	" " 1.00	390.00	
40' - 80'	" " 1.05	42.00	
50' - 90'	" " 1.10	55.00	
50' -100'	" " 1.10	55.00	
80' -110'	" " 1.15	92.00	
410' -120'	" " 1.20	492.00	
280' -130'	" " 1.20	336.00	
330' -140'	" " 1.25	412.50	
280' -150'	" " 1.30	364.00	
660' -160'	" " 1.35	891.00	$ 4,705.00

18 Inch Steel Pipe:

990 lin. ft. - 10 gauge steel pipe - Weight per foot 30 lbs. @ $4.70 per foot in place ---------- 4,653.00

10 Inch Steel Pipe:

1020 lin. ft. - 10 gauge steel pipe - Weight per foot 17 lbs. @ $2.75 per foot in place ---------- 2,805.00

Angles and Specials for Steel Pipe ----------	400.00
1 - 18 Inch Gate Valve in place ----------	250.00
1 - 16 " " " " " ----------	210.00
1 - 14 " " " " " ----------	170.00
1 - 12 " " " " " ----------	125.00
1 - 10 " " " " " ----------	100.00
1 - 8 " " " " " ----------	80.00
1 - 18 Inch Standpipe with Float Valve Control ------	2,000.00
1 - 14 " " " " " " ------	1,100.00
1 - 10 " " " " " " ------	1,000.00
20 - 6 Inch Gate Valves with Saddles, in place @ $75-	1,500.00
500 Lin. H. Concrete Trestle @ $5.00 ----------	2,500.00
40 - 2 Inch Air Valves in place @ $75.00 ----------	3,000.00
Miscellaneous Items not included above ----------	2,500.00
Total Cost of Cerro Pipe Line ----------	$86,180.00
Average Cost per foot ----------	$ 2.43

The distribution system covered by this estimate and shown on Plate 1 will make water easily available for all parts of

the District. However, the lands included within the District are rolling and, to reach all of the various knolls which will be cultivated, an additional cost of approximately $7.50 per acre will be necessary for small pipe laterals. Whether this cost be borne by the District as a whole and under its regular organization, or whether it be borne by individual land owners directly concerned is a matter of future policy to be determined later by the Board of Directors. It is an expenditure which will not be necessary for some time and one which I will omit from the general estimates of this report with this explanation.

Summary of Cost of Distribution System:

Vista Pipe Line	$ 550,847.00
San Marcos Pipe Line	82,665.00
Buena Line	300,962.00
Richland Line	191,738.00
Guajome Line	98,154.00
Cerro Line	86,180.00
Total Cost	$1,310,546.00

FUTURE EXTENSIONS.

When San Luis Rey Irrigation District, as now proposed, is fully irrigated, it will be a wise precaution to have included in its works a reserve pumping plant on the pumping site which is being acquired by the District adjoining San Luis Rey River some two miles above San Luis Rey Mission. From the mass diagram, Plate 5, it is evident that this pumping plant need not

be called into use oftener than perhaps once in thirty years, but its addition is an insurance against drought which is very desirable if not entirely necessary. As this construction is absolutely unwarranted until some time far in the future, an estimate of its cost at this time when prices are very much unsettled is quite impossible, and, since its construction should be deferred until far in the future, I will not include it in the estimates of my present report although I have made some approximate figures which lead me to believe that its cost with adequate steel mains for reaching the District would, under present prices, amount to approximately $130,000.00.

Item 7. Water Rights:

Many and conflicting theories have been advanced for determining the value of water rights. The Supreme Court of the United States has decided that a value must be allowed for such rights, but no rule has been defined for determining the value, and in practically every case, as in this one, values have been fixed by more or less arbitrary methods as dictated by judgment after weighing available and relevant evidence.

The value as fixed by sales of water rights of like character is relevant. Unfortunately evidence of such sales is in this case meager. Mr. Chas. H. Lee, Civil and Hydraulic Engineer, of Los Angeles, has made a careful compilation of water right values as determined by sale prices of stock in mutual water companies of Southern California. As these stocks include an obligation upon the part of the company to deliver water to the owner's lands, Mr. Lee has, from the gross sale value of the

stock, compiled what he terms the gross water right value. By deducting from the gross water right value the cost of works necessary to deliver water to the lands, Mr. Lee has deduced a net water right value. He has further divided these rights into three classes; (1) exclusively citrus; (2) citrus and diversified crops; (3) diversified crops, no citrus. For comparison, San Luis Rey Irrigation District should be rated in the second class.

The following data was introduced by Mr. Lee as Appendix B. in his testimony in the matter of Spring Valley Water Company vs. City and County of San Francisco, heard before the Master in Chancery, H. M. Wright, April 5, 1916.

Listing the companies of each class in order of gross water right value, the following is obtained:

	per M.I.	per m.g.d.
1. Exclusively Citrus.		
Lugonia Water Co.	$2,100	$163,000
San Antonio Water Co.	1,950	151,000
Canyon Water Co.	1,500	116,000
Del Monte Irrigation Co.	1,360	105,000
Temescal Water Co.	1,250	96,600
Gage Canal Co.	1,250	96,600
Redlands Water Co.	1,050	81,300
San Dimas Irrigation Co.	875	67,700
Average	$1,417	$109,600
2. Citrus and Diversified Crops.		
Alta Mutual Water Co.	$1,000	77,400
Thermal Belt Water Co.	1,000	77,400
Escondido Mutual Water Co.	950	73,500

	per M.I.	per m.g.d.
Riverside Water Co.	$ 750	$58,000
Santa Ana Valley Irrigation Co.	750	58,000
California Domestic Water Co.	500	38,700
South Side Improvement Co.	210	16,200
Los Nietos Ditch Co.	209	16,200
Irrigation Co. of Pomona	208	16,100
Average	$ 620	$47,900

3. Diversified Crops, No Citrus.

	per M.I.	per m.g.d.
Banning Water Co.	$ 612	$47,400
Moneta Water Co.	350	27,100
Stout Ditch Co.	175	13,500
McKenzie Ditch Co.	175	13,500
Arroyo Ditch Co.	80	6,200
Imperial Water Co. No. 5	72	5,570
Puente Land & Water Co.	45	3,480
Imperial Water Co. No. 1	43	3,330
Little Lake Irrigation Co.	25	1,930
Average	$ 175	$13,600

Generalizing the data at hand, gross water right values in citrus culture in Southern California range from $875 to $2,100 per miner's inch, averaging $1,417.

For citrus culture combined with diversified crops, values range from $210 to $1,000, and averages $620 per miner's inch.

For diversified crops with no citrus, the values range from $25 to $610 per miner's inch, and average $175.

From the data at hand, it would appear, therefore,

that gross water right values in Southern California are highest in citrus culture and lowest in diversified crop farming, including alfalfa, deciduous fruits, grain and vegetables. Values for the combination of the two lie between the extremes.

Expressed as ratios, the average for citrus culture is 2.3 times that for citrus culture combined with diversified crops, and 8 times that for diversified crops exclusive of citrus.

A similar analysis of net water right values results as follows:

	per M.I.	per m.g.d.
1. Exclusively Citrus.		
Lugonia Water Co.	$1,995	$154,000
San Antonio Water Co.	1,845	142,800
Del Monte Irrigation Co.	1,173	90,900
Temescal Water Co.	900	69,600
Gage Canal Co.	950	73,500
Redlands Water Co.	677	52,400
San Dimas Irrigation Co.	665	51,500
Average	$1,172	$ 90,700
2. Citrus and Diversified Crops.		
Santa Ana Irrigation Co.	$ 563	$ 43,500
Alta Mutual Water Co.	550	42,500
Thermal Belt Water Co.	550	42,500
Riverside Water Co.	190	14,700
Los Nietos Ditch Co.	171	13,200
South Side Improvement Co.	37	2,860
California Domestic Water Co.	Negative	Negative
Irrigation Co. of Pomona	Negative	Negative
Average (exclusive last 2)	$ 344	$ 26,500

Following are sale values, or values which have been actually awarded, in Southern California, in most instances for <u>domestic use</u>, however:

"$3,500 per miner's inch fixed by Judge Conrey for Sierra Madre where water was taken from the Baldwin Ranch for the use of the City.

$2,500 per miner's inch selling price at McClay Rancho in 1902.

$2,800 per miner's inch selling price from West Los Angeles Water Company.

$2,000 per miner's inch value fixed by California Railroad Commission in the matter of the petition of the City of Glendale to have valuations made of certain water systems within the city.

The City of Los Angeles has constructed its aqueduct from Owens Valley and has thus brought in a water supply at an actual cost in excess of $2,000 per miner's inch."

Most of the values here discussed are for the region of Los Angeles, Riverside and San Bernardino Counties. In the vicinity of San Luis Rey Irrigation District the water supply is, perhaps, even more limited. Here the development of agricultural land is limited by the ultimate available water supply. Many acres of otherwise valuable land must, so far as we know to-day, remain unirrigated and, therefore, of small value, because no water supply will be available for them. Under these circumstances, consider the case of one man owning lands without water and a second owning water rights. The application of water to the lands will at once greatly enhance the value of the lands. Naturally, the owner of the water rights can to a considerable extent command this enhanced value since his rights are in demand, in fact, actual competition for them exists. It will require an

expenditure for works to deliver this water to the lands, but seldom an expenditure equal to the enhanced value of the lands - does not the difference equal the value of the water rights to San Luis Rey Irrigation District, a value which the land owner will willingly meet, in addition to the cost of hydraulic works, in order to develop his lands?

Within San Luis Rey Irrigation District the application of water to lands for which no water rights are now held will probably cause an average increase in value of at least $125.00 per acre throughout the entire District. I am not unmindful of the fact that many parcels of land will be much more increased in value, but does this added value not arise from other causes such as environment, adaptability for dwelling places, etc., qualities which would not have existed to the same degree, if at all, without the application of water, but which are not due solely to its application?

Roughly, the hydraulic works which San Luis Rey Irrigation District proposes to construct or acquire will cost approximately $97.50 per acre. From an enhanced value of $125 per acre there is, therefore, a remainder of approximately $25 per acre as an allowance for water right value, or, more properly, the maximum price which the District can afford to pay for water rights, in addition to bearing the cost of necessary works for storing and conducting water from Warner Reservoir to its lands. It should be distinctly understood that a valuation of Volcan Land and Water Company's water rights as computed from their capability for enhancing the value of the lands within San

Luis Rey Irrigation District is not a measure of their value for other purposes, for instance for domestic consumption - a use to which it has been proposed to apply them - or even for irrigating some other lands which will have a greater or lesser appreciation in value due to their application, or one for which the necessary hydraulic works will cost more or less. Since this basis of value is dependent only upon the use of the water for irrigation, its incidental use for power development - a use which the Volcan Land and Water Company will reserve - does not detract from the value thus determined. In this connection it should be remembered that the use for power development is wholly subordinate to irrigation use, that the power projects on the supply canal are not projects as well suited to power development as are other possible projects utilizing the same water.

