P L A N S and E S T I M A T E S

For Obtaining a Water Supply

for the

LA MESA, LEMONGROVE AND SPRING VALLEY

IRRIGATION DISTRICT

by

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Jan. 1914.

LIST OF DRAWINGS

LIST OF TABLES.

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January 5th, 1921.

To the Directors of the
La Mesa, Lemongrove and Spring Valley
Irrigation District.

Gentlemen:-

I have been requested by you to present an estimate of the available water supply and cost of obatining water from the San Diego river at or near the old Mission dam for your irrigation District. This report is made accordingly.

DRAINAGE BASIN

For the purpose of estimating the water crop, the tributary drainage area is divided into four parts:

Above the diverting dam of the flume	104 sq. mi.
Between this diverting dam and the river gauging station at Lakeside	104 " "
Foothills below the Lakeside gauge	135 " "
Flat Cajon Valley lands	33 " "
Total - - - -	376 " "

The character of these sections of the basin varies, not only physically, but also in rainfall and run-off. The portion above the diverting dam being the highest and most rugged, has the greatest precipitation and water crop, estimated below at 156 acre feet per square mile. An acre foot is an amount of water that will cover one acre one foot deep, or 325,850 gallons. This supply is affected by the Cuyamaca flume diversions. Below the diversion dam and above the Lakeside river gauge, the basin is mountainous, but with markedly less elevation.

The river gauge is located above the mouth of the San Vicente Creek. This 104 sq. miles has an estimated run-off of 76 acre feet per square mile. The foothill area includes San Vicente Creek, and the remaining low hills surrounding Cajon Valley, with a low rainfall and with an estimated yield of but 39 acre feet per square mile. The flat floor of the Cajon Valley, while receiving a precipitation of from 10 to 12 inches annually, contributes little to the river, and is disregarded in the estimates of water supply.

The elevations of the entire basin vary from 6515 feet on Cuyamaca Peak to 350 feet in Cajon Valley.

RAINFALL

From previous studies I have found that broadly speaking the amount of seasonal precipitation increases at the rate of 0.6 inch per 100 feet rise in elevation above sea on the ocean side of the slope in San Diego County, as compared to a base station at sea level. From this it might be observed that elevation has great influence on the supply of water available from any given locality. A 64 year mean rainfall has been measured at San Diego of 9.62 inches near sea level, and at Julien, 4500 feet above sea level, a 26 year mean shows 27.68 inches. These long established stations are typical of the wide range in precipitation in this drainage basin. While the character of the storm, whether gentle showers or violent rains, greatly affects the stream flows, making it difficult to compare from the rainfall records, one year's water crop with another, yet generally there is little stream flow resulting from rain until the annual precipitation exceeds ten inches, and thereafter the ratio rapidly increases; hence, in greater part we find the largest yield from high elevations.

In regions of scant rain, such as San Diego County, when there are years of low rainfall the relative, effect on the streams is much greater than in other localities of copious precipitation. The effect on the streams of San Diego County for the seven dry years from 1897-8 to 1903-4 is well known to you all. During this time the rain at San Diego averaged 7 inches per season, or 73.5% of the mean.

This old record shows that during the eight years from 1855-6 to 1863-4 the seasonal average was 7.29 inches or 76% of the mean, and the eight year period from 1869-70 to 1876-7 was 7.6 inches, or 80% of the mean. The period 1897-8 to 1903-4 was the dryest in the 64 years of observation, yet the record clearly shows that other dry groups of years are to be expected, say at intervals of ten to fifteen years.

STREAM GAUGINGS

You are fortunate in having an unusual amount of data available, of stream flow, and this is a more certain guide than the deductions to be made from the rainfall observations, in determining the amount of water available for storage. On the San Diego river a record has been maintained at the Diversion Dam, as shown in the reports to the State Railroad Commission, from 1898-9 to 1911-12 inclusive. This is given in Table #2. At Lakeside the Geological Survey has maintained a valuable record from January 1906, the results of which are available to and including the season of 1911-12. These measurements are all shown in Table #1. A short record has been kept at the Mission Dam by the Cuyamaca Flume Co., which is reported to the Geological Survey. It shows 2894 acre feet in May and June, 1912, and 1920 acre feet for the season 1912-13, the year being divided July 1st. The run-off from the 12 square miles tributary to the Cuyamaca reservoir has been observed by the Flume Company since 1893-4. This is a small, high basin of unusually large precipitation, and is apt to be misleading if a direct comparison is made with other basins on the basis of area alone, as it yields 354.5 acre feet per square mile on an average year. If, however, the ratios of each year of observation to the average is determined, and this ratio is used in conjunction with other old stream records of this locality for purposes of extending back the estimated flows on the station of shorter record on the San Diego river it becomes good evidence of our available water crop. This is explained further below, and the analysis is given in Table II.

The Sweetwater river has been measured at the reservoir without interruption since the season 1887-8, and is of great value. The record is given in Table I, together with the percentage ratio to the mean. This record is in marked contrast to that at the Cuyamaca reservoir. Its basin adjoins that of the San Diego river, has 186 square miles in area, and its lower reaches have light rainfall and long sandy channels much resembling the conditions on the lower San Diego river. The 26 year mean on the Sweetwater shows a discharge of 61.9 acre feet per square mile of basin. The manner of comparing the discharge at the Diversion Dam with these two records is shown in Table II.

The Cuyamaca flume diverts water, as it is available, from the San Diego river at the Diversion Dam. Of the 104 square miles above this point the Cuyamaca reservoir regulates the run-off from 12, and delivers it to the flume. The amounts so diverted have been measured since 1898 (see Table II). The amounts that probably would have been diverted are estimated from a diagram for prior years in the table, and the net amount (waste) that would not have been, or were not diverted, and which were available for the lower valley, are shown in the last colume of Table II.

RUN-OFF OF SAN DIEGO RIVER AT THE DIVERSION DAM.

For the period 1898-9 to 1911-12 inclusive, during which records of flows were kept at the Diversion Dam, there was a mean flow, including the flume diversions, of 14,116 acre feet from the 104 square miles, or 135.7 acre feet per square mile. As compared to the Sweetwater and Cuyamaca reservoir records, as given in Table II, this was an 87% group of years in yield of water crop. Expanded to a 100% basis, this yield for an average year would have been 16,225 acre feet. From the yearly percentage of yield at Sweetwater and Cuyamaca, an estimate is deducted of the yield each year from the time the older records began, as shown in Table II. These quantities are used in Table V to obtain the aggregates for the proposed Mission reservoir.

RUN-OFF OF SAN DIEGO RIVER AT LAKESIDE.

The stream records were begun at Lakeside in 1905-6, and are available to 1911-12. During this period the total mean annual flow at this point was 33,177 acre feet from 208 square miles, including flume diversions, or 160 acre feet per square mile. The Sweetwater records for this period were 129% of the mean, which indicates 25,720 acre feet, or 124 acre feet per square mile for a 100% year at Lakeside. In a similar manner the Cuyamaca record indicates this period of Lakeside observation was 147% of the mean, and by deduction, we have on this basis 22,570 acre feet, or 109 acre feet per square mile for the Lakeside station. From the two independent computations we find that

Based on Sweetwater	25,720 a.f.	or	124 a.f.	per	sq.	mi.
" " Cuyamaca	22,570 "	"	109 "	"	"	"
Averaging the two	24,145 "	"	116.5	"	"	"

There has previously been estimated that the run-off for an average year above the Diversion Dam was 16,225 acre feet, and by subtraction it is determined that there enters below the flume, and above the Lakeside gauge 7920 acre feet from the 104 square miles, or 76 acre feet per square mile.

With the Sweetwater and Cuyamaca annual percentages, and this estimated mean yield of 7920 acre feet, Table III is constructed, and its results transferred to Table V, column 3.

As a rough check on the above computations, an estimate based on rainfall is here made. The precipitation above Lakeside varies from 12.5 inches annual, at the river gauge, to 30 inches along the crest, or a mean of 21 inches for the basin. According to my previous studies, as given in California Hydrography, this indicates a run-off of 120 acre feet per square mile, which is in fair harmony with the previous computation of 116.5.

FOOT-HILL RUN-OFF

The rainfall in the basin of San Vicente Creek, and on similar neighboring foothills varies from 12.5 inches to 16.5 inches annually, or a mean of 14.5 inches. From the run-off curve in California Hydrography this indicates a discharge of 40 acre feet per square mile. From personal observation of the ground, and based upon judgment, it is estimated that it should be about one-third of the rate of the basin above Lakeside per square mile, or 39 acre feet. This applied to the 135 square miles in question, gives 5265 acre feet for an average year. As this portion of the basin more nearly resembles that of the Sweetwater than of the Cuyamaca basin above that reservoir, the Sweetwater annual percentages only are used in expanding the mean as given in Table IV, and transferred to column 4 in Table V.

We therefore, have as a conclusion for the total annual yield above the Mission Dam inclusive of flume diversions, and for the present disregarding evaporation and pumping losses for average years

From above Lakeside	24,145	acre feet
From Lower foothills	5,265	" "
Total	29,410	" "

IRRIGATION IN CAJON VALLEY

According to evidence presented to the State Railroad Commission concerning the San Diego river, which evidence was collected by Mr. Alverson, there was being irrigated by pumping in 1912 between the Mission Dam and El Monte, water for the following areas.

