REPORT
ON
PROPOSED HYDRAULIC DEVELOPMENT
OF
WARNERS RANCH

MAY 1911

J. G. WHITE & COMPANY
INCORPORATED
ENGINEERS, CONTRACTORS
NEW YORK CHICAGO
SAN FRANCISCO

REPORT
ON
PROPOSED HYDRAULIC DEVELOPMENT
OF
WARNERS RANCH

MAY 1911

J. G. WHITE & COMPANY
INCORPORATED
ENGINEERS, CONTRACTORS
NEW YORK CHICAGO
SAN FRANCISCO

J. G. WHITE & COMPANY
INCORPORATED
ENGINEERS - CONTRACTORS
43-49 EXCHANGE PLACE,
NEW YORK, N.Y.

CORRESPONDENTS:
J. G. WHITE & COMPANY, LIMITED
9 CLOAK LANE, LONDON, E.C.
WARING & WHITE (1906) LIMITED
14 COCKSPUR ST. LONDON ENGLAND

CABLE ADDRESS
WHITEMOTH, NEW YORK
CODES USED
LIEBERS A.B.C. 4TH ED'N
BEDFORD McNEILL, A.I.
WESTERN UNION

REPORT

ON

PROPOSED HYDRAULIC DEVELOPMENT

OF

WARNERS RANCH

San Diego County

California.

J. G. WHITE & COMPANY
INCORPORATED

INDEX.

CORRESPONDENTS:
J.G.WHITE & COMPANY, LIMITED
9 CLOAK LANE, LONDON, E.C.
WARING & WHITE (1906) LIMITED
14.COCKSPUR ST. LONDON ENGLAND

J.G.WHITE & COMPANY
INCORPORATED
ENGINEERS CONTRACTORS
43-49 EXCHANGE PLACE,
NEW YORK, N.Y.

CABLE ADDRESS
WHITEMOTH, NEW YORK
CODES USED
LIEBERS A.B.C. 4TH ED'N
BEDFORD McNEILL, A.I.
WESTERN UNION

SAN FRANCISCO OFFICE
ALASKA COMMERCIAL BLDG

San Francisco, Cal., May 7, 1911.

Mr. W. G. Henshaw,

Mills Bldg.,

San Francisco, Cal.

Dear Sir;-

The following report embodies our conclusions arrived at after an investigation of the site of the proposed Warners Ranch development and the consideration of such data as are available for the determination of rainfall and runoff.

We have not investigated the ownership of water, lands, or necessary rights of way, understanding that these and all other legal matters are in other hands.

We are of the opinion that the data collected in our investigation are reliable and that the estimates and deductions based thereon are sound and conservative and that under normal and proper conditions these conclusions will be substantiated.

J.G.WHITE & COMPANY
INCORPORATED

I LOCATION

This project, Warners Ranch, is located in San Diego County, California (See Appendix #1) and contemplates the impounding of water from approximately 210 square miles drainage area of the San Luis Rey River at the outlet of Valle de San Jose or Warners Ranch, which lies 45 miles Northeast from the City of San Diego, Cal. At this point the San Luis Rey River flows through a narrow gorge, the foundation of which is such that it can readily be closed by a dam 100 feet high with a crest length of about 600 feet, and thus creating a storage reservoir having an area of 4,700 acres and a capacity of about 150,000 acre feet. The waters from this reservoir can be led along the south side of the river canyon and diverted into the adjoining Santa Ysabel watershed by means of a conduit of open cut and tunnel sections totaling 9-3/4 miles in length. The diversion is accomplished by a tunnel 6,000 feet long, opening into the head of Temecal Canyon, from whence the open cut section continues on the west side of the canyon to a point opposite the head of Pamo Valley where a regulating reservoir of 20 acre feet capacity can be built and a fall of approximately 1,500 feet obtained through a pipe line 5,750 feet long.

A Power House located on the floor of Pamo Valley would discharge its tail water direct into the Temescal Branch of the Santa Ysabel River and this tail water can again be impounded at the lower end of Pamo Valley where a dam 148 feet high and 1,000 feet long will store 35,000 acre feet in a reservoir of 805 acres area. This reservoir will also receive the waters from 111 square miles drainage area of the Santa Ysabel including the Southwest slopes of the Vulcan and Mesa Grande Mountains. The water from this Pamo Reservoir will be available for irrigation or other purposes.