Finally, after considering the above and other relevant facts, I am of the opinion that $1,075,000 is a fair value for the sale of Volcan Land and Water Company's water rights to San Luis Rey Irrigation District for the irrigation of the particular lands within that District, with the right to develop power reserved by Volcan Land and Water Company - the draft to be regulated to irrigation use should any conflict arise - this value to include pumping rights from a parcel of land adjoining San Luis Rey River directly north of the District as well as the right of storage and diversion from Warner Reservoir.

POWER DEVELOPMENT.

As previously mentioned, there are two power drops

along the main supply canal of San Luis Rey Irrigation District - Hellhole and Merriam Power drops. Estimates of the cost of constructing the necessary forebays, penstocks and power houses, with all necessary equipment, for these power drops have not been included in this report because the proposal made by Volcan Land and Water Company to San Luis Rey Irrigation District, which is the subject of this report, does not include the construction of these works by the District. Instead, the company proposes to reserve the water power developments at these two sites and to install them at its own expense, thus relieving the District of this item of cost and particularly of the steel pipe lines necessary for conducting water down the hillsides under pressure.

VALUE OF LANDS.

To acquire the system which San Luis Rey Irrigation District now seeks to acquire or construct and to still meet the requirements of the Statute (Statutes 1913, page 778) to the effect that the total bonded indebtedness must not exceed 60% of the aggregate value of the lands, water, water rights and irrigation works to be acquired or constructed, it is necessary that the total value of the lands included within the District be, if no allowance is made for bond discount, $3,529,686. I have not personally investigated the value of these lands as it will be the subject of an investigation of another Department of the State Government.

CONCLUSIONS.

My investigations lead me to the following conclusions in regard to San Luis Rey Irrigation District as proposed:

(a) The supply of water available for irrigation for the project is sufficient to irrigate the area of 43,000 acres included within the District, of which area not more than 25,200 acres will be available for irrigation during any one year. The District will be able to acquire the right to the use of the water necessary for its project.

(b) The soil is fertile and susceptible of irrigation. The probable amount of water needed for its irrigation will in most cases be an average of 1.0 acre foot per acre per annum, although a limited area can be adequately irrigated with 0.8 acre foot per acre per annum. All studies of the supply of water required have been made on this basis. No serious problems of drainage will arise in the District as now proposed.

(c) The District's irrigation system, as proposed, is feasible.

(d) The value of the water, water rights, canals, reservoirs, reservoir sites and irrigation works owned by the District or to be immediately acquired by it will have a value of $5,294,529.

(e) In order that the bonded indebtedness of the District shall not exceed 60% of the total value of the lands included, water, water rights and irrigation works, the land value should be equal to or greater than $3,529,686 (discount on bonds not taken into account).

(f) The approval of the District and of its proposed bond issue for constructing or acquiring its complete system of irrigation works is warranted so far as problems of water supply and engineering govern such approval.

Respectfully submitted,

W. L. Huber
Civil Engineer.

San Francisco, Cal.
November 4, 1918.

WALTER LEROY HUBER
CIVIL ENGINEER

TABLES.

San Francisco, Cal.
November 4, 1921.

Board of Directors,
Contra Costa County Water District,
Martinez, California.

Gentlemen:

I have the honor to submit herewith my report on the feasibility of a project for the irrigation of the lands in the Contra Costa County Water District, and my conclusions and recommendations are briefly as follows:

(a) That the District's entire water supply be obtained from the Sacramento River by means of a pumping plant located at or near Antioch, and that the water be delivered to the lands in the District by means of a gravity canal and distributing system.

(b) That the water supply to the District be sufficient to irrigate 50,000 acres of land, and that the pumping plant and canal be of sufficient capacity to deliver 85 second-feet of water to the lands in the District.

(c) That the District's entire water supply be diverted from the San Joaquin River at a point not more than one mile above the mouth of Marsh Creek, and that the water be delivered to the lands in the District by means of a gravity canal.

(d) That the location of the District and the source of its water supply be such that the entire area can be irrigated by gravity, and that no drainage water be pumped.

(e) That the District be divided into two units, the Byron unit and the Antioch unit, and that the Byron unit be developed first.

(f) That the first unit of the District to be developed contain approximately 15,000 acres, and that the Antioch unit contain approximately 35,000 acres.

(g) That the entire canal system be designed with sufficient capacity to irrigate 50,000 acres of land in the District, and that the Antioch unit be developed first.

(h) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(i) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(j) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(k) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(l) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(m) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(n) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(o) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(p) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(q) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(r) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(s) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(t) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(u) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(v) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(w) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(x) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(y) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

(z) That the Byron unit be developed with sufficient capacity to irrigate 15,000 acres of land in the District, and that the Byron unit be developed first.

CONCLUSIONS.

WALTER LEROY HUBER
CIVIL ENGINEER

WALTER LEROY HUBER
CIVIL ENGINEER

T A B L E N O. I.

Observed Stream Measurements - From 1903-1918;
Compiled from U.S. Geological Survey and Other Sources.
With Interpollations By William S. Post.

SAN LUIS REY WATERSHED

Quantities in Acre-Feet.

Month	San Luis Rey River: Near Mesa Grande (Warners Dam)	Near Pala	At Bonsall	Near Oceanside
1903-4				
Oct.		50		
Nov.		83		
Dec.		74		
Jan.		92		
Feb.		115		
March		2,558		
April		2,595		
May		996		
June		643		
July		234		
Aug.		123		
Sept.		119		
Total		7,680		
1904-5				
Oct.		154		
Nov.		143		
Dec.		227		
Jan.		1,174		
Feb.		8,386		
March		20,660		
April		3,862		
May		5,417		
June		1,369		
July		252		
Aug.		184		
Sept.		155		
Total		41,980		

TABLE NO. I. (continued)

San Luis Rey River

Month	Near Mesa Grande (Warners Dam)	Near Pala	At Bonsall	Near Oceanside
1905-6				
Oct.	131#	197		
Nov.	750b	1,059		
Dec.	446b	1,125		
Jan.	778b	1,320		
Feb.	2,511b	1,590		
March	47,012b	68,900		
April	10,343b	17,900		
May	2,921b	9,720		
June	1,670b	3,900		
July	780#	1,170		
Aug.	422#	633		
Sept.	147#	220		
Total	67,910	107,730		
1906-7				
Oct.		184		
Nov.		494		
Dec.		4,880		
Jan.		33,300		
Feb.		8,550		
Mar.		20,000		
April		9,940		
May		3,840		
June		1,360		
July		201		
Aug.		87		
Sept.		132		
Total		82,970		
1907-8				
Oct.		1,730		
Nov.		1,560		
Dec.		818		
Jan.		3,850		
Feb.		10,100		
March		3,760		
April		1,270		
May		812		
June		440		
July		184		
Aug.		209		
Sept.		119		
Total		24,940		

TABLE NO. I. (continued)

San Luis Rey River

Month	Near Mesa Grande (Warners Dam)	Near Pala	At Bonsall	Near Oceanside
1908-9				
Oct.		215		
Nov.		363		
Dec.		529		
Jan.		12,200		
Feb.		18,400		
March		8,420		
April		5,410		
May		1,700		
June		371		
July		329		
Aug.		315		
Sept.		298		
Total		48,550		
1909-10				
Oct.		307		
Nov.		738		
Dec.		6,580		
Jan.		26,500		
Feb.		3,700		
March		4,340		
April		3,040		
May		614		
June		325		
July		200#		
Aug.		150#		
Sept.		150#		
Total		46,640		
1910-11				
Oct.	110#	200#		
Nov.	120#	240#		
Dec.	170#	300#		
Jan.	2,180#	3,080		
Feb.	6,870/	10,700		
March	7,700#	11,500		
April	3,100#	4,640		
May	512/	695		
June	124	402		
July	108	240#		
Aug.	72	160#		
Sept.	101	220#		
Total	21,160	32,380		

T A B L E . N O. I. (continued)

Month	San Luis Rey River			
	Near Mesa Grande (Warners Dam)	Near Pala	At Bonsall	Near Oceanside
1911-12:				
Oct.	111	220#	0#	0#
Nov.	100	200#	0#	0#
Dec.	168	340#	0#	0#
Jan.	290	470#	0#	0#
Feb.	212	340#	0#	0#
March	4,640	5,800#	7,000#	6,000#
April	4,730	5,470	5,830#	7,380#
May	1,300	2,070	2,070	1,640
June	204	385/	36	0
July	100	221/	0	0
Aug.	81	191/	0	0
Sept.	90	203/	0	0
Total	12,030	15,910	14,940	15,020
1912-13:				
Oct.	229	246/	0	0/
Nov.	120	209	0	0/
Dec.	137	529	117	0/
Jan.	498	1,140	1,220	18
Feb.	1,870	1,090	2,280	1,830
March	1,810	1,290	2,220	1,290
April	672	583	607	110
May	254	344	17	0
June	83	232	5	0
July	52	178	0	0
Aug.	134	184	0	0
Sept.	54	143	0	0
Total	5,910	6,170	6,479	3,250
1913-14:				
Oct.	69	172	0	0
Nov.	120	238	0	0
Dec.	194	387	246	0
Jan.	4,840	6,120	6,270	5,130
Feb.	12,800	15,400	10,700	21,000
March	2,210	3,390	5,380	3,720
April	1,290	2,460	1,970	1,860
May	701	972	1,160	578
June	195	298	77	0
July	87	252	13/	0
Aug.	79	117	2/	0
Sept.	49	89	0	0
Total	22,630	29,900	25,820	32,290

TABLE NO. I. (continued)

Month	San Luis Rey River			
	Near Mesa Grande (Warners Dam)	Near Pala	At Bonsall	Near Oceanside
1914-15:				
Oct.	69	257	0	
Nov.	78	314	32	
Dec.	341	515	385	
Jan.	5,940	6,950	16,300	
Feb.	21,200	32,000	52,100	
March	9,650	16,000	18,900	
April	4,670	8,570	7,910	
May	15,600	24,400	25,800	
June	2,240	4,020	4,480	
July	458	588	300	
Aug.	100	432	13	
Sept.	89	387	0	
Total	60,440	94,430	126,220	
1915-16:				
Oct.	124/			0/
Nov.	278/			0/
Dec.	784/			992/
Jan.	146,047/			270,570/
Feb.	21,160/			39,710/
March	9,481/			24,420/
April	4,326/			8,800/
May	2,087/			2,506/
June	683/			814/
July	245/		930	314/
Aug.	338/		575	0/
Sept.	136/		591	0/
Total	185,690			348,130
1916-17:				
Oct.	853		2,252	2,025
Nov.	712		1,820	1,692
Dec.	3,086		3,510	4,285
Jan.	4,627		8,965	10,140
Feb.	7,626		14,830	16,040
March	3,920		6,975	6,950
April	4,525		4,430	4,490
May	2,013		3,685	2,860
June	610		1,176	698
July	112		27	0
Aug.	129		0	0
Sept.	198		0	0
Total	28,411		47,670	49,180

TABLE NO. I. (continued)

San Luis Rey River

Month	Near Mesa Grande (Warners Dam)	Near Pala	At Bonsall	Near Oceanside
1917-18:				
Oct.	183		119	0
Nov.	300		684	0
Dec.	418		966	337
Jan.	894		1,607	1,383
Feb.	1,082		1,447	1,403
March	17,230		27,860	30,450
April	1,452		1,292	1,234
May	853		746	421
June	433		310	71
July	151		55	0
Aug.	136		0	0
Sept.	148		0	0
Total	23,280		35,086	35,299

b- Records of Pacific Light & Power Co.
/- Volcan Land & Water Company Records.
#- Interpolated values.