Monte Valley	70	acres
Lakeside Valley	708	"
Cajon Valley	255	"
San Vicente Valley	207	"
Las Cochas	115	"
Total area	1,355	"

The amount of water actually pumped on to the above land according to estimates by Mr. Charles Lee, made to the Railroad Commission for the year 1912, was 5138 acre feet, on 1033 acres in Monte, Lakeside and Cajon Valleys. Making additions for an estimated amount pumped in the San Vicente and Las Cochas Valley, we would have a total amount of water pumped of 5850 acre feet, or a depth of 4.35 feet on each acre of land irrigated. This is an excessive amount of water, greater than can be consumed by the plants, even alfalfa. With the porous soils which predominate along the river bottoms, the excess water that is pumped probably returns again quickly to the underground supply. The total area of irrigable lands along the bottoms of the river above the Mission Dam, including San Vicente and Las Cochas creeks, is estimated in round numbers to be 5,000 acres. If your Irrigation District purchases the necessary lands for the Mission reservoir, this irrigable area would be reduced by 1,000 acres, leaving a net area above your reservoir of 4,000 acres, which ultimately may be supplied by pumping. The rights of these lands to a supply after you have built a dam is largely a legal question, and it is not presumed here to express an opinion on this subject, but for the purpose of this estimate in determining the water supply for the future, it is as-

sumed that 4,000 acres will be irrigated to a depth of approximately 3 feet each year, the staple crop being largely alfalfa. Of this amount one-half is assumed to be lost by evaporation, either from the soil or from the plants, which would indicate an average annual loss of water in the Cajon Valley ultimately of 6,000 acre feet per annum. This water is considered as first being withdrawn from the valley before any will be available for storage in the Mission reservoir, and this deduction is made in column 6 of Table V. and the general results shown in Table VI.

It is possible that after the new railroad to Imperial Valley is completed that this district will not be able to compete in growing alfalfa with the Imperial Valley, but if vegetables are substituted for forage plants, approximately an equal amount of water will be consumed.

Below the proposed Mission Dam, in what is called Mission Valley, there is an area of 3,460 acres in which some pumping is now going on for the growing of alfalfa. It is recommended that these areas be determined, and that estimates be made on the amount of water now being consumed here. Whether water will have to be supplied from your reservoir for the benefit of this Mission Valley land, is a legal question which I do not presume to answer, but it is of importance that you should obtain a competent opinion on this subject.

Of the 3,460 acres in the Mission Valley, probably 3,000 acres may be classed as possible farm lands, and the remainder river channel. In the growth of alfalfa the duty of water may be fairly taken as 3.0 acre ft. per annum, of which one-half is lost by evaporation and plant growth and the remaining half or 1.5 acre ft. returns to the water plane. If this 3,000 acres is all considered as ultimately to be irrigated with an annual loss of 1.5 ft. in depth, this would require 4,500 acre ft. of water per annum.

During the last 26 years, according to the estimate given in Table VI, there would have been wasted past the Mission Dam, occuring in wet years, an average of 9,078 acre feet, or more than enough to supply the Mission Valley. During the dry period beginning with 1895-6 it is estimated that there would have been 10 years when there would have been no waste passing your reservoir, if it were built to 34,000 acre ft. capacity.

On this assumption it would have been necessary for the irrigators in Mission Valley to have lowered their water levels by pumping about 50 ft. before the recharging of the gravels by wet years again began. However, there are 56.4 sq. miles of drainage area tributary to the river below the proposed dam, which it is estimated would have contributed to the Mission Valley about 1,000 acre ft. on average years. Any amount of water that you would have liberated for the Mission Valley, would have directly effected the supply available for your district, during 17 out of the 26 years covered by the hydrographic study given in this report, on the theory of the full development of the river. If it is necessary to supply Mission Valley with 4,500 acre ft. annually from the proposed Cajon reservoir, in addition to the pumping diversions estimated for Cajon Valley, then the supply remaining would not have been adequate for your district on the assumptions used in this report.

Probably this could be remedied by the construction of a higher dam, or by some rational agreement with the land owners in Cajon Valley, if your legal advisor deems it best.

In table VI, column 7, is given an estimate of the amount of water which will pass the Mission reservoir if it is built for a 34,000 acre foot capacity. The figures that are shown with the minus sign indicate the deficiency in the annual water crop.

EVAPORATION

Evaporation records have been kept on the Sweetwater reservoir, which has much the same elevation and exposure as the proposed Mission reservoir. There are available eight complete years of record, between the season 1889-90 and 1898-99 inclusive. For the period the average evaporation loss was 56.04 inches per annum. The record was obtained by noting the evaporation from a pan floating in the water up to May, 1893. There are four complete years in which this pan record was kept, which show an evaporation loss of 58.95 inches per annum. Subsequent to this pan record observations were kept with a Piche evaporating device, which is not considered as reliable as the pan.

4.8 feet, or 57.6 inches per annum is considered a reasonable evaporation loss to assume for your proposed new reservoir, and this amount has been deducted in the 6th column of Table VI. The 4.8 feet is loss from the surface area of the reservoir, and represents a large amount of water, especially if the water is held over in the surface reservoir for two or more years. These evaporation losses from surface reservoirs in San Diego County often amount to from 30 to 40% of the total water crop.

In estimating the evaporation loss, the average stage of the water in the reservoir for the season in question is estimated upon and the depth of 4.8 feet applied thereto. As long as any surface water occurs in your reservoir, this evaporation loss will have to be deducted before your supply is delivered.

UNDERGROUND RESERVOIR.

Extending from Monte to the Mission dam the San Diego river has broad, shallow channels of absorbant, sandy materials, into which the water will percolate rapidly. When a substantial flood occurs and a stream flow is established throughout the length of this valley, there will be a percolation by a vertical movement of the water from the surface stream to the underground water plane. When this plane is reached, a slow, lateral movement will be established toward the exterior portion of the underground reservoir. A small flood probably will be absorbed altogether before it reaches the Mission dam, and a large flood may pass in greater parts without completely saturating this underground reservoir. It is impossible to estimate absolutely the amount of, and manner in which these floods will enter into these gravels, but for the purpose of this estimate it is assumed that the underground reservoir must be full before the surface reservoir begins to fill. As far as the lower part of the Cajon Valley below Riverview is concerned, it would be impossible to impound surface water until all of the underground gravels were filled. A number of estimates have been made of the extent of this underground reservoir. Mr. Culbertson, I believe, has placed it at 45,000 acre feet; Mr. Lee at 50,000 acre feet, and I have previously estimated it as a total of 50,000 acre feet for the entire valley above the Mission dam. The capacity of the underground reservoir is considered in this report to be 31,100 acre feet

above Riverview and 13,900 acre feet between Riverview and the Mission dam available for your district below elevation 337.5 ft. Table VII is a study of the supply available from these two underground districts. The well records in the lower valley that can be obtained are very few and unsatisfactory and these conclusions may have to be modified. The area of the gravels which may be pumped below Riverview is about 1,225 acres, of which about 760 acres are in the reservoir site and 465 acres above it and below Riverview. The sands and gravels are estimated as aggregating 50 ft. in thickness. While this figure may be possibly too large, the area is conservatively taken. It must be remembered that the underflow down the valley towards the dam, while small, will be of some assistance to the district. When the dam is built, all flood waters will be stopped and held over the reservoir gravels, which must be filled before surface storage occurs, especially in years of low flow. Again, when the hydrographic tables were prepared they were based mostly on the records of the Sweetwater river at the Sweetwater dam, below long stretches of absorbent channel, where similar losses occur to those on the San Diego river. While Table No. VII may be arbitrary, it is believed to be a fair analysis.

In the discussion of the total available water supply from the San Diego river, the stream is considered as being regulated, not only by the surface reservoir, but also by this large underground reservoir. It is my opinion that surface reservoirs in San Diego County cannot alone be relied upon to tide over such dry years as occur in your neighborhood on account of the great evaporation losses, and the long continuance of the drouth. The underground reservoir has the advantage of eliminating a large portion of the evaporation loss.

SURFACE RESERVOIRS.

The lower end of the Cajon Valley offers enormous opportunities for the impounding of surface waters. The dam site is good, and the valley is broad and with a flat grade. The height to which the dam may be built is largely a financial question. In this discussion it is assumed that it will be built sufficiently high to regulate all of the surface run-off on two-thirds of the years, which is of 34,000 acre ft. capacity. There will, however, be years of very substantial waste. For instance, in the season of 1894-5, preceding your seven years of drouth, there would have been a waste beyond this reservoir of 97,097 acre feet of water, which would have been of great service to you, or to the Mission Valley. It is not feasible commercially to build storage reservoirs to catch the last drop of flood water. A diagram giving the capacity of the reservoir is attached to this report.

DESCRIPTION OF TABLES.

The study of this available water supply is unusually complex, and no claim is made as to its absolute accuracy. The flume diversions, pumping extractions, together with the uncertainties of the annual water crop make this a problematical discussion. The matter has been given most careful and extensive consideration on my part, because I believe it to be a most essential feature of this report.

It is assumed that the behavior of the river during the last 26 years is the best index of what we may expect in

the future. Tables I, II, III and IV are self explanatory. Table V shows the amounts of water that may be obtained from the different portions of the drainage basin, and column 7 shows the net amount available for storage, either surface or underground, after irrigation uses of Cajon Valley have been deducted. When the minus figures are given it means that irrigation diversions in the Cajon Valley have encroached upon the underground supply to such an extent that there will be a deficiency therein after the annual water crop has been projected into this underground basin.