II TOPOGRAPHY.

San Diego County has a general rising slope in a northeasterly direction from the coast to a range of mountains, whose summits reach an elevation of about 6,000 feet, paralleling the coast and 40 to 50 miles distant. These mountains border on the desert of the Imperial Valley lying to the East and define the area of comparatively heavy rainfall of the coastal slope. The coastal slope in detail is much broken up by low mountain ranges in irregular groupings which surround many beautiful level valleys of considerable extent while a broad mesa borders the ocean extending back five to ten miles.

The general effect as seen from the coast is that of a uniform slope approaching the main range whose sum-

mits blend into a level sky line forming a barrier between the coastal slope and the desert.

The watershed of Warners Ranch Reservoir lies in a basin or kettle-shaped formation entirely surrounded by the mountains of the main range. Its 210 miles of area include 67 square miles of valley or flat bottom land covered with natural grasses affording feed the year around. The north and west portions of the valley contain several small lakes retaining water throughout the year and many spring fed marsh areas which retain their moisture through the dry season. In the northwest edge of the valley are hot springs (Aguas Caliente), indicating that water sinks to a considerable depth and that there possibly exists enormous subterranean passages. The soil of the valley is a deep alluvial silt of black loam and disintegrated granite which forms a sponge of great absorptive capacity and from which the evaporation must be considerable.

The balance of the watershed area lies on the mountain slopes and summits. The summits generally are covered with pine growth,while the lower slopes at the west side of the basin are in oak or chapparal growth , and those of the eastern side are bare and precipitous and partake of the characteristics of the desert, while the soil is almost uniformly a disintegrated granite. It is apparent from our

investigations that this watershed has a climatic condition between that of the coastal slope and the desert.

The Santa Ysabel watershed of the Pamo Reservoir lies entirely upon the coastal slope and contains several valleys of small extent. Its slopes are covered with greasewood and chapparal, the summits being in pine with numerous groves of oak, and its soil is generally disintegrated granite. We believe this area enjoys the favorable precipitation conditions of the coastal slope and a normal condition of runoff.

III WATER SUPPLY.

The Warner Reservoir and the Pamo Reservoir watersheds are distinctly separated, the Warner watershed being drained by the San Luis Rey River, while the Pamo watershed supplies the headwaters of the Santa Ysabel River, a tributary to the San Dieguito River.

RAINFALL.

The gagings of the runoff of the rivers of this vicinity are, with the exception of those referred to below, not entirely reliable. Owing to their very limited scope and questionable accuracy, they do not furnish sufficient or reliable guidance to determine the actual water supply from the drainage areas mentioned. It has, therefore, been necessary to make a careful investigation of rainfall

RAINFALL DATA.

Elevation	Location		Mean Rainfall Inches	Furnished by	Duration of Observations
1,986	Aguanga	Riverside Co.	12.40	H. Hawgood	2 years
2,543	Campo	San Diego Co.	20.81	U.S.Weather Bureau	24 "
714	Chino	San Bernardino Co.	15.24	" " "	17 "
4,677	Cuyamaca	San Diego Co.	40.07	" " "	22 "
1,234	Elsinore	Riverside Co.	13.64	" " "	16 "
657	Escondido	San Diego Co.	15.21	" " "	16 "
700	Fall Brook	San Diego Co.	17.27	" " "	28 "
3,180	Warner Hot Springs	" " "	16.00	W. S. Post	5 "
4,500	Julian	" " "	25.86	U.S.Weather Bureau	24 "
3,500	Mesa Grande	" " "	30.70	W. S. Post	5 "
5,500	Nellie	" " "	50.00	" " "	7 "
2,800	Oak Grove	" " "	14.00	H. Hawgood	2 "
460	Poway	" " "	13.96	U.S.Weather Bureau	27 "
1,450	Ramona	" " "	16.00	W. S. Post	1896-present
93	San Diego	" " "	9.62	U.S.Weather Bureau	59 years
2,983	Santa Ysabel	" " "	27.75	H. Hawgood	10 "
1,350	Valley Center	" " "	20.03	W. S. Post	27 "
2,700	Warner Dam Site	" " "	17.00	H. Hawgood	1 "
3,000	Warner	" " "	14.00	" "	2 "

and runoff based on rainfall records and known performances of similar drainage areas, and then compare the calculated runoffs with those actually measured, under equal or similar conditions. There is available considerable reliable rainfall data pertaining to this territory, compiled by the U.S. Weather Bureau and by private engineers.