All other values from U.S. Geological Survey.

Table No. 2.

MEASURED RUNOFF OF SAN LUIS REY AT WARNER'S

SHOWING RUNOFF FROM OCTOBER TO MARCH INCLUSIVE & FROM APRIL TO SEPTEMBER INCLUSIVE

Season	Total Seasonal Runoff Acre Feet	Percent Runoff Year	Runoff Oct. To Mar. Incl. Acre Feet	Percent Total Seasonal	Runoff April To Sept. Incl. Acre Feet	Percent Total Seasonal
1905-06	67,910	214	51,628	76	16,282	24
1910-11	21,160	67	17,150	81	4,017	19
11-12	12,030	38	5,521	46	6,505	54
12-13	5,910	19	4,664	79	1,249	21
13-14	22,630	71	20,239	89	2,401	11
14-15	60,440	191	37,278	62	23,157	38
1915-16	182,068	586	174,542	96	7,526	4
16-17	28,411	90	20,824	73	7,587	27
17-18	23,280	74	20,107	86	3,173	14

Eliminating the year 1915-16 as extraordinary and averaging the other seasons there results:

74% of total seasonal runoff occurs from Oct. to March inclusive.

26% " " " " " " April to Sept. "

Assume 70% from October to March
30% from April to September.

Table No. 3.

RUNOFF SAN LUIS REY RIVER AT WARNER'S DAM.

Quantities in Acre-Feet.

Year	Total Seasonal Runoff (Warner's)	Runoff Oct. 1 to Mar. 31 (c)	Additional for Subterranean Stream (d)	Total Winter Runoff	Runoff Apr. 1 to Sept.30 (c)	Additional for Subterranean Stream (d)	Total Summer Runoff
1888-89	27,950	19,500	350	19,850	8,450	350	8,800
89-90	48,000	33,600	350	33,950	14,400	350	14,750
90-91	51,000	35,700	350	36,050	15,300	350	15,650
91-92	21,400	15,000	350	15,350	6,400	350	6,750
92-93	32,500	22,700	350	23,050	9,800	350	10,150
93-94	12,810	8,980	350	9,330	3,830	350	4,180
94-95	98,000	68,600	350	68,950	29,400	350	29,750
95-96	7,270	5,080	350	5,430	2,190	350	2,540
96-97	23,100	16,200	350	16,550	6,900	350	7,250
97-98	3,950	2,770	350	3,120	1,180	350	1,530
98-99	2,910	2,040	350	2,390	870	350	1,220
99-00	1,950	1,360	350	1,710	590	350	940
1900-01	13,950	9,760	350	10,110	4,190	350	4,540
01-02	8,840	6,180	350	6,530	2,660	350	3,010
02-03	16,020	11,200	350	11,550	4,820	350	5,170
03-04	5,784(b)	4,050	350	4,400	1,734	350	2,084
04-05	27,400(b)	19,200	350	19,550	8,200	350	8,550
05-06	67,910(a)	47,500	350	47,850	20,410	350	20,760
06-07	52,153(b)	36,600	350	36,950	15,553	350	15,903
07-08	17,734(b)	12,400	350	12,750	5,334	350	5,684
08-09	32,924(b)	23,000	350	23,350	9,924	350	10,274
09-10	30,899(b)	21,600	350	21,950	9,299	350	9,649
10-11	21,160(a)	17,150	350	17,500	4,010	350	4,360
11-12	12,030(a)	5,521	350	5,871	6,509	350	6,859
12-13	5,910(a)	4,664	350	5,014	1,246	350	1,596
13-14	22,630(a)	20,233	0	20,233	2,397	0	2,397
14-15	60,440(a)	37,278	0	37,278	23,162	0	23,162
15-16	185,690(a)	177,874	0	177,874	7,816	0	7,816
16-17	28,411(a)	20,824	0	20,824	7,587	0	7,587
17-18	23,280(a)	20,107	0	20,107	3,173	0	3,173

(a) Observed Runoff. (b) Computed from Pala. (c) Runoff from Oct. 1 to March 31, inclusive, estimated 70% of total seasonal where actual records not available.

(d) 700 acre feet per annum allowed prior to 1912-13 for subterranean stream uncovered and stopped with building of Warner Dam cut-off wall.

(e) Estimated 30% of total seasonal where actual records not available.

Table 4.

VOLCAN LAND & WATER CO.

EVAPORATION PAN RECORD

YEAR-1913.

Values in inches of depth. Drawing No 517.

Month	Pan No 1. In Water Cuyamaca Reservoir Elev 4500			Pan No 2 In Ground E. Cuyamaca Elev 4500			Pan No 3 In Air Warner Dam Elev 2700			Pan No 4 In Water Warner Dam Elev 2620			Pan No 5 In Water Big Lake Warner Ranch Elev 2740			Pan No 6 In Ground Big Lake Warner Ranch Elev 2740		
	Gross Evap	Rain #29	Mean Temp	Gross Evap	Rain #46	Mean Temp	Gross Evap	Rain #1	Mean Temp	Gross Evap	Rain #1	Mean Temp	Gross Evap	Rain #5	Mean Temp +	Gross Evap	Rain #5	Mean Temp +
JAN.		5.38	34.6		2.52		4.12	3.79	39.8	(3.00	3.79	39.8	(2.00	2.42	42.9	(2.00	2.42	42.9
FEB.		11.88	35.7		6.20		3.01	7.67	44.8	4.12	7.67	44.8	(3.30	3.97	43.3	(3.00	3.97	43.4
MAR.		2.12	37.8		1.86		5.93	1.58	47.8	3.79	1.58	47.8	4.31	1.17	47.5	3.58	1.17	47.5
APR.		.93	49.4	4.87	1.03		5.77	.83	50.8	4.17	.83	50.8	5.71	.40	52.6	4.97	.40	52.6
MAY		.51	55.9	8.38	.22		9.16	.30	55.7	3.89	.30	55.7	6.03	.06	59.3	4.96	.06	59.3
JUNE	9.25	.71	58.1	8.90	.13		7.40	.24	60.0	4.41	.24	60.0	5.76	.15	63.9	4.66	.15	63.9
JULY	8.18	.52	66.6	8.99	.72		10.07	.47	70.2	4.42	.47	70.2	6.51	.36	71.6	6.67	.36	71.6
AUG.	7.98	2.38	68.3	8.96	.21		9.62	.88	72.0	3.72	.88	72.0	5.53	.87	73.2	5.85	.87	74.9
SEPT	9.68	.02	65.0	9.39	2.10		9.04	.15	68.2	4.01	.15	68.2	6.18	T	71.3	6.73	T	71.3
OCT.	6.86	.34	54.2	7.49	.22		6.68	.23	(69.0	4.93	.23	(59.0	6.29	.12	61.7	4.90	.12	61.7
NOV	5.63	1.86	45.9	3.40	3.18		5.36	3.64	49.5	3.30	3.64	49.5	3.67	1.48	51.7	2.82	1.48	51.7
DEC.	2.85	3.33	38.5	2.30	1.75		2.77	1.70	42.2	3.40	1.70	42.2	2.79	.75	45.0	1.93	.75	45.0
TOTAL		32.98	50.9		20.14		76.93	21.48	55.0	47.16	21.48	55.0	58.08	12.35	57.1	52.07	12.35	57.1

Month	Pan No 7 In Water La Mesa Reservoir Elev 480			Pan No 8 In Ground Pamo Camp Elev 880			Pan No 9 In Ground Sutherland Damsite Elev 1930			Pan No 10 In Ground Santa Maria Damsite Elev 1265			Pan No 11 In Ground Carroll Damsite Elev 860					
	Gross Evap	Rain #60	Mean Temp	Gross Evap	Rain #63	Mean Temp	Gross Evap	Rain #61	Mean Temp	Gross Evap	Rain #62	Mean Temp	Gross Evap	Rain #64	Mean Temp			
JAN.	1.59	1.43	54.1															
FEB.	1.23	2.61	54.5															
MAR.	4.51	1.04	58.4															
APR.	6.19	.80	64.3															
MAY.	7.54	.30	66.9															
JUNE	6.98	.09	65.7															
JULY	9.64	.12	71.7															
AUG.	8.45	0	76.8															
SEPT	8.21	0	73.4															
OCT.	6.46	0	70.2															
NOV.	3.32	2.99	63.8															
DEC.	2.70	1.01	57.1															
TOTAL	62.92	9.79	64.9															

(-) Interpolated Value

+ Mean Temperature at Warner Springs

VOLCAN LAND & WATER CO.

EVAPORATION PAN RECORD

YEAR-1914.

Values in inches of depth. Drawing No 519.

Month	Pan No 1. In Water Cuyamaca Reservoir Elev 4500			Pan No 2 In Ground E. Cuyamaca Elev 4500			Pan No 3 In Air Warner Dam Elev 2700			Pan No 4 In Water Warner Dam Elev 2620			Pan No 5 In Water Big Lake Warner Ranch Elev 2700			Pan No 6 In Ground Big Lake Warner Ranch Elev 2700		
	Gross Evap	Rain #29	Mean Temp	Gross Evap	Rain #46	Mean Temp	Gross Evap	Rain #1	Mean Temp	Gross Evap	Rain #1	Mean Temp	Gross Evap	Rain #5	Mean Temp +	Gross Evap	Rain #5	Mean Temp +
JAN.	3.28	9.75	42.4	2.30	4.86		3.05	10.71	46.0	2.76	10.71	46.0	1.69	6.42	47.7	1.70	6.42	47.7
FEB.	5.46	6.94	42.5	3.32	5.16		3.38	8.05	47.5	(3.20	8.05	47.5	3.50	5.25	49.0	2.67	5.25	49.0
MAR.	7.20	2.35	47.4	5.26	1.05		5.55	3.10	51.2	4.11	3.10	51.2	4.60	1.20	54.2	3.49	1.20	54.2
APR.	5.60	3.80	49.4	5.30	.77		5.70	2.54	54.1	4.24	2.54	54.1	4.98	2.21	55.2	3.07	2.21	55.2
MAY	7.53	.64	53.8	6.19	.50		6.23	.09	57.0	3.87	.09	57.0	5.23	0	58.9	3.30	0	58.9
JUNE	8.99	.49	63.3	10.04	.10		8.35	.21	64.3	6.31	.21	64.3	6.61	.10	63.7	4.34	.10	63.7
JULY	10.9[illegible]	.04	70.6	12.23	0		11.16	.20	71.3	6.70	.20	71.3	8.17	.56	74.5	5.05	.56	74.5
AUG	[illegible]	1.33	70.5	12.42	.46		10.28	0	70.4	8.38	0	70.4	9.10	0	73.3	4.97	0	73.3
SEPT	7.52	.20	64.1	8.93	.23		8.59	.06	65.6	5.86	.06	65.6	7.75	T	68.5	4.59	T	68.5
OCT.	6.08	1.63	54.0	6.76	.46		5.96	.76	57.7	3.96	.76	57.7	5.04	.63	61.7	4.36	.63	61.7
NOV	3.28	1.18	48.8	4.20	1.38		5.78	1.13	58.3	2.95	1.13	58.3	3.62	.98	57.3	3.42	.98	57.3
DEC.	3.94	5.85	35.2	1.72	3.53		1.99	5.07	41.2	1.38	5.07	41.2	1.65	4.14	41.6	1.87	4.14	41.6
TOTAL	79.55	33.60	53.5	78.87	18.70		76.02	33.76	56.6	54.22	33.76	56.6	61.94	21.49	58.8	42.77	21.49	58.8