The figures with a plus sign show the surplus available for storage. Table VI, column 2, indicates the condition of the reservoir in the Fall, after the previous season's use. Where the minus sign is given it means that the surface reservoir has been depleted, and the underground reservoir drawn upon to the extent indicated by the figures, 45,000 acre feet being the limit to which withdrawals from the underground reservoir can be made. Column 3 indicates the net winter inflow, as taken from column 7, Table V, and column 4 shows the supply in the reservoir in the Spring at the beginning of the irrigation season, the minus figures indicating the extent to which the underground reservoir has been depleted. Column 5 indicates the amount of water which may be withdrawn by the Irrigation District from the surface reservoir, and column 6 that to be obtained from the gravels. It is assumed that when water is available in the surface reservoir, 12,000 acre feet will be extracted, but when underground water is to be drawn upon you will reduce your supply to a one-half normal, or 6,000 acre feet. Where the use is indicated as less than 6,000 acre feet, it shows that the full 6,000 is not available, and indicates by the figures the amount that is available. From this column it will be noted that during 18 out of 26 years, or say 2/3 of the time, the full supply would have been available, and that the 1/2 supply during years when they were pumping from the gravels, would have been available in all but five years, there being one season, 1903-4, when no water would have been available for your District, either from the surface or underground reservoir.

Column 8 indicates the waste past the Mission dam if built to a 34,000 acre foot capacity, except that the minus figures indicate the extent to which the annual water crop is unable to meet the demands of the underground reservoir.

DUTY OF WATER.

The gross area of the Irrigation District, as determined from subdivision maps, is 14,794. acres. A considerable portion of this area is not irrigable land, and will not require a normal amount of water. A number of prominent irrigators were interviewed relative to the amount of water required in your District, and there seemed to be quite an agreement to the effect that if a supply of one inch for ten acres on a broad average for the District is available, there will be a satisfactory service. During the four winter months, in ordinary years, little water is required, except for domestic uses. This is equivalent to

a depth of one foot on your irrigated land, and it is assumed in this study that there will not be over 12,000 acres of land which will require water in any one season. A great deal of the soil in your District is of such character that large amounts of water cannot be put upon it with safety.

It is realized by the writer that a more abundant supply of water would be desirable if it were available, but the situation in San Diego County is governed by the amount of water which may be depended upon, rather than the amount which may be an ideal quantity. Deficiencies in the supply can be largely mitigated by a most economical distribution of the water and cultivation of the land.

We have here an area blessed with the most delightful climatic conditions in the United States, if not in the world; highly prized for fine residential use, in the immediate proximity of a large city, that has been built up to a very high state of development in many portions of your District, there being 1,200 acres now under irrigation, and with a water supply at present which is inadequate. The situation positively demands more water, and the effort is to make the best possible solution of a difficulty. With a full comprehension of what the available supply actually is, it is a matter for the voter of your District to decide whether they wish to proceed in the matter. In my judgment, all the water possible, which is now being wasted into the Pacific Ocean, should be saved, and while the cost will be high, the necessities of the case demand the outlay.

SUPPLEMENTAL REPORT.

It is respectfully recommended that your resident engineer collect all possible data with reference to the logs of wells in the Cajon Valley, together with their output, and that the character and extent of the area from which you can pump underground water within your reservoir site, be defined by boring with hand augers. At present the record of stream flow at the Mission dam is being maintained by the Cuyamaca Water Co., and reported upon to the Geological Survey. This record is of the greatest importance to your District, and you should co-operate in this work in such a manner as to be certain, not only of its continuance, but of the availability of the records for your use.

QUALITY OF WATER.

Table VIII shows a large number of analyses of water that we made from wells along the San Diego river for the San Diego Chamber of Commerce. It will be noted that the quality of the water in the flume is of a high order. Starting in the Monte Valley the well water is good, containing about 2½ times as much mineral salt as is found in your flume water, or 24.5 grains per gallon. The water gradually becomes less satisfactory as you proceed toward the sea. A well at the Scripps ranch, on the north side of the river, shows 45.4 grains per gallon, which is within the limits of reasonable quality. The analysis from the lagoon on the Scripps ranch is probably misleading, as it was surface water in which the alkali had been somewhat concentrated. In the Mission Valley the quality of the water is not so good. One or two of the wells shows a surprisingly low salt contents, and others a surprisingly

high salt contents.

The flood waters that are impounded in the reservoir will be of better quality than the well waters, the large floods probably being the purer. I believe the flood waters will be entirely satisfactory for irrigating and domestic uses, and that the well water from the Scripps ranch will not be found seriously objectionable.

THE DAM.

Two dam sites have been considered. The first is situated about 600 ft. below the Old Mission dam at the lower end of Cajon Valley. At this point the elevation of the stream bed is 260 ft. above sea or 16 ft. higher than the lower site. The bed rock is considered as stripped to elevation 255. The bed of the stream at this point is 350 ft. wide and the length of the dam on top would be nearly 700 ft. The flow line of the reservoir is considered as 337.5 and the height of dam above the flow line is planned to be 10 ft. so that the maximum height of this dam would be 92.5 ft. Because of the width of the canyon, this site is not suitable to an arch type of dam and therefore a gravity dam has been estimated upon. That is a dam which relies on its weight alone for its stability. The total yardage of concrete in the dam would be 51,200, or about 8,000 cubic yards more than would be required in a dam at the lower site for a slightly greater reservoir capacity. The abutments are not so good at the upper dam site as at the lower one. For these reasons the lower dam site is estimated upon in this report.

At the lower dam site bed rock shows in the bed of the stream for a large portion of its 260 ft. of width. In making the estimate the canyon bed is considered as stripped to a level 5 ft. below the lowest bed rock visible. A trench excavation across the canyon has been made in part, which as far as developed shows the bed rock to be within these limits, Just below the dam site the grade of the stream drops over some small falls, 10 ft., which confirms what may be noted on the ground, to-wit, that there is a ledge of very hard igneous rock which traverses the canyon at this point. Test pits have been sunk on the two sides of the canyon at the line of the abutments which indicate that rock may be obtained within 10 ft. of the surface, which is the limit used in this estimate. No diamond borings have been made. Due to the existence of very large boulders in the canyon, they would be apt to be misleading in their evidence. The only certain method of determining the bed rock is to trench across the canyon and this work is now progressing. After the abutments are stripped and a careful inspection of them is made, it may be necessary to increase the cross-section of the dam if the rock is not perfectly sound.

The canyon at this lower dam site has a width at its base of 270 ft. and at the top of the dam (elev. 347.5) of 575 ft. The bed rock exposed in the bed of the canyon is an exceedingly hard massive crystaline rock with numerous fractures showing in sides of the canyon where it has been exposed to the weather and not eroded. Concrete made of this material would sustain unusually heavy loads. The maximum height of this dam above the exposed bed rock would be 103.5 ft. which would allow a crest elevation of 10 ft. above the flow line

of the full reservoir thus furnishing an entry head for the spillways which have been projected around the ends of the dam. The material from the spillways may be used for the building of the dam. They may be made of sufficient capacity to avoid over-topping of the dam with floods.

This dam would be of the arch type, as distinct from a gravity dam. Its load will be conveyed to the abutments in the form of pressure as is the case of the Sweetwater and the upper Otay. The radius of the dam would be 350 ft. and the pressure on the abutments 20 tons per sq. ft. A special committee of the American Society of Civil Engineers reporting on the strength of concretes finds that with mixtures of 1-3-6, with aggregates composed of granite or trap rock, the ultimate safe strength is 100 tons per sq. ft. and that a factor of safety of 3.07 should be allowed giving a safe bearing load of 32.5 tons per sq. ft. (Proceedings Feby. 1913 pg. 155) Among the notable concrete dams with thin sections and high loads on their abutments are the following:-

Bear Valley, Calif.	- Granite Concrete	53.5	tons	per	sq. ft.
Pathfinder U. S. R. S.	" "	16.0	"	"	"
Shoshone U. S. R. S.(326 ft. high	"	17.0	"	"	"
Barren Jack Australia	"	19.0	"	"	"
Crags, Calif.	trap "	16.0	"	"	"
Cajon San Diego Proposed	Granite "	20.0	"	"	"

The accepted specifications for the crushing strength of concrete made of a mixture of 1 cement to 6 of aggregates, at the end of 28 days, is 144 tons per sq. ft.

The load in compression on the arches of the Oceanside Concrete arch bridge is equivalent to over 40 tons per sq. ft. of concrete.

As the volume of concrete in an arch type of dam is directly proportional to the allowable pressure per sq. ft. on the abutments, this is an important feature to determine in designing this type of dam. No arched type of concrete dam has ever failed. If sound rock is found in the abutments the load of 20 tons is believed to be safe.

THE RESERVOIR.

The reservoir as here planned will extend from elevation 244 at the dam to 337.5 in Cajon Valley and have a capacity of 34,000 acre feet. This will cover an area of 1675 acres. Little capacity (2000 a.f.) is gained until a depth of 47 ft. is reached. The upper 13.5 ft. contains one half the capacity. Increasing the height of the dam 5.0 ft. would add about 8000 acre ft. to its capacity. The upper portions of the reservoir would be broad and shallow causing large evaporation which has been allowed for in the hydrographic studies. The upper portion of the reservoir has a sandy bed which would absorb water and from which it is proposed to pump water when the surface reservoir is dry as described above. While there may be small leakage through the seams in the rock around the abutments of the dam there will be none through the mountain range from the Cajon Valley, as has been suggested.

The writer does not hold himself qualified to furnish the best evidence concerning the value of lands for rights of way either for the reservoir or pipe lines. The board of directors of the district are qualified and have furnished this portion of the estimate.

MAIN PUMPING STATION.