These records have been tabulated in table of "Rainfall Data" hereto attached. From this table, curves were plotted showing the relation between rainfall and elevation above sea level of a given locality.

The three distinctive rainfall zones of the Pacific Coast are clearly represented in Southern California. In the first zone, from the Coast to the first mountain range, the annual precipitation increases with the altitude. As the warm humid air is forced into higher, cooler strata, the moisture carried is condensed, and begins to fall in the form of abundant rain.

The second zone extends from the first mountain spurs, over the mountain valleys, and to the last ridges bordering on the desert. The precipitation that has commenced continues to fall as the clouds pass on over the mountains and gradually cool off. The rainfall in this zone is therefore not so clearly dependent on the individual altitude of each station. It has a general relation to the altitude but it decreases in amount from the coast range inland.

The third zone is that of the arid lands back of the coastal mountain ranges. Here the rainfall is intermittent, torrential and frequently scarce.

In plotting the rainfall curves, it was found that for the stations located between the coast line and the first mountains, designated as first zone, a very smooth curve could be drawn taking in the points given. For stations located in the second zone the points would not lie as close to the curve of averages, but in a general way the precipitation for these stations shows satisfactory coincidence with the curve of averages.

The Warner Reservoir area is located in the second zone. Unfortunately most of the rainfall records for localities in this zone, at this particular site, are meagre and cover short periods only; but they are the best data available and give a fair degree of accuracy.

The Pamo Reservoir is located within the first zone. For this particular area numerous reliable records exist, and the conclusions drawn have been well supported by actual runoff figures, as below set forth.

RUNOFF.

The laws of runoff as referred to rainfall are fairly well established for Southern California. The records kept by some of the Water Companies in that vicinity, and in-

vestigations of the hydrographers of the U. S. Geological Survey have established the relation that may be expected, when the general characteristics of the territory are known.

It must be borne in mind that individual years are subject to great fluctuations. A year of light rainfall following a year of heavy rainfall will produce a runoff in excess of what normally could be expected for that year. A year of heavy rainfall following a very light year will show less runoff than normal. In view of these conditions, runoff records of individual years must be compared with each other, and with general rainfall conditions, that true conclusions may be derived.

Having these conditions in mind, the total yearly runoffs for the Warner watershed and the Pamo watershed have been calculated, and the yield of these watersheds determined in relation to the rainfall that might occur, whether it be a year of normal rainfall, or any percentage, high or low, of normal rainfall. The results were then compared with such measured flow from the areas, as were available.

For the Warner Reservoir record of measured runoff for only one year exists. The discharge coincides with the calculated runoff for a year of similar precipitation. But it is subject to reservation, as being only

a single instance.

For the Pamo Reservoir reliable records for five years have been kept. These records confirm the calculations for the Pamo runoff.

EVAPORATION.

The Evaporation losses have been determined on a basis of 48 inches annual loss for the exposed water area of Warner Reservoir, and 54 inches annual loss for the exposed water area of the Pamo Reservoir.

The results of the above calculation follow:

WARNER RESERVOIR.

The watershed of the Warner Reservoir, in years of normal rainfall, will yield annually approximately 25,000 acre feet - equivalent to 34 second feet (cubic feet per second) or 1,700 miners inches (4 inch pressure.)

In years of light rainfall, the runoff will be greatly reduced, and in years of heavy rainfall, correspondingly increased.

The construction of a Dam with 95 feet effective height will create a reservoir having storage capacity of 150,000 acre feet.

If the floods be stored and carried over from year to year, an equalized flow from Warner Reservoir can be expected, of net annually, 20,000 acre feet, or 27.4 second

feet, or 1,370 miners inches.

A yearly record has been calculated showing what performance could have been expected of Warner Reservoir, with a rainfall such as has occurred during the past thirty-four years.

This record shows delivery

during 31 years .....20,000 Ac.Ft. annually.
" 1 year (1899-1900) ..... 17,000 " " "
" 1 " (1901-1902) ..... 10,000 " " "
" 1 " (1903-1904) ..... 7,500 " " "
34 years.

During this time, the reservoir would have been emptied in the season of

1899 - 1900

1901 - 1902

1903 - 1904

POWER AVAILABLE.