Month	Pan No 7 In Water La Mesa Reservoir Elev 480			Pan No 8 In Ground Pamo Camp Elev 880			Pan No 9 In Ground Sutherland Damsite Elev 1930			Pan No 10 In Ground Santa Maria Damsite Elev 1265			Pan No 11 In Ground Carroll Damsite Elev 860					
	Gross Evap	Rain #60	Mean Temp	Gross Evap	Rain #63	Mean Temp	Gross Evap	Rain #61	Mean Temp	Gross Evap	Rain #62	Mean Temp	Gross Evap	Rain #64	Mean Temp			
JAN.	2.37	4.13	57.6	2.79	4.50	54.5	1.58	8.48		3.03	5.89							
FEB.	2.94	3.12	60.1	2.56	3.33	56.7	2.43	3.54		2.63	4.05							
MAR.	6.15	.61	65.2	3.51	1.14	62.4	3.33	1.54		4.03	.93							
APR.	6.16	1.34	65.7	3.56	1.37	67.2	3.58	3.82		4.88	2.21							
MAY.	5.48	.30	64.9	4.72	.53	69.3	3.73	.70		4.58	.70							
JUNE	7.76	.19	70.4	8.23	.24	71.4	6.06	.85		8.83	.38							
JULY	9.03	0	73.2	10.26	0	74.6	7.65	0		8.77	0							
AUG.	8.26	0	73.5	9.92	0	73.6	7.83	0		8.23	0							
SEPT.	6.54	0	72.1	6.68	.02	69.9	5.78	0		6.77	0							
OCT.	4.47	1.35	71.5	4.51	.90	64.7	6.52	1.32		5.49	1.09							
NOV.	4.34	1.17	68.7	3.16	1.65	61.0	3.42	1.86		4.69	1.15							
DEC.	2.37	2.67	55.6	1.40	2.73	49.5	3.07	3.96		1.83	3.01							
TOTAL	65.87	18.88	66.0	61.30	17.41	63.3	55.93	27.69		63.78	20.36							

+ Mean Temperature at Warner Springs

Table 4. (continued)

VOLCAN LAND & WATER CO.
EVAPORATION PAN RECORD — YEAR – 1915.
Values in inches of depth. Drawing No 520.

	Pan No 1 In Water Cuyamaca Reservoir ELEV 4500.			Pan No 2 In Ground E. Cuyamaca ELEV 4500			Pan No 3 In Air Warner Dam ELEV 2720			Pan No 4 In Water Warner Dam ELEV 2620			Pan No 5 In Water Big Lake Warner Ranch ELEV 2780			Pan No 686-A In Ground Big Lake Warner Ranch ELEV 2780		
Month	Gross Evap	Rain *29	Mean Temp	Gross Evap	Rain *28	Mean Temp	Gross Evap	Rain *1	Mean Temp	Gross Evap	Rain *1	Mean Temp	Gross Evap	Rain *5	Mean Temp+	Gross Evap	Rain *5	Mean Temp+
JAN.	3.67	1.145	38.9	2.53	0.74		2.38	1.115	42.4	1.75	1.115	42.4	1.06	7.62	43.8	1.63	7.62	43.8
FEB.	3.97	1.230	38.6	3.12	6.81		3.48	1.122	44.6	(3.03)	1.122	44.6	2.51	7.03	45.1	2.70	7.03	45.1
MAR.	4.56	3.67	46.9	4.77	1.01		4.47	2.30	49.2	3.62	2.30	49.2	3.16	.48	50.6	3.02	.48	50.6
APR.	3.75	7.31	47.8	3.29	3.22		3.75	6.67	53.3	3.85	6.67	53.3	3.64	5.43	52.9	4.25	5.43	52.9
MAY	4.52	8.22	58.0	4.92	2.34		5.14	3.23	55.4	4.44	3.23	55.4	6.17	1.12	55.7	4.73	1.12	55.7
JUNE	9.66	0	66.0	7.94	0		8.00	.07	63.5	9.21	.07	63.5	9.68	.07	66.6	7.86	.07	66.6
JULY	8.74	0	68.5	10.22	0		9.80	0	68.0	10.45	0	68.0	10.46	0	68.4	12.01	0	68.4
AUG.	10.30	.65	68.8	11.14	1.70		10.57	.04	71.5	8.70	.49	71.5	8.22	.61	75.2	9.89	.61	75.2
SEPT	7.16	.51	67.7	6.00	.10		6.50	.45	63.0	5.51	.02	63.0	7.08	.03	68.0	7.32	.03	68.0
OCT.	6.30	0	58.1	7.85	0		6.67	0	56.6	4.65	0	56.0	6.14	0	65.9	5.94	0	65.9
NOV.	3.99	2.94	47.1	3.90	1.15		3.70	1.06	48.0	2.48	1.06	48.0	4.39	.92	54.4	4.38	.92	54.4
DEC.	4.88	7.18	41.6	1.57	3.39		3.89	4.31	42.6	2.59	4.31	42.0	2.42	2.40	48.6	2.60	2.40	48.6
TOTAL	73.30	54.30	57.8	70.64	28.36		68.34	40.32	54.8	62.25	40.32	54.8	66.67	25.71	57.9	66.33	25.71	57.9

	Pan No 7 In Water La Mesa Reservoir ELEV 480			Pan No 8 In Ground Pamo Camp ELEV 680			Pan No 9 In Ground Sutherland Damsite ELEV 1210			Pan No 10 In Ground Santa Maria Damsite ELEV 1260			Pan No 11 In Ground Carroll Damsite ELEV 860					
Month	Gross Evap	Rain *62	Mean Temp	Gross Evap	Rain *63	Mean Temp	Gross Evap	Rain *61	Mean Temp	Gross Evap	Rain *62	Mean Temp	Gross Evap	Rain *63	Mean Temp			
JAN.	1.74	6.50	57.0	1.36	7.35	50.4	1.48	9.58		1.61	8.76		1.07	7.88				
FEB.	2.60	5.18	57.7	2.00	6.45	51.7	(2.05)	5.78		2.22	5.85		1.19	4.71				
MAR.	4.66	1.23	61.2	4.07	1.61	56.3	3.31	2.67		3.33	2.10		2.56	2.05				
APR.	5.15	.31	63.6	5.09	1.13	59.1	3.09	6.73		3.00	2.65		2.35	3.31				
MAY.	6.45	1.12	64.4	5.00	.31	61.0	3.61	8.35		4.15	2.81		3.02	2.06				
JUNE	5.01	.2	71.6	6.14	0	69.7	5.36	0		5.83	0		5.49	0				
JULY	9.34	0	74.8	6.52	0	72.5	6.02	0		6.62	0		6.83	0				
AUG.	7.90	.10	77.5	6.12	1.20	75.8	6.08	.11		6.93	1.20		6.71	.05				
SEPT.	6.02	.01	72.7	5.01	.04	69.4	4.50	.07		5.00	.002		5.02	.02				
OCT.	5.10	0	70.8	4.12	0	64.3	4.03	0		4.12	0		3.81	.03				
NOV.	4.11	1.17	64.8	2.20	0.96	55.1	2.15	1.47		2.78	1.31		2.42	.80				
DEC.	1.44	3.41	60.0	1.22	4.08	55.6	1.22	5.45		1.30	4.41		1.23	4.03				
TOTAL	62.65	21.11	64.8	47.04	29.16	61.3	42.54	37.91		46.62	29.1		43.67	24.91				

* Pan was moved to this location from previous location on May 1st. Pan No 6 is shown in the figure.
+ Mean Temperature at Warner Springs.

VOLCAN LAND & WATER CO.
EVAPORATION PAN RECORD — YEAR – 1916.
Values in inches of depth. Drawing No 518.

	Pan No 1. In Water Cuyamaca Reservoir ELEV 4500.			Pan No 2 In Ground E. Cuyamaca ELEV 4500.			Pan No 3 In Air Warner Dam ELEV 2720			Pan No 4 In Water Warner Dam ELEV 2620			Pan No 5 In Water Big Lake Warner Ranch ELEV 2780			Pan No 6A In Ground Big Lake Warner Ranch ELEV 2780		
Month	Gross Evap	Rain *29	Mean Temp.	Gross Evap	Rain *26	Mean Temp.	Gross Evap	Rain *1	Mean Temp.	Gross Evap	Rain *1	Mean Temp.	Gross Evap	Rain *5	Mean Temp+	Gross Evap	Rain *5	Mean Temp+
JAN.	.68	3.650	35.7	.06	2.685		2.34	3.383	40.5	2.83	3.383	40.5	1.19	2.388	43.7	1.55	2.388	43.7
FEB.	4.65	3.50	44.7	2.67	1.25		4.43	1.34	49.1	(3.00)	1.34	49.1	3.48	1.02	53.1	2.74	1.02	53.1
MAR.	6.26	4.51	50.2	5.09	2.69		6.57	2.21	53.1	(5.00)	2.21	53.1	5.64	1.40	56.7	5.25	1.40	56.7
APR.	6.57	.74	53.2	5.12	.94		6.33	.24	54.1	(6.00)	.24	54.1	7.00	.09	57.3	5.19	.09	57.3
MAY.	7.21	.64	55.2	8.25	.17		7.18	.50	56.0	(7.00)	.50	56.0	9.36	.18	58.6	7.23	.18	58.6
JUNE	8.25	0	63.8	10.49	0		8.65	0	64.3	4.30	0	64.3	8.91	0	67.0	9.03	0	67.0
JULY	10.05	2.12	70.7	8.20	1.31		10.14	.15	71.0	2.72	.15	71.0	11.52	.30	74.3	8.97	.30	74.3
AUG.	8.68	2.09	66.7	9.07	.80		9.63	.18	70.1	6.36	.18	70.1	10.45	.50	73.0	8.99	.50	73.0
SEPT	6.11	1.35	63.9	8.26	.29		13.81	.16	65.2	5.07	.16	65.2	9.30	.08	70.5	8.02	.09	70.5
OCT.	3.15	5.13	48.0	5.07	1.95		4.30	2.46	51.9	2.71	2.46	51.9	7.12	1.07	56.5	5.49	1.07	56.5
NOV.	3.82	.13	45.0	4.42	.01		3.85	.10	47.5	2.36	.10	47.5	2.44	.11	54.0	4.71	.11	54.0
DEC.	2.40	5.26	37.2	2.43	2.33		1.79	4.82	41.7	1.16	4.82	41.7	(1.30)	2.84	44.7	2.26	2.84	44.7
TOTAL	67.85	61.97	52.8	68.97	37.99		78.22	46.01	55.4	53.71	46.01	55.4	78.73	31.47	59.1	70.45	31.47	59.1