The pumping system requisite is complex. During 18 out of the 26 years given in the hydrographic study (Table VI) water will be taken from the main reservoir at an elevation of 245 ft. and delivered through a pipe to the main pump 4300 ft. down the canyon at an elevation of 240 ft. When the reservoir is just empty there will be no pressure on the intake of the pump but on two-thirds of the time this pressure will be over 50 ft. and when the reservoir is full it will be 92.5 ft. To this extent the lift will be balanced. The flow line of the main distribution reservoir will be at elevation 580 ft. and the lift will therefore be 340 ft. plus an estimated friction loss in the force main of 22 ft. making a total lift of 362'except as noted above. There are 3000 acres (about 20 per cent.) of the district that will be above this low level service and below a proposed high level service that will start at Elev. 700 ft. It is also desired to supply the town of La Mesa (Elev. 539) from the high level service so as to furnish a domestic pressure. To meet these requirements a small high level reservoir of 2,000,000 gallon capacity at elevation 700 is provided at the upper end of the force mains near the larger 30,000,000 gallon (92 acre ft.) reservoir of 580 ft. elevation. This estimate provides for 2-18 inch force mains 10,300 ft. in length each, with a capacity of 250 miner's inches (5 second ft.) each, extending from the main pumps to the distribution reservoirs, By an arrangement of valves either pipe may be discharged into either reservoir. There is proposed two high duty steam crank and fly wheel piston pumps of the Corliss type, each with a capacity of 250 miner's inches with water tube boilers. One of these pumps will pump to the low level reservoir all the time except on an emergency when it may be made to lift to the high level. An efficiency of over 90 percent. may be otbained. The second pump will operate two-fifths of its time to the high service and three-fifths to the low service. In this manner a higher efficiency and lower costs may be obtained than by constructing a small plant at the 580 ft. reservoir and pumping to the 700 ft. reservoir, and the machinery and attendance will be under one roof.

The plant should be installed in such a manner that it may be consistently increased to its full capacity of 1000 miner's inches. The estimated cost of the steam plant is $63,000. Without the building for a 500 mi. in. capacity. For one-half of this capacity the cost would be about $40,000.

The greatest efficiency and reliability may be obtained at this main pumping station with a high duty steam plant. It will call for an installation involving approximately 550 H.P. with oil at $1.00 per barrel, the total cost per Kilowatt hour for <u>continuous operation</u>, including all charges, would be 1.0¢. With an operation of ten hours per day it would amount to 1.4¢ per Kilowatt hour. This is assuming a steady load. The load in the winter time would probably not be over one-half of the summer load, and the average cost of operation would be somewhere between 1.4 and 1.0¢ per Kil. hour, or say 1.2¢ per Kilowatt hour.

If these figures are compared with commercial prices for electrical energy, then allowance must be made for lower efficiencies in the pumps and motors and also for fixed charges thereon.

The Fairbanks Morse Company have been exceedingly kind in giving estimates on the cost of furnishing power with their Internal Combustion Oil Burning Engines. These engines are of a very satisfactory type in units up to, say 100 H.P. They have some plants established in California of 200 H.P. capacity but in these high powered units, I do not know that their reliability has been sufficiently established to base a water service upon for towns and highly developed communities. Considering all charges for operation, interest and depreciation, they estimate that it will cost 2.3¢ per thousand gallons to pump 500 inches, or 45,000 gallons to a total elevation of 385 ft. This is on a basis of continuous operation with a full load and the figures would have to be materially modified when the plant is operating on less than full duty, as indicated for the steam plant above. This plant would be direct connected with 15" x 18" 175 lb. pressure Duplex center packed plunger pumps of the Fairbanks-Morse type. The plant would be in two units and the total cost erected, excluding the building, would be $61,226., which is almost as great as a steam plant.

I have recently been interested in purchasing a pumping plant for a Mutual Water Company, in which I am one of the holders, and we have bought this type of equipment, but as stated above, I would hesitate to install such large units here. While the gas engine has greatly improved during the last few years and is now a strong competitor of steam, its reliability for continued service through a long term of years in such high units is yet to be thoroughly established. Copies of the estimates of the Fairbanks-Morse Company which are conservatively made are enclosed.

From the figures quoted on electric power to Director Grable, the use of electric energy furnished commercially for the main pumping plant in the canyon is not recommended.

WELLS IN CAJON VALLEY.

This estimate is based on the development and delivery from wells of 500 miner's inches of water to the District, but the units can be installed in such a manner as to deliver but one-half of this amount, if desired. The full amount of water to be used in the District is to be ultimately 1,000 inches, but when the surface reservoir is exhausted and pumping from wells is resorted to, then the supply is considered as reduced one-half so that it may be continued through a longer drouth period.

It is desirable to sink 10 wells in the upper portion of the reservoir site in the most porous soils, these wells to be 16 inches in diameter with a total depth of 100 feet. The level of the water in these wells will range from zero to 60 ft. If the dam is built and the reservoir flooded, the gravels will be completely saturated so that when the reservoir is empty and the pumping is begun the water will be standing at the surface. The total depth to which the water will fall is indefinite but in this report this is considered as being 60 ft. when the underground gravels are exhausted. There should be an underflow into your underground reservoir from the upper valleys of possibly 100 miner's inches,under normal conditions, but at the end of a cycle of dry years when pumping has been going on extensively

above you during that period, this underflow will be reduced and in the hydrographic study it is not considered. These wells will have to be so constructed and operated that when the reservoir is flooded the well and the equipment will not suffer injury. This may be accomplished in either of two ways. First, the plant may be operated by compressed air which is delivered from a plant located outside of the flow line of the reservoir. This has been considered in two ways. First, the establishment of air compressors at the main pumping station in the canyon and the piping of the air a distance of some five miles to the wells. When 500 inches are being pumped, at a total extreme lift of 60 ft., the volume of air required will be so great that the friction losses will overbalance the merit of operating the compressors at a central station, or the main air line will be so large as to be excessively expensive.

An estimate has also been prepared of the cost of installing a Fairbanks-Morse Oil Burning Engine at Santee which will operate compressors and deliver water from the wells. The estimates of the Fairbanks-Morse people on the cost of accomplishing this are transmitted with the report. The estimated cost, based on a 500 inch output of 60 ft. for the maximum head is $60,000., including the piping to the wells, but not the cost of the wells or the compressor house. It will involve purchasing 2-200 H.P. engines and 2-22 by 14 by 18" Sullivan Duplex two stage air compressors with complete fittings. The difficulty with the air compressing type of well pump is the very low efficiency that is obtained. If the plant is in good running order for these low heads, this would not amount to over 25%.

Another method of pumping from these wells is by means of centrifugal pumps of the Layne & Bowler type, which practically amounts to a centrifugal pump sunk in the casing of the 16 inch wells and operated from an electric motor placed on top of the ground. If this device is used, the motor would have to be so attached to the pump that it could be removed when the reservoir starts to fill. This can be accomplished so that the motors need not suffer injury from flooding and the wells can be capped so as to prevent their silting up. The advantage of this type of pump over the air compressor is that an efficiency of 40% should be obtained instead of 25 for air lifts, thus calling for less power.

Estimates have been made of the cost of generating this power at the main pumping plant where high duty boilers would be available. The only costs for operating this service would be for supplies and fixed charges. It must be constantly kept in mind that the cost of running these plants is largely dependent on the continuity of the service. In our case the water load will vary with the different months of the year, as well as between wet and dry seasons.

With 150 H.P. continuous service of condensing engines and water tube boilers, steady load, with oil at $1. we could expect to deliver power by steam at our main station for about 1.0¢ per kilowatt hour, and with a 50% service factor, this would be 1.3¢. It would be necessary on this plan to build

seven miles of power line which would cost in the neighborhood of $8,000., and there would be losses in transmission and transforming that have been provided for in the above rates.

A quotation on the cost of power delivered by the San Diego Gas & Electric Company at Santee was given to Mr. Grable at 1½¢. This is understood to be per kilowatt hour, with a minimum charge per annum of $4,000. If this power is purchased it will obviate the necessity of immediately installing the generator or compressing machinery.

If arrangements are made for entering into contracts, say on the 1st of April for the following twelve months, the reservoir condition for the following summer will be known, and if it is unnecessary to do any pumping for that season, the lines may be disconnected and the minimum charge avoided. This is largely a business matter which your directors should be able to arrange in a satisfactory manner with the power company.

On the basis of high duty steam pumping engines, with water tube boilers, and on the assumption that electrical energy will be generated at the main pumping station and transmitted to electrically operated pumps at the Santee wells, the cost per 1000 gallons of water delivered to the distribution reservoirs will be 2.6¢. This assumes a 100 per cent. load factor and 500 miner's inches of output. It allows for all operating expenses, interest and depreciation, the fixed charges being about one-half of this expense. When there is fifty feet of water in the reservoir which will occur over two-thirds of the time, the cost of delivering water to the distributing reservoirs will be about 2½¢ per thousand gallons for operation and fixed charges on the pumping plant based on the same load factor and output as above. These estimates do not include interest charges on the dam in Cajon Gorge or on the cost of the reservoir lands.

The consideration of this entire pumping system, is so vital to the prosperity of your district that it should be given a great deal of thought. Every dealer in equipment is particularly keen and effective in making arguments in favor of his own class of goods, and while their statements are made in good faith, there are so many modifying conditions, such as reliability of service, variability of cost with intermittent loads, etc., that it is difficult to reach a final conclusion in a short study, such as necessarily has had to be given to the preparation of this report. The effort has been made to use figures that are reliable and safe, but if further investigations indicate that it would be wise to alter the judgment, this should be done without embarrassment.

DISTRIBUTION SYSTEM.