The Power output from 20,000 acre feet annually, acting under 1,500 feet effective head, at 75% plant efficiency, will amount to

7,000 H.P. Power house output (12 hr. load)

5,222 K.W. " " " " " "

Corresponding power available for wholesale delivery within a reasonable radius of transmission

6,300 H.P. (12 hr. load)

4,700 K.W. " " "

Annual delivery 20,586,000 kilowatt hours

PAMO RESERVOIR.

The watershed of the Pamo Reservoir, in years of normal rainfall, will yield annually, approximately 28,000 acre feet - equivalent to 38 second feet (cubic feet per second) or 1,900 miners inches (4 inch pressure)

In years of light rainfall, the runoff will be greatly reduced; in years of heavy rainfall, greatly increased.

The construction of a dam with 140 feet effective height will create a reservoir having storage capacity of 35,000 acre feet.

If the regulated runoff from Warner Reservoir, during winter, and the floods of the Pamo watershed, be stored and carried over in the Pamo Reservoir from year to year, an equalized flow from Pamo Reservoir can be expected, of net annually, 22,000 acre feet.

A yearly record has been calculated showing what performance could have been expected of Pamo Reservoir with a rainfall such as has occurred in the past thirty-five years. This record shows delivery

during 30 years .....22,000 acre feet annually
" 1 year (1893-1894) .....21,500 " " "
" 1 " (1876-1877) .....20,000 " " "
" 1 " (1899-1900) .....16,500 " " "
" 1 " (1903-1904) .....14,750 " " "
" 1 " (1898-1899) .....14,000 " " "

During this time the Reservoir would have been emptied in the season of

1876 - 1877

1882 - 1883

1893 - 1894

1898 - 1899

1899 - 1900

1903 - 1904

In addition to the above, the Pamo Reservoir would normally receive from the Warner Reservoir during the six summer months 10,000 acre feet.

The total quantity of water that could be expected annually during irrigation season, from Pamo Reservoir under normal conditions, would then be:

From storage in Pamo ....22,000 acre feet
From Warner summer flow..10,000 " "
Total .....32,000 " " per irrigation season

For an irrigation season of 200 days, corresponding flow is

During the season ..... 80 second feet, or

" " " .....4,000 miners inches (4 inch pressure)

IV STRUCTURES

We recommend the following structures to accomplish the purposes of this project until further detailed investigations show that safety or economy demand changes.

WARNERS RANCH IMPROVEMENT

It will be necessary to relocate roads now in the Reservoir Area. These roads now connecting Santa Ysabel with Nellie and Pala by the Valley of the San Luis Rey River should be carried from the dam along the south side of the Reservoir.

In order to improve the runoff conditions of this watershed, it is advisable to construct a system of ditches along each edge of the valley to intercept and facilitate the runoff from the slopes and to pick up the principal water courses through the Valley. In addition smaller lateral ditches should be run out into the valley floor to drain the shallow lakes and marshes, thus saving considerable water from evaporation.

WARNERS RANCH DAM.

The dam site proposed is located in a narrow gorge leading out of the valley and presents a very favorable opportunity for an economical storage of water. From the surface indications the foundation across the stream bed and the north bank is of disintegrated granite, and the south bank a cliff of seamy and broken granite.

Although the hillsides are strewn with granite boulders and nodules, there seems to be no suitable quarry of hard rock close at hand. Monkey Hill in the reservoir site might develop a good quarry and a cliff of rock lies several hundred feet above the site on Mesa Grande Mountains; but both of these sources of supply are somewhat inaccessible. We therefore propose an earth fill type of dam having a 30 foot top width, 3 on 1 slopes upstream and 2½ on 1 slopes down stream. The downstream toe should be built of a considerable rock fill to permit drainage without sloughing. The earth fill can be procured from the floor of the valley and consists of black loam, clay and disintegrated granite, which should be spread in 6 inch layers rolled and wet. A concrete cutoff wall should be built from end to end of the dam, founded on an impervious strata and extending up into the earth fill a distance of 10 feet. The upstream slope should be paved 3 feet thick with heavy stone, the downstream slope

provided with paved drainage gutters and the balance seeded to tough grasses.