	Pan No 7 In Water La Mesa Reservoir ELEV 480			Pan No 8 In Ground Pamo Camp ELEV 680			Pan No 9 In Ground Sutherland Damsite ELEV 1210			Pan No 10 In Ground Santa Maria Damsite ELEV 1260			Pan No 11 In Ground Carroll Damsite ELEV 860			Pan No 12 In Water Lake Elsinore ELEV		
Month	Gross Evap	Rain *62	Mean Temp.	Gross Evap	Rain *63	Mean Temp.	Gross Evap	Rain *61	Mean Temp.	Gross Evap	Rain *62	Mean Temp.	Gross Evap	Rain *63	Mean Temp.	Gross Evap	Rain *64	Mean Temp.
JAN.	1.85	10.13	53.6	.43	24.47	50.9	(.40)	(26.4)		.57	22.4		.56	14.94	49.1		14.83	46.0
FEB.	2.75	1.58	62.1	(2.00)	1.29	57.7	(1.80)	1.50		(2.00)	(1.30)		1.28	1.27	55.3		.78	55.5
MAR.	3.98	1.08	65.1	3.10	1.47	59.5	3.01	4.76		3.30	(1.52)		2.66	1.94	59.5		1.14	60.6
APR.	5.77	.01	65.8	5.46	.21	62.9	4.07	.55		4.38	.13		3.89	.32	60.7		.20	66.0
MAY.	8.33	.10	66.0	7.61	.17	64.6	5.75	.43	65.0	5.76	.12		5.34	.21	62.2	7.75	0	66.1
JUNE	7.65	0	69.2	8.01	0	68.4	6.46	0	61.5	(6.23)	0		5.61	0	67.3	7.95	0	74.0
JULY	9.90	.21	72.6	10.25	.14	73.4	7.13	.28	71.5	6.98	.04		6.24	.02	71.2	8.42	0	78.3
AUG.	7.87	0	74.9	8.71	.25	75.1	6.54	.02	67.2	6.49	0		5.95	.02	72.0	8.58	.02	76.0
SEPT.	5.81	.36	72.2	7.01	.14	71.9	4.95	.29	74.3	5.01	.14		4.49	.29	68.3	6.41	.51	73.0
OCT.	4.89	2.11	64.7	4.18	1.80	61.3	2.81	3.26	52.1	2.99	2.00		2.50	1.66	58.1	3.12	.95	60.6
NOV.	5.54	.10	62.0	4.02	.16	57.6	2.37	.26	47.2	2.85	.15		2.52	.20	53.4	3.12	.04	53.2
DEC.	3.09	1.98	55.7	2.54	2.69	52.0	1.46	4.32	41.1	2.45	3.11		1.70	3.26	45.7	1.90	2.23	45.0
TOTAL	67.43	17.62	63.2	64.12	32.79	62.0	48.72	41.67	(56.2)	48.99	31.45		43.04	24.13	60.1		20.70	62.3

+ Mean Temperature at Warner Springs.
(-) Estimated Values.

Table 4. (continued)

VOLCAN LAND & WATER CO.

EVAPORATION PAN RECORD

YEAR – 1917.

Values in inches of depth.

Standard Pan 3'x3'x10" except No 3.

By D.A. McCLUNG - Feb 1917

Month	Pan No 1. In Water Cuyamaca Reservoir ELEV. 4630			Pan No 2 In Ground E. Cuyamaca ELEV. 4630.			Pan No 3 In Air Warner Dam 5 gallon pan ELEV. 2700			Pan No 13 In Ground Warner Dam ELEV. 2680.								
	Gross Evap.	Rain .28	Mean Temp.	Gross Evap.	Rain .46	Mean Temp.	Gross Evap.	Rain .91	Mean Temp.	Gross Evap.	Rain .91	Mean Temp.	Gross Evap.	Rain	Mean Temp.	Gross Evap.	Rain	Mean Temp.
JAN.	2.75	7.34	33.1	0.97	4.12		1.70	5.90	40.4		5.90	40.4						
FEB.	2.01	7.94	37.5	1.66	6.05		2.25	8.20	44.8		8.20	44.8						
MAR.	2.94	1.78	38.6	3.65	1.27		4.45	1.06	45.4		1.06	45.4						
APR.	2.88	5.11	45.3	2.83	2.83		5.95	4.85	50.5		4.85	50.5						
MAY.	4.38	1.88	47.4	5.16	.37		5.96	1.43	53.5		1.45	53.5						
JUNE	6.58	0	66.5	6.83	0		7.85	0	67.1	7.04	0	67.1						
JULY	6.91	1.17	72.9	8.46	2.50		7.99	.44	74.5	6.88	.44	76.5						
AUG.	8.56	0	71.0	9.06	0		8.60	0	71.9	7.52	0	71.9						
SEPT.	7.12	.86	66.7	6.52	.39		7.83	.05	68.5	5.91	.05	68.5						
OCT.	(6.00)	.03	62.9	5.45	0		5.52	0	60.8	4.20	0	60.8						
NOV.	(4.00)	1.24	52.8	3.28	.43		3.34	.80	50.2	2.29	.80	50.2						
DEC.	(2.00)	0	46.9	3.50	0		2.71	0	47.4	1.91	0	47.4						
TOTAL	57.61	28.50	Mean 53.4	58.37	17.86	Mean	63.85	19.75	Mean 56.2		19.75	Mean 56.2			Mean			Mean

Month	Pan No 7 In Water La Mesa Reservoir ELEV. 420			Pan No 8 In Ground Pamo Camp ELEV. 680			Pan No 9 In Ground Sutherland Domsite ELEV. 1050			Pan No 10 In Ground Santa Maria Domsite ELEV. 1050			Pan No 11 In Ground Carroll Domsite ELEV. 960			Pan No 12 In Water Lake Elsinore ELEV.		
	Gross Evap.	Rain .00	Mean Temp.	Gross Evap.	Rain .88	Mean Temp.	Gross Evap.	Rain .91	Mean Temp.	Gross Evap.	Rain .95	Mean Temp.	Gross Evap.	Rain .68	Mean Temp.	Gross Evap.	Rain	Mean Temp.
JAN.	2.72	4.91	54.1	1.56	4.10	49.2	1.18	6.24	38.8	2.16	4.51		1.07	4.85	46.5	1.60	3.12	42.8
FEB.	2.88	2.39	58.7	2.25	2.88	54.2	1.83	6.01	44.5	1.65	3.04		1.95	3.61	51.3	1.88	3.09	48.8
MAR.	4.17	.47	60.2	4.16	.49	54.5	3.12	.80	47.8	3.27	.51		3.26	.67	53.1	3.93	.45	48.4
APR.	3.39	2.02	56.7	3.85	1.89	53.0	3.89	3.01	51.0	3.80	2.06		3.82	2.12	52.8		.99	50.0
MAY.	4.05	.45	58.8	4.32	.76	62.0	3.52	1.81	51.1	3.86	1.00		3.21	.67	62.8			
JUNE	6.98	.0	64.8	8.05	0	73.0	6.56	0	66.8	6.57	0		5.91	0	73.0			
JULY	7.60	T	71.4	8.60	0	78.8	6.64	.02	72.9	8.73	0		6.17	0	78.4			
AUG.	8.08	T.	72.6	8.50	0	75.7	6.86	T	70.5	5.18	0		5.97	.03	75.3			
SEPT.	7.38	T	78.0	7.50	0	74.1	5.41	0	68.9	3.60	0		5.07	0	73.0			
OCT.	5.12	.62	67.8	5.48	T	67.7	3.97	0	62.1	3.01	0		3.98	.15	68.9			
NOV.	4.10	.17	61.4	3.38	.39	58.8	2.23	.72	50.8	2.64	.42		2.47	.50	62.1			
DEC.	3.48	T	52.4	3.22	0	56.4	1.81	0	48.7	2.30	0		1.94	0	58.4			
TOTAL	60.09	10.63	Mean 62.6	60.99	10.86	Mean 63.7	46.99	19.51	Mean 56.1	46.17	11.54	Mean	44.84	12.60	Mean 63.5	Discontinued		Mean

(–) Estimated Values

VOLCAN LAND & WATER CO.

EVAPORATION PAN RECORD

YEAR – 1918.

Values in inches of depth

Standard 3'x3'x10" Pans except No 3.

Month	Pan No 1. In Water Cuyamaca Reservoir ELEV 4630			Pan No 2 In Ground E. Cuyamaca ELEV 4630.			Pan No 3 In Air Warner Dam Spotter pan ELEV 2700			Pan No 13 In Ground Warner Dam ELEV 2680.								
	Gross Evap.	Rain .28	Mean Temp.	Gross Evap.	Rain .46	Mean Temp.	Gross Evap.	Rain .91	Mean Temp.	Gross Evap.	Rain .91	Mean Temp.	Gross Evap.	Rain	Mean Temp.	Gross Evap.	Rain	Mean Temp.
JAN.	(3.00)	4.26	39.3	3.19	2.75		4.26	2.76	44.4	2.04	2.76	44.2						
FEB.	3.61	5.61	42.6	2.72	4.25		2.03	3.78	47.1	1.54	3.78	47.1						
MAR.	(3.00)	15.70	45.3	1.91	9.57		6.01	14.99	51.5	2.26	14.99	51.8						
APR.	5.24	0		4.75	.0		4.45	.07	54.8	3.90	.07	54.0						
MAY.	5.85	.45		6.60	.20		4.17	.97	55.6	4.39	.97	55.6						
JUNE	6.20	.59		7.90	1.30		6.37	.73	72.3	5.87	.73	72.8						
JULY	9.02	.11		10.83	.13		7.64	0	72.8	7.17	0	72.8						
AUG.	7.11	7.37	68.8		1.48		6.45	.41	71.4	6.26	.41	71.4						
SEPT.																		
OCT.																		
NOV.																		
DEC.																		
TOTAL			Mean			Mean			Mean			Mean			Mean			Mean

Month	Pan No 7 In Water Murray Reservoir ELEV 530			Pan No 8 In Ground Pamo Camp ELEV. 680			Pan No 9 In Ground Sutherland Domsite ELEV 1050			Pan No In ELEV.			Pan No 11 In Ground (Carroll Dam) Lake Hodges ELEV 660			Pan No In ELEV.		
	Gross Evap.	Rain .00	Mean Temp.	Gross Evap.	Rain .88	Mean Temp.	Gross Evap.	Rain .91	Mean Temp.	Gross Evap.	Rain	Mean Temp.	Gross Evap.	Rain .68	Mean Temp.	Gross Evap.	Rain	Mean Temp.
JAN.	(3.00)	7.42	54.5	2.20	2.17	52.6	1.70	2.27	44.3				2.03	3.70	55.1			
FEB.	(4.00)	2.13	55.9	2.56	2.44	55.8	2.01	4.00	50.0				2.32	2.78	56.9			
MAR.	(3.00)	2.30		3.87	6.27	58.8	2.72	9.97	55.8				2.56	6.56	60.2			
APR.	4.02	0		4.80	.06	61.6	4.24	.14	56.4				3.81	.04	63.1			
MAY.	6.27	.13	63.0	5.89	1.11	64.6	4.76	1.78	60.6				4.90	.96	66.1			
JUNE	6.63	.0	73.0	7.55	.07	76.1	5.17	.16	76.4				5.95	.04	74.4			
JULY	8.20	.04	74.1	8.72	.0	77.0	7.73	0	74.8				6.61	.05	74.3			
AUG.	8.22	.12	74.6	8.38	.02	76.6			75.1				5.82	.13	76.5			
SEPT.	6.55	.09	75.2		0	75.2								.10	76.0			
OCT.																		
NOV.																		
DEC.																		
TOTAL			Mean			Mean			Mean			Mean			Mean			Mean

(–) Estimated Values

Table No. 5.