All pipe considered in the distribution system in this estimate is rivetted steel. The force mains to have a factor of 4.2 net, and to consist of 2-18" pipes ranging from 3/16 to No. 10 gauge steel. In the general distribution system the heaviest plate will be No. 9 gauge on a 24" line and the lightest considered is No. 12 gauge on the 8" laterals, which are the smallest sizes used. The distribution system is for the handling of 500 inches of water to the different portions of the district, as indicated on the map. This is on the basis of practically an inch to 30 acres. The ultimate supply of water to be furnished

is to be 1000 inches and this can be accomplished by subsequently developing the distribution system much as a municipality develops a domestic system by laying additional mains in outlying portions of the district. It is quite possible that a good deal of concrete pipe may be used in this distribution system, which is desirable on account of the shorter life of the steel pipe. The concrete pipe will be less expensive than the steel pipe. In this preliminary estimate about 10,600 ft. of covered concrete conduit of full capacity is included and also 650 feet of tunnel north of La Mesa.

The Board of Directors of the Irrigation District who are particularly familiar with the requirements and conditions of the District, have gone over the ground in the field with your consulting engineer and have defined the extent of territory to which the pipe lines shall be laid at present, the idea being that extensions shall be made as the requirements develop. The map will indicate just where the pipes are to be laid and the extent of territory to be covered. It will be noted that there are certain hill areas that are above the high level system.

The Directors state that the owners of these lands will put in their own pumping plant to raise the water to higher elevations as they see fit. There are a number of local distribution system at La Mesa, Lemongrove and Spring Valley, with which the mains will connect and which extend to additional territory.

PRESENT DEVELOPMENT.

Table No. 9 is a statement compiled by the Directors of the district, showing the present development of this area. This irrigation district is distinctly different from many that have been created in the state, in that it already has been extensively developed, there being at present 2,040 inhabitants, and the present land values have been estimated at $4,254,500. with 65,000 citrus trees and 9,000 deciduous trees. The district now has water rights to the extent of 138 miner's inches, which is used when available. The area is practically a suburb of the city of San Diego and is largely occupied by beautiful suburban homes with climatic conditions of most attractive character. Good roads, transportation and pleasant social conditions all tend to greatly enhance the attractiveness of the surroundings. Probably there is no other irrigation district that has ever been created in the state that would justify so heavy an expense per acre for obtaining an adequate water supply. The value of the lands, irrespective of the investment in the prospective work, would amply protect the bond issue, provided the water supply is reasonably secured. It is very difficult for one who has lived in the northerly portions of California to appreciate the great necessity for water and its high value in this locality. It is not a question of complying with ideal conditions of water supply, but the problem is to do the best you can with the limited water resources that are available.

Estimate of the
Cost of obtaining and distributing water for the La Mesa, Lemongrove and Spring Valley Irrigation District from the San Diego River, based upon an immediate supply of 500 miner's inches (10 s.f.) and an ultimate supply of 1000 miner's inches.

Cajon Dam for a flow line elevation of 337.5 ft., a crest elevation of 347.5 ft. and a reservoir capacity of 34,000 acre ft.

43,273	c.y. of concrete at 1 bbl. cement per c.y. and 15% of large stone at $5. per c.y.	$216,365.
10,000	c.y. of stripping at $1.00	10,000.
4,000	c.y. excavation of spillways. The stone to go into the dam as much as possible and is estimated for in the concrete at 50¢	2,000.
800	c.y. of concrete lining in spillways reinforced with steel bars at $7.00	5,600.
	Outlet of reservoir	10,000.
	Road changes 1½ miles	10,000.
	Clearing reservoir	2,500.
	Equipment for construction	50,000.
	Lumber for camps and various work	10,000.
	Total	$316,465.
	Engineering and administration 5%	15,823.
	Contingencies 15%	47,470.
	Total Construction Cost	$379,758.
	Estimate of reservoir lands made for the Board of Directors by H. Parks to Elev. 330' - $242,200. for 1220 acres, and for elev. 337.5 for 1670, a. $354,200.	354,200.
	Note no allowance made for legal expenses. If work is let by contract add 15 per cent. to construction cost.	
	Total	$733,958.

(Cost per acre ft. of storage - $21.50)

Estimated cost of Santee Wells for 500" Capacity.

10-16"	double cased wells, each 100' deep at $400.		$4,000.
7500'	Collection pipe - 12" diam. to Main at 85¢ - concrete	$6,375.	
3500'	Main 18" diam. concrete at $1.28	4,480.	
24000'	Main 24" " steel and concrete at $2.70	64,800.	75,655.
10	Deep well turbine pumps and motors erected complete at $1500.		15,000.
	Transmission line and transformers for distribution to wells		5,000.
	Total for wells and pumps		$99,655.
	On basis of electric generating plant at main pump station		
	Additional cost for 2-75 K. W. generators, 2 engines complete		8,000.
	Boiler capacity provided in main plant. 7 miles of transmission lines and transformers		8,000.
			$115,655.
	Engineering and supv. 5%		5,782.
	Contingencies 10%		11,565.
			$133,002.

Note: No charge for housing necessary power line built along highway.

Main Pumping Plant Force Mains and Summit Tunnel.

2.	High duty, cross compound, crank and fly wheel, Corliss pumping engines of 250" capacity each and	
3.	Water tube boilers and	
	All necessary fittings and connections, foundations and boiler settings, except house	$65,000.
	Pipe connections and valves	1,000.
	Pump house	6,000.
	2-18" riveted steel force mains aggregating 20,600 lin. ft.	40,000.
	1200' of tunnel at $30.	36,000.
	600' of portal cuts at $4.	2,400.
		$150,400.
	Engineering and supervision 5%	7,520.
	Contingencies 10%	15,040.
	Total construction cost	$172,960.
	Rights of way estimated by the board	1,000.
	Total cost	173,960.

Distribution System.

Low service distribution reservoir 30 m.g. capacity, earthen hydraulic fill type 24,000 c.y. at 50¢	$12,000.
Hi Service domestic reservoir - earth dam concrete lined - 7100 c.y. earth 2 mil. gal. capacity	10,340.
10,600' of covered concrete conduit of 1000 miner's inch capacity at $4.65	49,290.
650' of tunnel lined at $25.	16,250.
Distribution System: Steel pipe trenching at 5¢ per c.f. Estimates on pipe from manufacturers. On basis of distribution of 500 mi. in. Minimum size 8 inches in diam.	128,049.
Engineering & Supervision 5%	10,796.
Contingencies 7%	15,115.
Rights of way estimated by the Board	
For reservoirs	2,300.
High Level pipe line	1,020.
Low level pipe line	1,510.
Total	$246,670.

Summary.

Dam and reservoir	$733,958.
Main Pumping Plant	173,960.
Santee wells, pumps and power lines and pipe lines	133,002.
Distribution system and two distribution reservoirs	246,670.
Grand total	$1,287,590.

On the basis of the above estimate, the cost per acre for this water supply to your district would be $87.03. Lands for agriculture in Southern California, without water have little value. After deducting for taxes they will scarcely earn interest on over $50.00 per acre. With water they may be made to pay on a valuation of $500 if, as in the case of your district, they are adapted to citrus culture or winter gardening. Those lands upon which citrus groves have matured, if furnished with water, are worth from $1,000 to $2,000 per acre, and if their water supply is inadequate, these high values are seriously endangered.

For suburban residential purposes with water, these values are still higher, and the necessity of water is greater. The conclusion is, therefore, apparent that you should proceed with your efforts to conserve the waste of flood water of the San Diego river that is now going to the sea. There is no more charming locality in the state of California than the one embraced by your boundaries.

(Signed) J. B. Lippincott.
Consulting Engineer.

TABLE I

RAINFALL AND RUN-OFF DATA.

Year	Rain San Diego Inches	%	Rain Julian Inches	%	Runoff Sweetwater at Dam a.f.	%	Runoff Cuyamaca At Dam a.f.	%	Runoff San Diego Lakeside a.f.	%
87-88	9.82	102			7048	61				
88-89	11.02	115			25253	219				
89-90	15.02	156			20532	178				
90-91	10.47	109			21565	187				
91-92	8.70	90	22.25	80	6198	54				
92-3	9.26	96	25.10	91	16260	141				
93-94	4.97	52	41.30	149	1338	12	2563	60		
94-95	11.90	124	31.70	114	73412	637	11279	266		
95-96	6.21	65	12.00	43	1321	11	2152	51		
96-97	11.78	123	22.40	81	6892	60	4216	99		
97-98	4.99	52	13.50	49	4	0	834	20		
98-99	5.24	54	10.75	39	245	2	472	11		
99-1900	5.97	62	20.25	73	0	0	260	6		
00-1	10.45	109	24.75	89	828	7	3031	72		
1-2	6.17	64	24.45	88	0	0	2351	55		
2-3	11.76	122	30.75	111	0	0	2516	59		
3-4	4.40	46	15.25	55	0	0	492	12		
4-5	14.32	149	40.70	147	13760	120	6831	160		
5-6	14.68	158	45.50	164	35000	304	12780	301	73141+	
6-7	10.62	111	32.50	117	30000	261	9259	218	48880	
7-8	8.55	89	24.50	89	5787	50	3201	75	13720	
8-9	10.23	107	27.80	100	16126	140	7172	169	43200	
9-10	9.79	102	23.85	86	8775	76	5134	121	23000	
10-11	11.99	125	28.35	102	3363	29	2765	65	15500	
11-12	10.75	112	26.70	97	4463	39	3520	83	14800	
12-13	5.97	62	17.26	62	1077	9	4255	100		
Period	64 years		22 years		26 years		20 years		7 years	
Mean	9.62		27.68		11510		4254		33177	
Area					186 sq. mi.		12.0 sq. mi.		208 sq.mi	
Av. run-off per/sq. mi.					61.9		354.5		160.0	

+ Jany. to Sept. inc.

TABLE II

Estimated Run-Off Above Cuyamaca Diversion Dam,

104 sq. mi. in acre feet.