Beyond the north end of the dam is a dip in the profile where a spillway should be provided. This dip should be excavated to a level eight feet below the crest of the dam and be provided with a concrete sill, apron and side walls forming abutments for a bridge carrying the road from Smith Mountain. Provisions should be made for flash boards permitting a 4 foot control of the spillway.

OUTLET CONTROL.

A reinforced concrete gate tower should be erected above the upstream toe of the dam close to the south bank of the gorge. This tower should contain inlet gates at different elevations and outlet gates at the bottom leading into a concrete lined tunnel driven through the south bank to a flat area below the dam where the open lined conduit would begin. Access to the tower would be had over a foot bridge from the shore.

CONDUIT.

The conduit should be built with a gradient of one foot in 1000 feet as thus the loss of head will be less and the tunnels shorter than were a steeper gradient adopted. The tunnels should be lined to dimensions of 5

feet horizontal and 6 feet vertical with semicircular top. The lining should be 6 inches thick and all spaces back of lining filled with handstone. The ditches should be in excavation and lined with 4 inches of lightly reinforced concrete to dimensions of 3 foot bottom with 1 on 1 slopes, and capable of carrying 3 foot depth of water. The flumes should be of 6 foot diameter semicircular section riveted steel supported by timber trestles.

REGULATING RESERVOIR.

An excellent location is available where a regulating reservoir having a capacity of about 20 acre feet may be formed by an earth dam across a small hillside canyon. A suitable overflow and waste channel together with headworks including gates, racks and screens should be provided.

PRESSURE PIPE.

We would recommend a single pipe line of riveted and lap welded steel having an average diameter of 30" laid in trench and covered and provided with suitable anchorages.

POWER HOUSE.

The building for housing the hydro-electric apparatus should be fire-proof, built of steel and concrete and including in addition to the principal operating room suitable compartments for transformers, space for auxili-

aries and switchboard and the high tension switching apparatus.

EQUIPMENT.

The power house equipment should consist preferably of 3-- 2,500 k.v.a. generators, each capable of delivering 2,000 k.w. at 80% power factor and direct connected to impulse water wheels of 3,800 h.p.

Auxiliary apparatus should include duplicate exciter equipment, both water wheel and motor driven, step up transformers, switchboard and oil switches, lightning arresters, et c., et c.

TRANSMISSION.

Assuming for the purpose of this report the delivery of the power generated to San Diego the transmission line would be approximately 45 miles in length. We have estimated on a wooden pole line, supporting one three phase circuit, with copper of ample cross section and insulated for 66,000 volts.

SUB-STATIONS.

Again assuming the delivery of all power generated at the low tension side of the step down transformers, there would be required one sub-station of fireproof construction housing the necessary transformers,

switching and control apparatus.

STEAM AUXILIARY.

On account of perfect regulation of the water afforded by the storage at Warners Ranch reservoir, the comparatively inexpensive forebay or regulating reservoir and the relatively large tunnel section made necessary for construction reasons the proposed hydro-electric plant will be as flexible in operation for all practical purposes as a steam plant of similar capacity and size of units. Under the circumstances, it does not appear necessary or advisable to go to the expense of an auxiliary steam plant, as its greatest value would be for protection to service during periods of interruption which if it became necessary could be practically eliminated by the duplication of the transmission line, assuming always its careful construction and skilled operation.

As an alternative, however, to even the duplication of the transmission line for the relatively small capacity involved, it would be possible to market the output of the plant to consumers who would be reasonably lenient in the matter of interruptions or who have sufficient steam capacity already installed to enable them to maintain their own reserves.

PAMO DAM.

The site of the Pamo dam is in a canyon just below Pamo Valley. Solid rock foundation shows on the north bank adjacent to the stream and indications of ledge are evident on the south bank; but it appears that this rock may lie deeply covered on the higher slopes. Based upon the information now available, we recommend that an earth fill type dam be adopted for this site similar to that proposes for Warners Ranch. A much larger but similar spillway should be provided, also outlet control works as before. A thorough investigation should be made of this site to determine the extent of the rock foundation; and it may develop that a rock fill dam would be more suitable and could be built higher to the benefit of the project.

The foregoing suggestions and estimates on structures which follow are not to be considered as final but are the result of our preliminary investigation and a review of such surveys and data as your engineers have been able to present.

J.G.WHITE & COMPANY
INCORPORATED

V ESTIMATES OF COST.