OBSERVED RAINFALL WARNER'S RESERVOIR

Stations No.	Name	1911-12 Oct. to Mar.	1911-12 April to Sept.	1912-13 Oct. to Mar.	1912-13 April to Sept.	1913-14 Oct. to Mar.	1913-14 April to Sept.	1914-15 Oct. to Mar.	1914-15 April to Sept.
1.	Warner's Dam Site	18.84	7.04	17.38	2.87	27.43	4.94	31.63	10.52
2.	Damrons	18.83	7.01	21.26	5.77	27.73	3.81	33.86	13.37
3.	Monkey Hill	7.14	4.54	8.27	2.90	12.95	1.71	17.84	4.44
4.	Warner's Summer Road	9.98	5.35	10.42	2.39	15.96	2.48	20.79	6.48
5.	Puerta la Cruz	9.30	4.90	10.19	2.49	15.22	2.98	20.88	7.26
MEAN		12.82	5.77	13.50	3.28	19.86	3.18	25.00	8.42
TOTAL SEASONAL		18.59		16.78		23.04		33.42	

Table No. 5. (continued)

OBSERVED RAINFALL AVERAGE, 8 RESERVOIR

Table No. 5.

No.	Stations Name	1915-16 Oct. to Mar.	1915-16 April to Sept.	1916-17 Oct. to Mar.	1916-17 April to Sept.	1917-18 Oct. to Mar.	1917-18 April to Sept.	Average Oct. to Mar.	Average April to Sept.	Average Total Seasonal
1.	Warner's Dam Site	42.85	1.23	19.54	6.79	22.33	2.18	25.71	5.08	30.79
2.	Damrons	48.45	0.84	22.55	7.45	23.55	3.03	28.03	5.90	33.93
3.	Monkey Hill	(22.40)	(0.56)	(9.47)	(3.30)	(10.55)	(1.40)	12.66	2.69	15.35
4.	Warner's Summer Road	32.29	0.57	11.09	4.21	13.34	2.19	16.27	3.35	19.62
5.	Puerta la Cruz	29.62	1.05	10.86	(3.28)	(12.90)	(1.80)	15.57	3.39	18.96
	MEAN	35.12	0.85	14.70	5.01	16.53	2.12	19.65	4.08	23.73
	TOTAL SEASONAL	35.97		19.71		18.65				

Station #3 abandoned July 1, 1915. Values here inserted are estimated.

Station #5 abandoned July 1, 1917. Values in parentheses are estimated.

Observed total average annual rainfall 23.73.

83% occurring from Oct. to Mar. and 17% from April to Sept.

For purposes of report assume this relation 80% - 20%.

Table No. 6.

ESTIMATED RAINFALL UPON WATER SURFACE

WARNER'S RESERVOIR

SEASON	Average Percent years for 9 base stations S.D.Co. 44 year period	Adjusted Percentage for 28 year period	Estimated Rainfall on Reservoir Inches	90% of Estimated Rainfall Inches	Winter Rain Oct. to Mar. incl. Inches (1)	Summer Rain Sept. to Apr. incl. Inches (2)
1888-89	127	123	28.2	25.4	20.3	5.1
89-90	155	151	34.6	31.1	25.0	6.2
90-91	142	138	31.7	28.5	22.8	5.7
91-92	95	92	21.1	19.0	15.2	3.8
92-93	103	100	23.0	20.7	16.6	4.1
93-94	71	69	15.8	14.2	11.4	2.8
94-95	129	125	28.7	25.8	20.6	5.2
95-96	60	58	13.3	12.0	9.6	2.4
96-97	111	108	24.8	22.3	17.8	4.5
97-98	60	58	13.3	12.0	9.6	2.4
98-99	54	52	11.9	10.7	8.8	2.1
99-00	73	71	16.3	14.7	11.8	2.9
1900-01	94	91	20.9	18.8	15.0	3.8
01-02	76	74	17.0	15.3	12.2	3.1
02-03	110	107	24.6	22.1	17.7	4.4
03-04	51	50	11.5	10.4	8.3	2.1
04-05	145	141	32.4	29.2	23.3	5.8
05-06	150	146	33.5	30.2	24.2	6.0
06-07	116	113	25.9	23.3	18.6	4.7
07-08	85	82	18.8	16.9	13.5	3.4
08-09	112	109	25.0	22.5	18.0	4.5
09-10	94	91	20.9	18.8	15.0	3.8
10-11	101	98	22.5	20.3	16.2	4.1
11-12	91	88	# 18.59	/ 16.7	/ 11.5	/ 5.2
12-13	63	61	# 16.78	/ 15.1	/ 12.2	/ 3.0
13-14	109	106	# 23.04	/ 20.7	/ 17.9	/ 2.9
14-15	151	147	# 33.42	/ 30.1	/ 22.5	/ 7.6
15-16	155	151	# 35.97	/ 32.3	/ 31.6	/ 0.8
(16-17)			#(19.71)	/ 17.8	/ 13.2	/ 4.5
(17-18)			#(18.65)	/ 16.8	/ 14.9	/ 1.9
Total	2,883	2,800				
Mean	103	100				
Period	103	100				

Table No. 6.

ESTIMATED RAINFALL UPON WATER SURFACE

WARNER'S RESERVOIR

SEASON	Average Percent Years for 9 Base stations: 44 year period	Adjusted Percent- age for 28 year period	Estimated Rain- fall on Reser- voir Inches	90% of Estimated Rain- fall Inches	Winter Rain Oct.to Mar. Incl. Inches (1)	Summer Rain Sept.to Apr. Incl. Inches (2)
1888-89	127	129	28.5	25.4	20.3	5.1
89-90	186	181	34.6	31.1	25.0	6.2
90-91	142	138	31.7	28.8	23.8	5.7
91-92	96	92	21.1	19.0	15.2	3.8
92-93	108	100	23.0	20.7	16.6	4.1
93-94	71	69	15.8	14.2	11.4	2.8
94-95	129	128	28.7	25.8	20.6	5.2
95-96	60	58	13.3	12.0	9.6	2.4
96-97	111	108	24.8	22.3	17.8	4.5
97-98	60	58	13.3	12.0	9.6	2.4
98-99	64	52	11.9	10.7	8.8	2.1
99-00	73	71	16.3	14.7	11.8	2.9
1900-01	94	91	20.9	18.8	15.0	3.8
01-02	76	74	17.0	15.3	12.2	3.1
02-03	110	107	24.6	22.1	17.7	4.4
03-04	51	50	11.3	10.4	8.3	2.1
04-05	146	141	32.4	29.2	23.3	5.8
05-06	150	146	33.5	30.2	24.2	6.0
06-07	116	113	25.9	23.3	18.6	4.7
07-08	85	82	18.8	16.9	13.5	3.4
08-09	112	109	25.0	22.5	18.0	4.5
09-10	94	91	20.9	18.8	15.0	3.8
10-11	101	98	22.5	20.3	16.2	4.1
11-12	91	88	18.89#	16.7 ✓	11.6 ✓	5.1 ✓
12-13	63	61	16.78#	15.1 ✓	12.2 ✓	3.0 ✓
13-14	109	106	23.04#	20.7 ✓	17.9 ✓	2.9 ✓
14-15	151	147	33.42#	30.1 ✓	22.5 ✓	7.6 ✓
15-16	155	151	35.97#	32.3 ✓	31.6 ✓	0.8 ✓
(16-17):			(19.71)	17.8 ✓	13.2 ✓	4.6 ✓
(17-18):			(18.65)	16.8 ✓	14.9 ✓	1.9 ✓
Total	2,885	2,800				
Mean	103	100				
Period	103	100				

Explanatory Notes - Table 6:

(1) = 80% of total seasonal.

(2) = 20% " " "

\# = Average of observed rainfall at 5 stations near reservoir 3 of which are in the flooded area.

✓ = Observed.

Table No. 7.

NET EVAPORATION

SEASON	October 1 to March 31, inclusive			April 1 to September 30, inclusive		
	Gross Evap. Inches	Rainfall Inches	Net Evaporation & Rainfall Inches / Feet	Gross Evap. Inches	Rainfall Inches	Net Evaporation & Rainfall Inches / Feet
1888-89	19	20.3	# 1.3 / # 0.11	35	5.1	- 29.9 / - 2.50
89-90	19	25.0	# 6.0 / # 0.50	35	6.2	- 28.8 / - 2.40
90-91	19	22.8	# 3.8 / # 0.32	35	5.7	- 29.3 / - 2.44
91-92	19	15.2	- 3.8 / - 0.32	35	3.8	- 31.2 / - 2.61
92-93	19	16.6	- 2.4 / - 0.20	35	4.1	- 30.9 / - 2.58
93-94	19	11.4	- 7.6 / - 0.63	35	2.8	- 32.2 / - 2.68
94-95	19	20.6	# 1.6 / # 0.13	35	5.2	- 29.8 / - 2.48
95-96	19	9.6	- 9.4 / - 0.78	35	2.4	- 32.6 / - 2.71
96-97	19	17.8	- 1.2 / - 0.10	35	4.5	- 30.5 / - 2.54
97-98	19	9.6	- 9.4 / - 0.78	35	2.4	- 32.6 / - 2.72
98-99	19	8.8	- 10.2 / - 0.85	35	2.1	- 32.9 / - 2.74
99-00	19	11.8	- 7.2 / - 0.60	35	2.9	- 32.1 / - 2.68
1900-01	19	15.0	- 4.0 / - 0.33	35	3.8	- 31.2 / - 2.60
01-02	19	12.2	- 6.8 / - 0.57	35	3.1	- 31.9 / - 2.66
02-03	19	17.7	- 1.3 / - 0.11	35	4.4	- 30.6 / - 2.55
03-04	19	8.3	- 10.7 / - 0.90	35	2.1	- 32.9 / - 2.74
04-05	19	23.3	# 4.3 / # 0.36	35	5.8	- 29.2 / - 2.43
05-06	19	24.2	# 5.2 / # 0.43	35	6.0	- 29.0 / - 2.41
06-07	19	18.6	- 0.4 / - 0.03	35	4.7	- 30.3 / - 2.52
07-08	19	13.5	- 5.5 / - 0.46	35	3.4	- 31.6 / - 2.63
08-09	19	18.0	- 1.0 / - 0.08	35	4.5	- 30.5 / - 2.54
09-10	19	15.0	- 4.0 / - 0.33	35	3.8	- 31.2 / - 2.60
1910-11	19	16.2	- 2.8 / - 0.23	35	4.1	- 30.9 / - 2.57
11-12	19	11.5	- 7.5 / - 0.62	35	5.2	- 29.8 / - 2.48
12-13	19	12.2	- 6.8 / - 0.57	35	3.0	- 32.0 / - 2.67
13-14	19	17.9	- 1.1 / - 0.09	35	2.9	- 32.1 / - 2.67
14-15	19	22.5	# 3.5 / # 0.29	35	7.6	- 27.4 / - 2.28

Table No. 7. (continued)

SEASON	October 1 to March 31, inclusive: Gross Evap. Inches	Rainfall Inches	Net Evaporation & Rainfall Inches	Net Evaporation & Rainfall Feet	April 1 to September 30, inclusive: Gross Evap. Inches	Rainfall Inches	Net Evaporation & Rainfall Inches	Net Evaporation & Rainfall Feet
1915-16	19	31.6	# 12.6	# 1.05	35	0.8	- 34.2	- 2.85
16-17	19	13.2	- 5.8	- 0.48	35	4.5	- 30.5	- 2.54
17-18	19	14.9	- 4.1	- 0.34	35	1.9	- 33.1	- 2.76

# Indicates the rainfall exceeds the evaporation and there is a net increase in the lake.

- Indicates the evaporation exceeds the rainfall and the lake is lowered.