	Sweetwater	Cuyamaca	Mean	16225 a.f. x per ct estimated	Measured	Flume Diversion	Net Waste
87-8	61		61	9897		5000	4897
8-9	219		219	35533		7000	28533
9-90	178		178	28880		6800	22080
90-1	187		187	30340		6800	23540
1-2	54		54	8762		4300	4462
2-3	141		141	22872		6500	16377
3-4	12	60	36	5841		3500	2341
4-5	637	266	452	73337		7000	66337
95-6	11	51	31	5030		3200	1830
6-7	60	99	80	12980		5500	7480
7-8	0	20	10	1622		1500	121
8-9	2	11	7	1135	1218	1218	0
9-1900	0	6	3	486	665	665	0
1900-1	7	72	40	6490	4513	2584	1929
1-2	0	55	27	4381	5456	2964	2492
2-3	0	59	30	4867	9304	3854	5450
3-4	0	12	6	9730	1672	1334	338
4-5	120	160	140	22715	22081	2808	19273
5-6	304	301	302	48999	36275	6141	30134
6-7	261	218	240	38940	34313	5605	28708
7-8	50	75	62	10060	14124	6920	7204
8-9	140	169	154	24987	22592	5822	16770
9-10	76	121	99	16063	16963	5812	11151
1910-11	29	65	47	7626	12124	6228	5896
11-12	39	83	61	9897	17412	3544	13868
12-13	9	100	55	8923	9467	4800	4667

Discharge of S. D. river at flume 1898-9 to 1911-13 inc. 14116 a.f. for an 87% period, or mean 16225 a.f.
Discharge S. D. river at Lakeside 1905-6 to 1911-12 inc. 33180 a.f. for an 138% period, or 24145 a.f. mean.

TABLE III

Estimated Run Off Between Diversion Dam and G. S. Gaging Station. % Mean of Sweetwater and Cuyamaca, 104 Sq. Miles.

Season	Mean %	Estimated Run-off acre feet
87-8	61	4831
8-0	219	17282
9-90	178	14098
90-1	187	14810
1-2	54	4277
2-3	141	11167
3-4	36	2851
4-5	452	35798
95-6	31	2455
6-7	80	6336
7-8	10	792
8-9	7	554
9-00	3	238
1900-01	40	3168
1-2	27	2138
2-3	30	2376
3-4	6	475
4-5	140	11088
1905-6	302	23918
6-7	240	19008
7-8	62	4910
8-9	154	12196
9-10	99	7841
1910-11	47	3722
11-12	61	4831
12-13	55	4356

Mean Run Off 7920 A. F.

TABLE IV.

Run off From Foothills Between G. S. Gaging Station and Mission Dam 135 sq. miles. mean discharge 5265 acre feet.

Year	Sweetwater %	Estimated Run-off acre feet
1887-8	61	3212
8-9	219	11530
9-90	178	9372
90-1	187	9846
1-2	54	2843
2-3	141	7424
3-4	12	632
4-5	637	33538
95-6	11	579
6-7	60	3159
7-8	0	0
8-9	2	105
9-1900	0	0
1900-1	7	369
1-2	0	0
2-3	0	0
3-4	0	0
4-5	120	6318
5-6	304	16006
6-7	261	13742
7-8	50	2633
8-9	140	7371
9-10	76	4001
1910-11	29	1527
11-12	39	2053
12-13	9	474
Mean		5265

33 sq. mi. deducted for Cajon Valley Flat Lands.

TABLE V.

Study of the Net Amounts of Water of the San Diego River above Mission Dam Available for Storage either Surface or Underground after Deducting for Flume Diversions and Losses due to Irrigation in Cajon Valley. All in acre feet.

(1) Season	(2) Net Above Flume Div.	(3) From Flume to Lakeside	(4) From Foothills	(5) Total above Mission Dam	(6) Irrigation Uses in Cajon Val.	(7) Net Amount + or - for storage
1887-8	4897	4831	3212	12,940	6000	+ 6940
88-9	28533	17282	11530	57,345	6000	+ 51345
89-90	22080	14098	9372	45,550	6000	+ 39550
1890-1	23540	14810	9846	48,196	6000	+ 42196
91-2	4462	4277	2843	11,582	6000	+ 5582
92-3	16377	11167	7424	34,968	6000	+ 28968
93-4	2341	2851	632	5,824	6000	- 176
94-5	66337	35798	33538	135,673	6000	+ 129673
1895-6	1830	2455	579	4,864	6000	- 1136
96-7	7480	6336	3159	16,975	6000	+ 10975
97-8	122	792	0	914	6000	- 5086
98-9	0	554	105	659	6000	- 5341
99-00	0	238	0	238	6000	- 5762
1900-1	1929	3168	369	5,466	6000	- 534
1-2	2492	2138	0	4,630	6000	- 1370
2-3	5450	2376	0	7,826	6000	+ 1826
3-4	338	475	0	813	6000	
4-5	19273	11088	6318	36,679	6000	+ 30679
1905-6	30134	23918	16006	70,058	6000	+ 64058
6-7	28708	19008	13742	61,458	6000	+ 55458
7-8	7204	4910	2633	14,747	6000	+ 8747
8-9	16770	12196	7371	36,337	6000	+ 30337
9-10	11151	7841	4001	22,993	6000	+ 16993
1910-11	5896	3722	1527	11,145	6000	+ 5145
11-12	13868	4831	2053	20,752	6000	+ 14752
12-13	4667	4356	474	9,497	6000	+ 3497

TABLE VI.

Study of Available Supply for La Mesa Above Mission Dam After deducting for Flume Diversions and 6000 a.f. Annual Loss from Irrigation in Cajon Valley. Capacity of Surface Reservoir 34,000 a.f. and River Gravels from Monte to Mission Dam 45,000 a.f. Estimated capacity of gravels for District 13,000 a.f. All quantities in acre feet; - indicates deficiency.

1	2	3	4	5	6	7	8
	Surface Reservoir Supply			Use From Surface Reservoir.	Use From Gravels	Evpration	Waste
Season	Fall(3)	Winter Inflow	Spring				Below Mission Dam
1887-8	34000	6940	34000	12000		6000	6940
88-89	16000	51345	34000	12000		6000	33345
89-90	16000	39550	34000	12000		6000	21550
1890-1	16000	42196	34000	12000		6000	24196
91-2	16000	5582	21582	12000		3600	0
92-3	5982	28968	34000	12000		6000	950
93-4	16000	-176	16000	12000		2400	(1) -176
94-5	1600	+129673	34000	12000		6000	97097
1895-6	16000	-1136	16000	12000		2400	(1) 1136
96-7	1600	+ 10975	11439	10239 (4)		1200	0
97-8	0	- 5086	-5086	0	6000	0	(1) -5086
98-9	-11086	- 5341	-16427	0	6000	0	(1) -5341
99-00	-22427	- 5762	-28189	0	1900	0	(1) -5762
1900-1	-30089	- 534	-30623	0	2733	0	(1) - 534
1-2	-33356	- 1370	-34726	0	2315	0	(1) -1370
2-3	-37041	+ 1826	-35215	0	3913	0	0
3-4	-39128	- 5187	-44315	0	0	0(2)	(1)-5187
4-5	-44315	+ 30679	-13676	0	6000	0	0
1905-6	-19636	64058	+34000	12000		6000	9737
6-7	+16000	55458	34000	12000		6000	37458
7-8	16000	8747	24747	12000		4320	0
8-9	8427	30337	34000	12000		6000	4764
9-10	16000	16993	32993	12000		5750	0
1910-11	15243	5145	20388	12000		3360	0
11-12	5028	14752	19780	12000		3360	0
12-13	4420 -4083	3497	7917	12000		0	0

(1) Deficiency in gravels above
(2) Gravels depleted - No extractions possible in year 1903-4
(3) After deducting pumping from all gravels
(4) -10239 a.f. all water used from surface reservoir - No Pumping.

TABLE VII

Condition of Cajon Valley Underground Reservoirs, for the group of dryest years (1895-6 to 1904-5) based upon the assumption of 13900 acre feet storage available for La Mesa below Riverview and 31900 acre feet available for Cajon Valley Irrigators, a total of 45,000 acre feet.

		L A M E S A		C A J O N		
Season	Total Water Crop	Use	Gravels Depletion Fall	Use	Gravels Depletion Fall	Total Depletion Fall
1895-6	4864					
96-7	16975		0	6000	0	0
97-8	914	6000	-6000	6000	- 5086	-11086
98-9	659	6000	-12000	6000	-10427	-22427
99-1900	238	1900	-13900	6000	-16189	-30089
1900-1	5466	2733	-13900	6000	-19456	-33356
1-2	4630	2315	-13900	6000	-23141	-37041
2-3	7826	3913	-13900	6000	-25228	-39128
3-4	813	0	-13900	6000	-30415	-44315
4-5	36679	6000	- 6000	6000	-13636	-19636

Years discharging less than 1000 acre feet are considered as supplying gravels above Riverview, and the years 1900-1 to 1902-3 inclusive are divided equally between the upper and lower gravels.
The year 1904-5 is considered as filling the lower gravels, the surplus going into the upper gravels.

