R E P O R T

on the

POSSIBLE DEVELOPMENT OF HYDRO-ELECTRIC POWER
ON THE SANTA YSABEL CREEK.

Proposed by

VOLCAN LAND & WATER COMPANY

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D. A. McClung,

November 1, 1917

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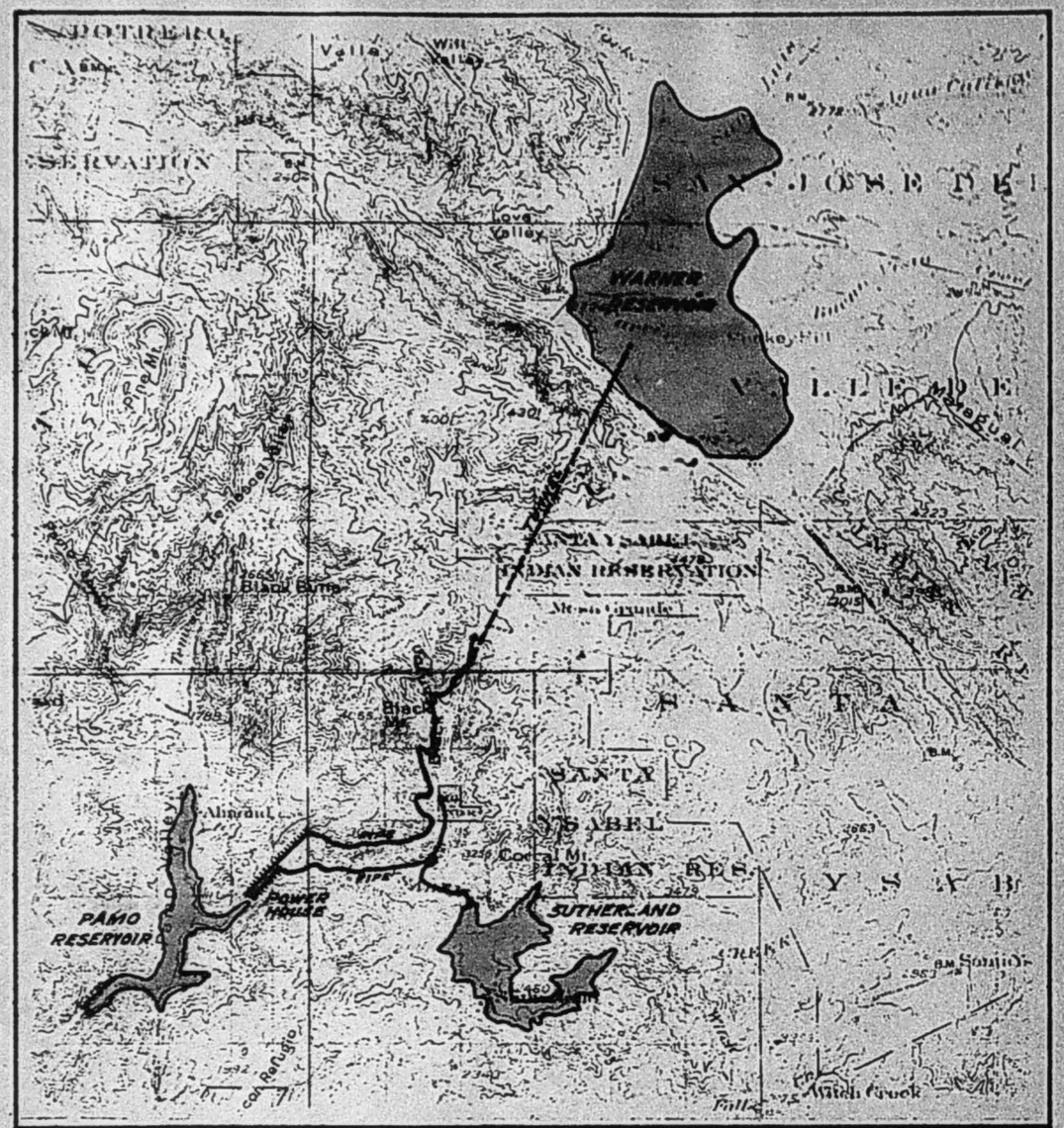
PLATE I



GENERAL MAP

WARNER-SANTA YSABEL POWER PROJECT

SCALE OF MILES

PIPE ON GRADE
TUNNEL
PRESSURE PIPE

NOV. 1, 1917.
O.A.M.