Table No. 8.

ESTIMATED RELINQUISHMENTS AT WARNER'S TO SATISFY THE ESCONDIDO DIVERSION

SEASON	Estimated Runoff at Warner's Acre Feet	Estimated Relinquishments for Escondido Acre Feet
1888-89	27,500	0
89-90	45,500	0
90-91	51,000	0
91-92	21,000	0
92-93	31,250	0
93-94	15,250	960
94-95	99,220	0
95-96	7,210	1,900
96-97	23,990	460
97-98	3,680	2,450
98-99	2,690	1,350
99-00	2,300	720
1900-01	13,360	1,050
01-02	9,250	1,500
02-03	15,120	400
03-04	5,784	1,500
04-05	27,451	0
05-06	67,910	0
06-07	52,153	0
07-08	17,734	0
08-09	32,924	0
09-10	30,900	0
1910-11	21,160	0
11-12	12,030	830
12-13	5,910	2,030
13-14	22,630	460
14-15	60,440	0
15-16	182,068	0
16-17	28,411	0
17-18	23,280	680

Note:- These relinquishments are taken to be the same as those computed in the Lippincott-O'Shaughnessy report.

Table No. 7. (continued)

SEASON	Estimated Net Monthly Flow at Warner's in Acre Feet												
	October	November	December	January	February	March	April	May	June	July	August	September	Total
1888-89	0	0	0	0	0	0	0	0	0	0	0	0	0
89-90	0	0	0	0	0	0	0	0	0	0	0	0	0
90-91	0	0	0	0	0	0	0	0	0	0	0	0	0
91-92	0	0	0	0	0	0	0	0	0	0	0	0	0
92-93	0	0	0	0	0	0	0	0	0	0	0	0	0
93-94	0	0	0	0	0	0	0	0	0	0	0	0	0
94-95	0	0	0	0	0	0	0	0	0	0	0	0	0
95-96	0	0	0	0	0	0	0	0	0	0	0	0	0
96-97	0	0	0	0	0	0	0	0	0	0	0	0	0
97-98	0	0	0	0	0	0	0	0	0	0	0	0	0
98-99	0	0	0	0	0	0	0	0	0	0	0	0	0
99-00	0	0	0	0	0	0	0	0	0	0	0	0	0
1900-01	0	0	0	0	0	0	0	0	0	0	0	0	0
01-02	0	0	0	0	0	0	0	0	0	0	0	0	0
02-03	0	0	0	0	0	0	0	0	0	0	0	0	0
03-04	0	0	0	0	0	0	0	0	0	0	0	0	0
04-05	0	0	0	0	0	0	0	0	0	0	0	0	0
05-06	0	0	0	0	0	0	0	0	0	0	0	0	0
06-07	0	0	0	0	0	0	0	0	0	0	0	0	0
07-08	0	0	0	0	0	0	0	0	0	0	0	0	0
08-09	0	0	0	0	0	0	0	0	0	0	0	0	0
09-10	0	0	0	0	0	0	0	0	0	0	0	0	0
1910-11	0	0	0	0	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0	0	0	0	0
12-13	0	0	0	0	0	0	0	0	0	0	0	0	0
13-14	0	0	0	0	0	0	0	0	0	0	0	0	0
14-15	0	0	0	0	0	0	0	0	0	0	0	0	0
15-16	0	0	0	0	0	0	0	0	0	0	0	0	0
16-17	0	0	0	0	0	0	0	0	0	0	0	0	0
17-18	0	0	0	0	0	0	0	0	0	0	0	0	0

Table No. 7.

ESTIMATED MONTHLY FLOW OF SAN LUIS REY RIVER AT WARNER'S

October 1 to March 31, inclusive

SEASON	Estimated Net Monthly Flow at Warner's in Acre Feet						
	October	November	December	January	February	March	Total
1888-89	0	0	0	0	0	0	0
89-90	0	0	0	0	0	0	0
90-91	0	0	0	0	0	0	0
91-92	0	0	0	0	0	0	0
92-93	0	0	0	0	0	0	0
93-94	0	0	0	0	0	0	0
94-95	0	0	0	0	0	0	0
95-96	0	0	0	0	0	0	0
96-97	0	0	0	0	0	0	0
97-98	0	0	0	0	0	0	0
98-99	0	0	0	0	0	0	0
99-00	0	0	0	0	0	0	0
1900-01	0	0	0	0	0	0	0
01-02	0	0	0	0	0	0	0
02-03	0	0	0	0	0	0	0
03-04	0	0	0	0	0	0	0
04-05	0	0	0	0	0	0	0
05-06	0	0	0	0	0	0	0
06-07	0	0	0	0	0	0	0
07-08	0	0	0	0	0	0	0
08-09	0	0	0	0	0	0	0
09-10	0	0	0	0	0	0	0
1910-11	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0
12-13	0	0	0	0	0	0	0
13-14	0	0	0	0	0	0	0
14-15	0	0	0	0	0	0	0
15-16	0	0	0	0	0	0	0
16-17	0	0	0	0	0	0	0
17-18	0	0	0	0	0	0	0

- Indicates the evaporation exceeds the rainfall and there is a net increase in the reservoir and the figure is the evaporation minus the rainfall.

TABLE 9.

STORAGE STUDY FOR WARNER RESERVOIR

DRAFT OCTOBER 1 TO MARCH 31 - 9300 ACRE FEET; - DRAFT APRIL 1 TO SEPTEMBER 30 - 18700 ACRE FEET.

Season	Stored Oct. 1 Acre-Ft.	Run-Off Acre-Ft.	Draft Acre-Ft.	Mean Area Reservoir Acres	Evaporation Less 90% Rainfall Feet	Evaporation Less 90% Rainfall Acre-Ft.	Total Withdrawal Acre-Ft.	Net Addition or Deduction Acre-Ft.	Waste Acre-Ft.	Stored April 1 Acre-Ft.	Run-Off Acre-Ft.	Draft Acre-Ft.	Released for Escondido Acre-Ft.	Mean Area Reservoir Acres	Evaporation Less 90% Rainfall Feet	Evaporation Less 90% Rainfall Acre-Ft.	Conserved Evap. Acre-Ft.	Total Withdrawal Acre-Ft.	Net Addition or Deduction Acre-Ft.	Waste Acre-Ft.	Stored Oct. 1 Acre-Ft.	Season
1888-89	180 000	19 850	9 300	5 800	+ 0.11	+ 640	- 8 660	+11 190	0	191 190	8 800	18700	0	5 800	- 2.50	-14500	+ 2750	-30450	-21 650	0	159 540	1888-89
89-90	159 540	33 950	9 300	5 700	+ 0.50	+2 850	- 6 450	+27500	0	187040	14 750	18 700	0	5 850	- 2.40	-14000	+ 2750	-29 950	-15 200	0	181 840	89-90
90-91	181 840	36 050	9 300	5 950	+ 0.32	+ 1 900	- 7400	+28 650	10 490	200000	15 650	18700	0	5 950	- 2.44	-14500	+ 2750	-30 450	-14 800	0	185 200	90-91
91-92	185 200	15 350	9 300	5 900	- 0.32	- 1 900	-11 200	+ 4 150	0	189 350	6 750	18700	0	5 600	- 2.61	-14 600	+ 2 750	-30 550	-23800	0	165 550	91-92
92-93	165 550	23 050	9300	5400	- 0.20	- 1 080	-10 380	+12 670	0	178 220	10 150	18700	0	5400	- 2.58	-14 000	+ 2 750	-29 850	-19800	0	158420	92-93
93-94	158 420	9 330	9 300	5 100	- 0.63	-3 200	-12 500	- 3 170	0	155 250	4 180	18700	960	4700	- 2.68	-12 600	+ 2750	-29 510	-25330	0	129 920	93-94
94-95	129 920	68 950	9300	5 200	+ 0.13	+ 680	- 8 620	+60 330	0	190 250	29 750	18700	0	5 850	- 2.48	-14500	+ 2750	-30450	- 700	0	189 550	94-95
95-96	189 550	5 430	9300	5 800	- 0.78	-4 520	-13 820	- 8 390	0	181 160	2 540	18700	1900	5400	- 2.71	-14600	+ 2750	-32450	-29910	0	151 250	95-96
96-97	151 250	16 550	9300	5 100	- 0.10	- 510	- 9 810	+ 6740	0	157 990	7 250	18700	460	4 800	- 2.54	-12200	+ 2750	-28610	-21 360	0	136 630	96-97
97-98	136 630	3 120	9300	4400	- 0.78	-3440	-12 740	- 9 620	0	127 010	1 530	18700	2450	3800	- 2.72	-10300	+ 2750	-28 700	-27170	0	99 840	97-98
98-99	99 840	2 390	9300	3350	- 0.85	- 2 850	-12 150	- 9 760	0	90 080	1 220	18700	1350	2800	- 2.74	- 7670	+ 1 900	-25 820	-24600	0	65 480	98-99
99-00	65 480	1 710	9300	2400	- 0.60	- 1 440	-10 740	- 9 030	0	56450	940	18700	720	2000	- 2.68	- 5360	+ 1 430	-23 350	-22410	0	34 040	99-00
1900-01	34 040	10 110	9 300	1800	- 0.33	- 600	- 9 900	+ 210	0	34 250	4 540	18700	1050	1500	- 2.60	- 3900	+ 1 050	-22600	-18060	0	16 190	1900-01
01-02	16 190	6 530	9300	1 200	- 0.57	- 680	- 9 980	- 3 450	0	12740	3 010	13 250	1 500	600	- 2.66	- 1600	+ 600	-15750	-12 740	0	0	01-02
02-03	0	11 550	4 650	400	- 0.11	- 44	- 4 694	+ 6 856	0	6 856	5 170	11460	400	140	- 2.55	- 360	+ 200	-12 020	- 6 850	0	0	02-03
03-04	0	4 400	4 400	0	- 0.90	0	- 4 400	0	0	0	2 084	584	1 500	0	- 2.74	0	0	- 2 084	0	0	0	03-04
04-05	0	19 550	9 300	650	+ 0.36	+ 230	- 9 070	+10 480	0	10 480	8 550	18 170	0	600	- 2.43	- 1460	+ 600	-19 030	-10 480	0	0	04-05
05-06	0	47 850	9 300	1 400	+ 0.43	+ 600	- 8 700	+39 150	0	39 150	20 760	18700	0	1950	- 2.41	- 4 700	+ 1 350	-22 050	- 1 290	0	37 860	05-06
06-07	37 860	36 950	9300	2250	- 0.03	- 70	- 9 370	+27 580	0	65 440	15 903	18700	0	2500	- 2.52	- 6 300	+ 1 700	-23300	- 7 397	0	58 043	06-07
07-08	58 043	12 750	9300	2400	- 0.46	- 1 100	-10 400	+ 2 350	0	60 393	5 684	18700	0	2250	- 2.63	- 5 900	+ 1 560	-23040	-17 356	0	43 037	07-08
08-09	43 037	23 350	9 300	2200	- 0.08	- 180	- 9 480	+13 870	0	56 907	10 274	18700	0	2200	- 2.54	- 5 580	+ 1 550	-22 730	-12456	0	44451	08-09
09-10	44 451	21 950	9300	2200	- 0.33	- 730	-10 030	+11 920	0	56 371	9 649	18700	0	2200	- 2.60	- 5 720	+ 1 550	-22870	-13221	0	43 150	09-10
1910-11	43 150	17 500	9300	2150	- 0.23	- 495	- 9 795	+ 7705	0	50 855	4 360	18700	0	2000	- 2.57	- 5 150	+ 1 400	-22450	-18090	0	32 765	1910-11
11-12	32 765	5 871	9300	1800	- 0.62	- 1 115	-10 415	- 4 544	0	28 221	6 859	18700	830	1500	- 2.48	- 3 720	+ 1 050	-22200	-15341	0	12 880	11-12
12-13	12 880	5 014	9300	1 100	- 0.57	- 630	- 9 930	- 4 916	0*	7 964	1 596	7 030	2 030	300	- 2.67	- 800	+ 300	- 9 560	- 7964	0	0	12-13
13-14	0	20 253	4 650	850	- 0.09	- 80	- 4 730	+15 503	0	15 503	2 397	15 820	460	850	- 2.67	- 2 270	+ 650	-17 900	-15 503	0	0	13-14
14-15	0	37 278	9300	1 200	+ 0.29	+ 360	- 8 950	+28 328	0	28 328	23 162	18700	0	1700	- 2.28	- 3 880	+ 1 180	-21400	+ 1 762	0	30 090	14-15
15-16	30 090	177 674	9300	4 000	+ 1.05	+ 4200	- 5 100	+172 774	2 862	200 000	7 816	18700	0	5850	- 2.85	-16 700	+ 2 750	-32650	-24 834	0	175 166	15-16
16-17	175 166	20 824	9300	5 700	- 0.48	- 2 740	-12 040	+ 8 784	0	183 950	7 587	18700	0	5400	- 2.54	-13 700	+ 2 750	-29650	-22 063	6 013	200 000	16-17
17-18	200 000	20 107	9300	6 050	- 0.34	- 2 060	-11 360	+ 8 784	8 784	200 000	3 173	18700	680	5800	- 2.76	-16 000	+ 2 750	-32 630	-29457	0	170 543	17-18