TABLE VIII
Analysis of Water

Sample No.	Date	Location	Authority	Grains Per Gal.
---	Fall 1912	City pipes (mountain water)	Whitney	19.0
---	Aug. 1913	Upper San Diego river above flume in pool	Smith-Emery	17.7
5	Aug. 1913	San Diego flume at Monte	"	10.1
4	"	Well at Monte Ranch	"	24.5
6	"	Well from Lower Monte Valley	"	28.0
7	"	Well 1/2 mile north of Santee	"	27.8
8	"	Scripps House water, said to come from well on north side of bottom in Cajon Valley	"	45.4
--	"	From lagoon on Scripps Ranch	"	90.0
17	"	Well Mission Valley, near Gravilla, Mission Valley	"	85.4
15	"	Well at mouth of Murphy Canon Mission Valley	"	70.0
16	"	Well below mouth of Murphy Canon, Mission Valley	"	51.5
14	"	Hoff well near city boundary	"	28.0
13	"	Johnson well, 1/2 mi. above Murray Canon, Mission Valley	"	48.0
12	"	Glenn well at mouth of Murray Canon, Mission Valley	"	116.5
3	"	Bates well 1/2 mi. east of Harrington's store, from 720 ft. level, well 900 ft. deep	"	76.5
---	July 1913	Same well	Un. of Cal.	77.0
9	Aug. 1913	Balboa oil well, 2410 ft. deep 1 mi, above city pumping plant from 700 ft. level	Smith-Emery	69.0
10	"	Stebbin well (shallow) near Balboa well, 3/4 mi. above old city pumping plant	"	141.5
1	"	City well at pumping station near center of valley	"	19.4
2	"	Wind mill well opposite old city pumping station	"	58.6
		Average of wells in Mission Valley		61.8
		Santa Ynez river, source for Santa Barbara	U.S.G.S.	42.0
		Venture river, source for Ventura	"	39.0
		San Gabriel river, source for Azusa	"	12.0
		Santa Ana river, source for Redlands	"	9.0

TABLE IX.

Present Development of Irrigation District.

Precinct	Population	Land Values	Water Used Mi. In.	Trees Citrus	Deciduous	Grain Acres
1	750	$1,172,000	27.3	9027	2085	1500
2	700	731,500	30.0	9500	3100	750
3	500	1,186,000	46.2	43100	1000	
4	70	715,000	35.0	3000	3000	700
5	20	450,000	0.0	24	36	2000
	2040	$4,254,500	138.5	64651	9221	4950

Compiled by the Directors of the District.

(C O P Y)

FAIRBANKS, MORSE & CO.

423-429 East Third St.

Los Angeles, Cal. 12/17/13

Mr. J. B. Lippincott,
#1100 Central Bldg.,
C i t y.

Dear Sir:-

We beg to submit to you estimate as to cost of a pumping plant for the La Mesa Irrigation District at Santee, Calif. This pumping plant to have a capacity of 500 miner's inches, or 4500 gallons of water per minute to a total elevation of 385 ft. with provision for pumping 140" to a total elevation of 490 ft. These elevations include pipe friction. Suction is to be practically from nothing to 100 ft. pressure.

For this proposition we would recommend three separate units of 200 H.P. each. For this we would recommend and propose to install the following machinery:

3 -200 H.P. Fairbanks-Morse Type "RE" Internal Combustion Vertical Multi-Cylinder Oil-Burning Engines, complete with batteries, magnetos, fuel tanks, pipe and fittings, exhaust pipe and fittings, water pipe and fittings, circulating pumps, pulleys and belts, foundation bolts. These engines are to be equipped with -

- 3 - 42" Fairbanks Morse Eclipse F. C. Couplings, for direct connection to countershaft of power pumps.
- 2 - 15" x 18" 175 lb. pressure Duplex Center-Packed, Plgr. Pat. Fairbanks-Morse Power Pumps.
- 1 - 13" x 18" 225 lb. pressure Duplex Center-Packed Plgr. Pat. Fairbanks-Morse Power Pump. All necessary foundation bolts. All necessary suction lines, valves and fittings to extend to outside of building. All necessary relief valve lines and fittings.
- 1 - 6 H.P. Fairbanks-Morse Spec. Elec. Vert. Engine, complete with fuel tank, battery, water tank and fittings.

- 1 - 4" x 6" Fairbanks-Morse Vert. Air Compressor, for air-starting engines.
- 6 - 20" x 60" Air Pressure Tanks.
- 1 - Belt.
  All necessary air pipe, valves and fittings.
- 3 - Vacuum Gauges.
- 3 - Pressure Gauges.
- 1 - Gauge Panel with pipe and fittings.
- 3 - Oil Filters with pipe and fittings.
- 2 - 13,000-gal. Oil Storage Tanks.
- 1 - Oil Pump with pipe and fittings.
  All necessary bolts, gaskets.
  Necessary cement for concrete foundations.
  " gravel " " "
  " lumber " " "
  Freight to Santee, Cal.
  Hauling from Santee to point of erection (6 miles)
  Mechanics to erect the above machinery.
  Board and lodging.
  Railroad fare.
  Livery.

The cost of the above machinery, installed as above specified, would be $61,226.20. Approximate shipping weight, 425,000 lbs.

The operating and fuel expense of this plant would be as follows:

$ .0275	cost of #2 Tops per gal. Los Angeles carload.
.0128	freight per gal. to Santee, Cal.
.012	hauling to plant.
.0523	total cost of one gallon at plant.

72	gallons per hour for 600 H.P. load at .12 gal. per H.P.H.
1440	" for 20 hours run per day.
$ 75.31	fuel cost per day of 20 hours.
2259.30	fuel cost 30 days of 20 hours each.
280.00	lubricating oil for 30 days of 20 hours each.
400.00	four engineers per month.
2939.30	total operating expense of 30 days of 20 hours each.
97.978	" " " for 20 hours.
4.898	" " " " 1 "
.0816	" " " " 1 minute, or 500", or 4500 gallons, or 10 sec. ft. to a total elevation of 385.ft.
.0081	cost one second ft. per minute (1.8¢ per 1000 gal. JBL.)

For 140" pumped to an elevation of 490 ft. 4 hrs. per day, the fuel cost would be as follows:

J.B.L. #3 12/17/12

200 H.P. consuming 96 gals. per 4 hours, or 2880 gals. for 30 days of 4 hrs. each:

$150.62	fuel cost
2.16	lubricating oil
100.00	engineer
252.78	total cost per month.

8.426 per day of 4 hrs.
2.106 per hour
.0351 per minute, or 140", or 1260 gals. or 2.8 sec. ft. to a total elevation of 490 ft.
.0126 cost one sec. ft. per minute.

Interest and depreciation on $70,000.00 valuation of pumping plant would add the following cost to the operating expense:

$7000.00	depreciation.
4900.00	7% interest
$11900.00	
991.00	per month
1.3773	per hour
.0229	per minute
.0229	Interest and Depreciation 1 minute
.0816	Operation
$ .1045	total cost to pump 500", or 4500 gals. or 10 sec. ft. to a total elevation of 385 ft.
.0104	cost one sec. ft. per minute to 385 ft. total head
.0229	2.3¢ per 1000 gal.
.0351	
.058	total cost to pump 140", or 1260 gals. to a total elevation of 490 ft.
.0206	cost one sec. ft. per minute.

We have gone over this proposition quite thoroughly, and we feel sure we have covered every item of expense that would be met in installing a pumping plant of this size and capacity, except the cost of pump-house, suction line and discharge pipe line.

We have an installation very similar to this at the Western Water Co., Bakersfield, being three 250 H.P. engines direct-connected to Fairbanks-Morse duplex O.P.O.C. power pumps. Our estimate is figured only for estimating purposes, and everything is figured for that purpose, with the understanding that you could use these figures with the assurance that they are liberally high enough for your estimate, which you propose to submit to your parties.

Hoping we may have the pleasure of going into details of this proposition further with you, we are,

Yours very truly,
FAIRBANKS, MORSE & CO.
by Nies

FPH/WH

(C O P Y)

FAIRBANKS, MORSE & CO.

423-429 East Third Street,

Los Angeles, Cal. 12/22/13

Mr. J. B. Lippincott,
#1100 Central Bldg.,
C i t y.

Dear Sir:-

We beg to submit the following proposition as an addition to our former proposition on the pumping system for the La Mesa Irrigation District. This proposition is to consist of a pumping plant for pumping water by compressed air, and to have a capacity of 4500 gallons of water per minute pumping against a total head of 60 ft. For this proposition we would recommend the following machinery:

Plant located near wells.

2-	200 H.P. Fairbanks-Morse Type "RE" Internal Combustion, Vertical, Multi-Cylinder, Oil-Burning Engines, all complete same as in our former proposition.
2-	50" x 28" Friction Clutch Pulleys.
200-	ft. 28" Dbl. Leather Belt.
2-	22" x 14" x 18" Sullivan Duplex Two-Stage Air Compressors, Type "WJ"
2-	42" x 100" Air Receivers and fittings.
5000-	ft. 7" Std. Pipe.
5000-	ft. 6" " "
5000-	ft. 5" " "
25000-	ft. 4" " "
1500-	ft. 2" " "
1500-	ft. 7" O.D. Casing
	Necessary fittings for above pipe.
	Laying above pipe.
	Cement.
	Gravel.
	Freight.
	Hauling.
	Mechanics for erecting machinery.
	Board and lodging.
	R.R. Fare.
	Livery.

The approximate cost of the above machinery would be $60,000.00. Approximate shipping weight, 940.000 lbs.

The operating expense of this plant would be somewhat less in proportion than our former proposition. The oil would cost at Santee $0.0403 per gallon.

50 gals. per hour.
$2.015 cost of fuel oil, per hour.
$1.18 interest and depreciation on $60,000. per hour.
.55 per hour for engineer.
.35 " " " lubricating oil.
$4.095 total per hour.

$ .06825 cost to raise 4500 gals. per minute, or
.01517 per 1,000 gals.

This plant would be located as near as possible to the wells to be pumped, which we understand are to be 1½ miles from Santee, and which are 25 ft. lower than Santee. This would make a very easy proposition to run the fuel oil from Santee to this power plant by gravity, where it could be stored in a tank, and then pump the oil from this tank to the upper pumping station by means of a force pump. For this proposition we would recommend the following:

1 - 5 H.P. Fairbanks-Morse Type "NB" Oil Engine, complete with all standard appliances.
40 - ft. 3" Sg. Leather Belt.
1 - 2½ x 4 Duplex Power Pump.
37000 - ft. 2" Blk. Pipe.
8000 - ft. 4" " "
Necessary fittings.
All installed complete.