RESERVOIR--Reconstruction of Roads.	$ 2,000.		
Draining and Ditching...	25,000.	27,000.	
DAM, SPILLWAY, OUTLET CONTROL.....			147,340.
CONDUIT.			
Ditches	39,500 feet @ $ 3.05...	$120,475.	
Tunnels	11,464 " @ 16.00...	193,944.	
Flumes	600 " @ 10.00...	6,000.	
Roads	20 miles@ 600.00...	12,000.	332,419.
FOREBAY & PIPE LINE.....			110,000.
Total Hydraulic ...			616,759.00
ELECTRICAL.			
3 - 2,000 k.w. generators water wheels, transformers, exciters, switchboard, et c.	@ 18.00...	$108,000.	
Buildings at Power House.....		40,000.	
Transmission line 45 mi.	@2000.00...	90,000.	
Sub-station building and apparatus, San Diego.....		36,000.	
Total Electric.....			274,000.00
Engineering & Contingencies; 15%			133,614.00
Interest during construction; 3½%			35,853.00
Organization and Legal			25,000.00
Total Power Development			$1,085,226.00
IRRIGATION.			
Pamo Dam, Spillway, Outlet Control			455,900.00
Engineering & Contingencies: 15%			68,385.00
Interest during construction; 3½%			18,350.00
Total Irrigation Development			$ 542,635.00

J.G.WHITE & COMPANY
INCORPORATED

VI MARKET.

We have not investigated the markets for either water or electricity, but a merely perfunctory examination of conditions at San Diego and vicinity leads us to believe that they should find a ready market at prices which would yield a fair return on the investment.

VII EARNINGS.

ELECTRIC.

Assuming a wholesale market at San Diego for the entire electrical output delivered at the low tension side of the sub-station transformers and a rate of 1¢ per k.w.h., with a load factor of 50%, the financial results of that part of the project should be about as follows:

These results are premised upon normal conditions and skilled and competent management.

Gross income from sale of 20,586,000 k.w.h. @ 1¢	$205,860.00
Operating expenses including taxes, maintenance and repairs	56,320.00
Net after operation	149,540.00
Interest charges, 7% on estimated cash cost	75,966.00
Surplus	$ 73,574.00

The above interest charges do not include allowance for cost of water or water rights, lands, rights of way, or franchises, nor, as before stated, does our estimate in-

clude the cost of a distributing system in San Diego.

VIII CONCLUSION.

In our investigation of the Warners Ranch Project, we have been hampered by the limited amount of data available, which is reliable, and which bears directly upon the problem. Numerous rainfall records have been compiled for that section of the state but only one station, that at Agua Caliente, lies within the drainage area of the Warner Reservoir. By reason of the peculiar topographic location, it becomes necessary to use extreme caution in drawing conclusions from records compiled from adjacent areas.

There can be no doubt that a large amount of water is precipitated in the area tributary, but how much of this may be available in runoff and how much is absorbed and later evaporated is largely a matter of expert opinion and can only be determined exactly by actual gaugings at the dam site. Government gaugings have been maintained at Pala on the San Luis Rey River some 20 miles below the dam site and these records, which for a number of excellent reasons are not considered accurate for the purpose of this report, are the only available records of runoff for the stream, which cover a period longer than one year.

The ditches for which we have made provision

in our estimates are for the diversion of water from the mountain slopes more directly into the reservoir. These would doubtless have beneficial influence on the runoff and should be particularly valuable in years of low rainfall, as the storage of water from wet to dry years is heavily taxed by evaporation. The improvement by this or other means of this dry year runoff would make possible a larger equalized flow from the reservoir.

The importance of this is self evident and we would recommend that a detailed study be made of the reservoir site for the purpose of determining what work may be profitably carried out to benefit of the runoff.

We would also recommend that a gauging station be established at the dam site, that at least five rainfall stations be located in the drainage area and that prior to actual construction there should be available records from these for at least one full year. It is needless to say that these stations should be under the direction of some competent observer.

Elsewhere in our report we have recommended against the construction of a steam reserve or auxiliary plant. It will be noted in the statement of runoff for the Warner Reservoir that during the thirty-four years of record

the electric development would either have to be operated at reduced capacity or entirely shut down during a part of three years, or one year in eleven, the maximum reduction during the entire period being to approximately 37½% of normal.

It therefore appears that the necessity of a steam reserve is measured entirely by the insurance on continuous service which it may be necessary to carry in order to profitably market the output of the hydro-electric plant.