* Assumed

Table No. 9(a).

COST OF CONCRETE PIPE AT YARD

DIAM. OF PIPE INCHES	HEAD IN FEET	STATIC PRESSURE IN LBS.	WORKING PRESSURE IN LBS.	THICKNESS OF SHELL IN INCHES	CU.YDS. CONCRETE PER FOOT OF PIPE	COST OF CONCRETE PER CU.YD. IN PLACE	COST OF CONCRETE PER FOOT OF PIPE	WEIGHT OF STEEL PER FOOT OF PIPE IN LBS.	COST OF STEEL PER LB. IN PLACE	COST OF STEEL PER FOOT OF PIPE	TOTAL COST OF PIPE PER FOOT	WEIGHT PER FOOT OF PIPE IN LBS.
6	10	5	7	2	.0065	$30	$.20	1.0	$.10	$.10	$0.30	27
	150	64	96	2	.0065	30	.20	5.0	.10	.50	0.70	31
12	10	5	7	2	.011	30	.33	1.6	.10	.16	0.49	44
	150	64	96	2	.011	30	.33	9.0	.10	.90	1.23	51
24	10	5	7	3	.066	20	1.32	4.0	.09	.36	1.68	269
	150	64	96	3	.066	20	1.32	28.0	.09	2.52	3.84	293
36	10	5	7	4	.13	20	2.60	7.0	.09	.63	3.23	532
	120	52	78	4	.13	20	2.60	55.0	.09	4.95	7.55	580
42	10	5	7	4	.149	20	2.98	8.0	.09	.72	3.70	608
	100	44	66	4	.149	20	2.98	50.0	.09	4.50	7.48	650

Table No. 10.

COST OF PIPE TRENCHES.

Size of Pipe	Outside Diameter	Size of Trench	Cu. Yds. per Foot	Cost Per Cu. Yd. Excavation	Cost Per Cu. Yd. Backfill	Total Cost per Foot
6"	10"	22"x 34"	.193	0.95	0.30	0.24
8"	12"	24"x 36"	.222	0.95	0.30	0.28
10"	14"	26"x 38"	.254	0.95	0.30	0.32
12"	16"	28"x 40"	.289	0.95	0.30	0.37
14"	19"	31"x 43"	.340	0.95	0.30	0.43
16"	21"	33"x 45"	.380	0.95	0.30	0.49
18"	23"	35"x 47"	.425	0.95	0.30	0.53
20"	25"	37"x 49"	.466	0.95	0.30	0.61
22"	27"	39"x 51"	.512	0.95	0.30	0.64
24"	30"	42"x 54"	.583	0.95	0.30	0.73
26"	33"	45"x 57"	.660	1.02	0.30	0.87
28"	35"	47"x 59"	.711	1.02	0.30	0.94
30"	37"	49"x 61"	.770	1.02	0.30	1.02
32"	39"	51"x 63"	.827	1.02	0.30	1.09
34"	41"	53"x 65"	.900	1.02	0.30	1.19
36"	44"	56"x 68"	.942	1.02	0.30	1.24
38"	46"	58"x 70"	1.05	1.07	0.30	1.44
40"	48"	60"x 72"	1.11	1.07	0.30	1.52
42"	50"	62"x 74"	1.18	1.07	0.30	1.62
44"	52"	64"x 76"	1.26	1.07	0.30	1.73

12" cover assumed on all pipe.

Up to 24" Pipe, Assumed 75% Earth and 25% Rock and Loose Rock.
24" to 36" " " 70% " " 30% " " " "
36" to 44" " " 66% " " 34% " " " "

Earth figured at 0.60 per cu. yd. Other at 2.00 per cu. yd.

Table No. 11.

COST OF HAULING AND DISTRIBUTING CONCRETE PIPE.

Size of Pipe Inches	Weight Per Foot in Pounds	Weight Per Foot in Tons	Cost Per Ton Haul and Distribution	Cost Per Foot Haul and Distribution
6	30	.015	3.00	0.05
8	36	.018	3.00	0.06
10	42	.021	3.00	0.07
12	48	.024	3.00	0.09
14	87	.044	3.00	0.14
16	126	.063	3.00	0.19
18	165	.083	3.00	0.25
20	204	.102	3.00	0.31
22	243	.122	3.00	0.37
24	282	.141	3.00	0.43
26	328	.164	3.00	0.49
28	374	.187	3.00	0.57
30	421	.211	3.00	0.64
32	467	.234	3.00	0.71
34	513	.257	3.00	0.77
36	560	.280	3.00	0.84
38	583	.292	3.00	0.88
40	606	.303	3.00	0.91
42	630	.315	3.00	0.95
44	654	.327	3.00	0.99

Haul assumed as an average of 3 miles.

Cost of haul and distribution assumed as $1.00 ton mile.

Weights of pipe are averages for all heads.

Table No. 11.

Size of Pipe Inches	Weight Per Foot in Pounds	Weight Per Foot in Tons	Cost Per Ton Haul and Distribution	Cost Per Foot Haul and Distribution
6	30	.015	3.00	0.05
8	36	.018	3.00	0.06
10	42	.021	3.00	0.07
12	48	.024	3.00	0.09
14	87	.044	3.00	0.14
16	126	.063	3.00	0.19
18	165	.083	3.00	0.25
20	204	.102	3.00	0.31
22	243	.122	3.00	0.37
24	282	.141	3.00	0.43
26	328	.164	3.00	0.49
28	374	.187	3.00	0.57
30	421	.211	3.00	0.64
32	467	.234	3.00	0.71
34	513	.257	3.00	0.77
36	560	.280	3.00	0.84
38	583	.292	3.00	0.88
40	606	.303	3.00	0.91
42	630	.315	3.00	0.95
44	654	.327	3.00	0.99

Haul assumed as an average of 3 miles.

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Table No. 11.

Size of Pipe Inches	Weight Per Foot in Pounds	Weight Per Foot in Tons	Cost Per Ton Haul and Distribution	Cost Per Foot Haul and Distribution
6	30	.015	3.00	0.05
8	36	.018	3.00	0.06
10	42	.021	3.00	0.07
12	48	.024	3.00	0.09
14	87	.044	3.00	0.14
16	126	.063	3.00	0.19
18	165	.083	3.00	0.25
20	204	.102	3.00	0.31
22	243	.122	3.00	0.37
24	282	.141	3.00	0.43
26	328	.164	3.00	0.49
28	374	.187	3.00	0.57
30	421	.211	3.00	0.64
32	467	.234	3.00	0.71
34	513	.257	3.00	0.77
36	560	.280	3.00	0.84
38	583	.292	3.00	0.88
40	606	.303	3.00	0.91
42	630	.315	3.00	0.95
44	654	.327	3.00	0.99

Haul assumed as an average of 3 miles.

Cost of haul and distribution assumed as $1.00 ton mile.

Weights of pipe are averages for all heads.

Table No. 12.

TOTAL COST OF CONCRETE PIPE IN PLACE.

Size	Cost Per Foot At Yard	Haul and Distribution	Trench and Backfill	Laying	Head	Total
6"	0.30	0.05	0.24	0.05	10	0.64
6"	0.70	0.05	0.24	0.05	150	1.04
12"	0.50	0.09	0.37	0.07	10	1.03
12"	1.23	0.09	0.37	0.07	150	1.76
24"	1.68	0.43	0.73	0.24	10	3.08
24"	3.84	0.43	0.73	0.24	150	5.24
36"	3.23	0.84	1.24	0.42	10	5.73
36"	7.55	0.84	1.24	0.42	120	10.05
42"	3.70	0.95	1.62	0.50	10	6.77
42"	7.48	0.95	1.62	0.50	100	10.55
44"	3.85	0.99	1.73	0.50	10	6.97
44"	7.90	0.99	1.73	0.50	100	11.02

Ed Fletcher Papers

1870-1955

MSS.81

Box: 38 Folder: 5

Business Records - Reports - Huber, W.L - "Engineer's Report upon Proposed San Luis Rey Irrigation District"