This proposition would cost approximately $13,500.00. Approximate shipping weight would be 235,000 lbs.

This pumping station would have a capacity of 6,000 gals. in 10 hours, and would only have to be operated one day in three to supply the necessary oil for the upper pumping station.

The operating expense of this plant would be approximately $7.91 per day, and would cost to pump 6,000 gals. once every three days $0.00396 per gallon. This would be practically about one-third the cost to haulthis oil to the upper pumping station, and rough figuring would make a saving of cost on the fuel oil of about $0.65 per hour.

We hope the data that we have given you on our Oil Engine will meet with your favorable approval, to the extent that you will feel confident enough in our machinery to recommend to your parties to consider bids on this type of machinery, for we feel

that we can submit a proposition to your party that will compare favorably with any other methods or means of pumping water, both as to first cost and to operating expense, as well as to durability and high class of machinery.

Hoping we may have the pleasure of taking this up with you further, we are,

Yours very truly,

(Signed) FAIRBANKS, MORSE & CO.

By Nies

FPN/WN

(C O P Y)

TERRY ENGINEERING & MACHINERY CO.

POWER PLANT & MACHINE SHOP EQUIPMENT

126-128 South Los Angeles St.

Los Angeles, Cal. December 27, 1913.

Mr. J. B. Lippincott,
1100 Central Building,
City,

Dear Sir:-

Complying with your request for preliminary estimate of a pumping plant to be located near La Mesa, Cal., we take pleasure in submitting the following estimate:

DUTY

It is estimated that the main pumping units will be required to raise 4,500 gallons per minute to an elevation of 385 ft. with 1/2 of the quantity elevated 105 ft. higher. The cost of operation hereafter stated, is based on one unit being run continually against a head of 490 ft. and one unit against a head of 385 ft. There may also be included in the power plant, electric generating units to supply current for pumping a series of wells situated approximately 7 miles from the power station, and delivering the water from wells, pumping the same down to a maximum depth of 60 ft.

MACHINERY IN POWER HOUSE

The pumping machinery in the power house is to consist of two cross compound Corliss engines, crank and fly wheel pumping enignes, each having a capacity of delivering 2250 gallons per minute against a pumping head of 385 or 490 ft. Two or three boilers to be supplied, the size and number depending on the final decision as to the head the water is to be discharged against, or the electrical installation installed. In the power plant will be all the necessary superheaters, reheating receivers, condensers, boiler feed appliances, piping, valves and fittings for the proper erection of a pumping plant of this character.

COST

Our estimate of the cost of this plant, complete with foundations, but not building, and without the electrical equipment, would be approximately SIXTY THREE THOUSAND ($63,000.00) Dollars. If the electrical equipment was added, consisting of two 75 Kilowatt engine driven generators, direct connected to tandem compound four valve engine, with proper exciters, switch board panels, etc., would be approximately EIGHT THOUSAND ($8,000.00) DOLLARS, or a total cost of SEVENTY ONE THOUSAND ($71,000.00) DOLLARS for the machinery in the power station.

POLE LINE

The cost of seven (7) miles of transmission, together with transformers, would be approximately EIGHT THOUSAND ($8,000.00) DOLLARS.

TURBINE PUMPS AT WELLS

The cost for a bored well turbine pump of the highest efficiency pattern, together with the necessary motor, belting, erected complete, and having a capacity of fifty (50) inches of water at a maximum depth of 60 ft. will be FIFTEEN HUNDRED ($1500.00) DOLLARS per well, or a total cost of FIFTEEN THOUSAND ($15,000.00) DOLLARS for ten wells having a capacity of 500 inches.

COST OF PUMPING WATER

Assuming that the electrical equipment is installed in the power house, and the current supplied for raising 500 inches of water 60 ft. from the wells, and that the power house elevates this water 1/2 by pumping constantly to 385 ft. and 1/2 to 490 ft., the cost of operation would be approximately as follows:

Oil required, 122 gallons per hour, cost at $1.00 per barrel $2.92 per hour. Three engineers at $3.00 per day, $9.00 and one at $5.00, equals 60¢ per hour. Oil and waste, 10¢, total cost per hour's operation, $3.62. Quantity of water pumped 270,000 gallons. Cost per thousand gallons .0138.

The above figures are preliminary, but are sufficient, we believe to cover any requirements for machinery you may find necessary to put in. If there is any additional information you may desire, kindly advise, and we will take pleasure in giving you same. Awaiting your further favors, we are

Yours truly,

TERRY ENGINEERING & MACHY. CO.

TSS-WTW By T. S. Smith.

(Copy)

KROGH MANUFACTURING COMPANY

Manufacturers of

PUMPING MACHINERY.

Engineers and Contractors.

Los Angeles, California, Dec.29, 1913

Mr. J. B. Lippincott,
1100 Central Bldg.
City.

Unless otherwise specified deliveries are F.O.B. our factory, Our prices are subject to change without notice, and are made for prompt acceptance. All orders are accepted subject to delays occasioned by accidents, strikes, fire or causes beyond our control, and with the understanding that while goods proving defective will be replaced F.O.B. our factory, NO claims for damages or labor will be allowed unless previously authorized in writing.

Dear Sir:-

As per your request for pumping machinery to go into 16" well, with a total head of 60 feet, we submit the following:-

1 - 13" O.D. Krogh automatic water balanced deep-well Turbine pump, direct connected to a 15 H.P. 1200 RPM, 3-phase vertical motor, installed on concrete foundations. Pumps to be 70-ft. from the surface and deliver water 10 ft. from pumps on the surface.

These pumps would deliver 50 miners inches of water at 17 or 18 cents per hour; at 1½¢ per kilowatt hour.

For the above service we name you a price of $1398.00 each, this estimate being for pumps installed in your wells not more than 3 miles from Santee, San Diego Co., Cal. This price includes pumps installed complete with motor, but does not include electric wiring. In order to enable us to make the price above quoted, it would be necessary that we receive orders for at least 5 pumps to be installed at one time.

Trusting this estimate will meet with your approval and that we may have the opportunity of submitting bids in the future, we remain

Yours very truly,
(signed) Krogh Mfg. Co.
By F. L. Emerson

VH/L

C H A S. C. M O O R E & C O. E N G I N E E R S.

Los Angeles, January 5th, 1914

Mr. J: B. Lippincott,

Central Building,

Los Angeles, California.

Dear Sir:-

We hand you herewith specifications covering complete pumping plant for La Mesa, California. This plant to have a capacity of 500 miner inches pumping against a total head of 477'. We have made up an estimate covering the cost of this pumping station and find that it will be approximately $74,000. This price does not include building, machinery foundations, fuel oil storage tanks, pipe lines outside of building walls or air lift equipment: the cost of the air lift machinery will be given independently in this letter.

As we understand the operating conditions of this plant, the main pumping units will be required to pump three-fifths of the total amount against a head of 357', and two-fifths of the amount against a head of 477'. We have designed a plant with two pumping engines, each having a capacity of 250 miners inches pumping against a total head of 477'. When it is required to pump into the low level reservoir the steam pressure will be lowered so that one or both pumps can be operated with the best economy while pumping at its maximum capacity. In case it is desired to pump into both reservoirs at the same time the lower steam pressure will be used, one pump handling 250" into the low level reservoir and the other 200" into the high level reservoir, and when the low level reservoir is cut out both pumps can be switched to the high level reservoir, the steam pressure raised and then each will handle their maximum capacity of 250" against the 477' head.

Regarding the amount of fuel required, advise that the total quantity of oil per year required by the plant when the high lift pumping engine is pumping 200" against 477' and the low lift engine is pumping 250" against 357', 24 hours per day, 365 days per year, would be 14,176 barrels of oil per year. This is the maximum amount of oil required under any condition of operation, since if both pumping units were operating on the low lift head at full capacity of 250", it would require less boiler horsepower and less fuel. The portion of this oil chargable to the separate units under this condition of operation would be 7340 barrels per year to the high lift pump when delivering 200" and 6856 barrels per year to the low lift pump when delivering 250", and with oil at $1.00 per barrel, would mean with the high lift pump the cost of 10¢ per inch day, and the low lift pump 7½¢ per inch day.

Assume that we add $6000. for building, and $3000. for machinery foundations, the total first cost would be approximately $83,000.

Fixed charges of 13% of $83,000. equals	$ 10,790.00
Supplies	600.00
Labor	6,000.00
Fuel	14,176.00
Total cost per year	$ 31,566.00

This is equal to approximately 11-3/4¢ per inch day, while pumping in proportions as given above.

The size of the building required for the main pumping plant will be approximately 47' wide by 82' long by 20' high underneath trusses. If the plant was extended for double this capacity it would double the size of the building. There will be required for foundations for all of the machinery in the main pumping plant approximately 5300 cu. ft. of concrete.

In regard to raising the water to suction line we would suggest that an air compressor plant be erected near the wells. For this plant there will be required two motor driven air compressors, each sufficient to take care of the total capacity of the main pumping plant: each of the compressors will require about 150 H.P. motor to drive same, motor to be belted to the compressor. The cost of this compressor station will be approximately $18,000.00, exclusive of building and foundations. Building required will be about 35' wide by 70' long. Knowing the cost of power at this point you can estimate the cost of getting the water to the main pumping units.

Trusting this will give you all information you require at this time, we are

Yours very truly,

Chas. C. Moore & Co., Engineers

By W. W. Smith.