Yours very truly,

H. S. Gillette

Secretary.

APPROVED

Henry D. Gardner.

Manager
San Francisco Office.

DESCRIPTION OF THE TOPOGRAPI[C]AP OF THE UNITED STATES

The United States Geological Survey is making a topographic map of the United States. This work has been in progress since 1882, and about three-tenths of the area of the country, excluding outlying possessions, has been mapped. The mapped areas are widely scattered, nearly every State being represented, as shown on the progress map accompanying each annual report of the Director.

This great map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The four-cornered division of land corresponding to an atlas sheet is called a *quadrangle*. The sheets are of approximately the same size: the paper dimensions are 20 by 16½ inches; the map occupies about 17½ inches of height and 11½ to 16 inches of width, the latter varying with latitude. Three scales, however, are employed. The largest scale is 1:62500, or very nearly one mile to one inch; i. e., one linear mile on the ground is represented by one linear inch on the map. This scale is used for the thickly settled or industrially important parts of the country. For the greater part of the country an intermediate scale of 1:125000, or about two miles to one inch, is employed. A third and still smaller scale of 1:250000, or about four miles to one inch, has been used in the desert regions of the far West. A few special maps on larger scales are made of limited areas in mining districts. The sheets on the largest scale cover 15′ of latitude by 15′ of longitude; those on the intermediate scale, 30′ of latitude by 30′ of longitude; and those on the smallest scale, 1° of latitude by 1° of longitude.

The features shown on this map may, for convenience, be classed in three groups: (1) *water*, including seas, lakes, ponds, rivers and other

times, are shown, not by dots and dashes. Ponds part of the year are sh lines. Salt-water marshe ruling interspersed with water marshes and swa broken horizontal lines.

Relief is shown by Each contour passes thr the same altitude. One v the ground will go neith but on a level. By the are the shapes of the pla shown, but also the elev seacoast itself is a contou of elevation being mean line at, say, 20 feet above would be the seacoast if t land to sink 20 feet. S the valleys and forward and spurs. On a gentle far from the present coa slope it is near it. Thus tour lines far apart on t slope; if close together, a contours run together in vertically under the one cliff. In many parts of t or hollows with no outlets. surround these, just as th small hollows known as s by hachures, or short das curve. The contour inte tance in feet between one stated at the bottom of e varies according to th

but by lines of dry during a blique parallel n by horizontal lue, and fresh- lue tufts with

nes in *brown*. ts which have s a contour on nor downhill, tours not only and mountains he line of the datum or zero The contour s the line that to rise or the runs back up points of hills contour line is ile on a steep n of these con- dicates a gentle pe; and if the s if each were hey indicate a are depressions tours of course d hills. Those ually indicated inside of the e vertical dis- d the next, is This interval r of the area

their descriptions, as well as the descriptions and geodetic coordinates of triangulation stations, are published in the annual reports and bulletins of the Survey. The publications pertaining to specified localities may be had on application.

The works of man are shown in *black*, in which color all lettering also is printed. Boundaries, such as State, county, city, land-grant, reservation, etc., are shown by broken lines of different kinds and weights. Cities are indicated by black blocks, representing the built-up portions, and country houses by small black squares. Roads are shown by fine double lines (full for the better roads, dotted for the inferior ones), trails by single dotted lines, and railroads by full black lines with cross lines. Other cultural features are represented by conventions which are easily understood.

The sheets composing the topographic atlas are designated by the name of a principal town or of some prominent natural feature within the district, and the names of adjoining published sheets are printed on the margins. The sheets are sold at five cents each when fewer than 100 copies are purchased, but when they are ordered in lots of 100 or more copies, whether of the same sheet or of different sheets, the price is two cents each.

The topographic map is the base on which the facts of geology and the mineral resources of a quadrangle are represented. The topographic and geologic maps of a quadrangle are finally bound together, accompanied by a description of the district, to form a folio of the Geologic Atlas of the United States. The folios are sold at twenty-five cents each, except such as are unusually comprehensive, which are priced accordingly.

Applications for the separate topographic maps

Ed Fletcher Papers

1870-1955

MSS.81

Box: 42 Folder: 11

Business Records - Reports - J.G. White & Co., - "Report on Proposed Hydraulic Development of Warners Ranch"