INTRODUCTION

This Report is intended to set forth the results of an investigation of the probable output of hydro-electric power which may be developed at a hydro-electric plant to be located on the Santa Ysabel Creek at Pamo reservoir site in the Southwest quarter (SW¼) of Section 13, Township 12 South, Range 1 East, San Bernardino Meridian.

The power plant and collecting and transmission works are planned to utilize to the fullest extent the available head and stream flow in the Santa Ysabel river below the Sutherland dam site, the Black Canyon Creek below Mesa Grande, and the San Luis Rey River below the Warner Dam Site. The total static head below Warners exceeds 1,600 feet. The total static head below Sutherland and Black Canyon exceeds 880 feet.

The flow of the San Luis Rey and Santa Ysabel rivers is regulated by storage in the Warner and Sutherland Reservoirs respectively and the safe net yield of these two streams is taken from the Report of the Board of Engineers, dated February 24, 1917. Black Canyon offers no storage possibilities, so it is proposed to divert Black Canyon, when available, in preference to Warner and Sutherland supply, which may be held over by storage until the flow of Black Canyon falls below the required amount. The Warner water is to be used before drawing upon Sutherland in order to reduce the loss by evaporation from Warner Reservoir, which covers considerable area.

Below the power plant it is proposed to catch and store all of the used water in Pamo reservoir up to its maximum capacity.

The water may be distributed from Pamo for irrigation or other uses.

It is assumed in this report that the demand for power is uniform throughout the year, but the storage facilities at Warner and Sutherland make it possible to care for a variation im the power demand during the year, and storage at Pamo will care for variations in demand for irrigation or domestic supply.

The data upon which this report is based was obtained from the Report of the Board of Engineers referred to above, and Hydrographic records and surveys of the Volcan Land and Water Company.

The report is arranged as follows:

1. Description of Proposed System.
2. Elevation and Heads.
3. Water Supply.
4. Power Output and Capacity.
5. Conclusions.

DESCRIPTION OF PROPOSED SYSTEM

Plate 1 shows the scheme for utilizing the water from the three streams, San Luis Rey, Black Canyon and Santa Ysabel.

The San Luis Rey water is collected in the Warner Reservoir and discharged through a tunnel to Black Canyon where it is carried in a pipe and discharged through a penstock to the Power House at Pamo. The Santa Ysabel water is collected in the Sutherland Reservoir and carried by a pipe line and discharged through a penstock to the Pamo Power House.

There are two schemes for using Black Canyon water.

No. 1. All Black Canyon water is diverted just above the crossing of the Sutherland pipe line and put into the Sutherland pipe.

No. 2. Part of the Black Canyon water is diverted just above the outlet of the Warner-Black Canyon tunnel and put into the Warner-Black Canyon pipe line. The remainder of the Black Canyon water is put into the Sutherland pipe line as in No. 1.

The Power House is located on the right bank of the Santa Ysabel River just above the high water line of the Pamo Reservoir and discharges into Pamo. The Power Plant should be able to use water from either penstock alone or both together.

ELEVATION AND HEADS

This data has been determined by field surveys by the Volcan Land and Water Company.

Elevation Outlet Warner Reservoir	2,648
Elevation Outlet Warner-Black Canyon Tunnel	2,639
Elevation Top of Warner-Pamo Penstock	2,615
Elevation of Nozzle at Pamo Power House	1,045
Total Static Head	1,603
Friction Loss	45
Effective Head	1,558
Elevation Outlet Sutherland Reservoir	1,930
Elevation Top of Sutherland-Pamo Penstock	1,905
Elevation Nozzle at Pamo Power House	1,045
Total Static Head	885
Friction Loss	29
Effective Head	856
Elevation Upper Black Canyon intake	2,710
Elevation Bower Black Canyon intake	2,040
Elevation High Water Line Pamo Reservoir	1,015

WATER SUPPLY

The safe net yield of the Warner and Sutherland reservoirs has been determined by the Board of Engineers in their report dated February 24, 1917, and their figures have been used in this report, namely 34 second feet from Warner and 15.5 second feet from Sutherland.

The Volcan Land and Water Company has records of the flow at the gaging station at the mouth of Black Canyon for 5 years last past. There is also record of the Santa Ysabel River at Sutherland during the same period. The nature and proximity of the two watersheds and inspection of simultaneous measurements indicates that Black Canyon and the Santa Ysabel River have the same characteristics and regimen, and it is therefore feasible to compute the probable runoff of Black Canyon for years of which there is no record by comparison with the accepted values for Sutherland. In order to do this a runoff relation curve has been made. (Plate 3)

The probable runoff of Black Canyon was then computed from the curve by using the values of Sutherland runoff as determined in the Board of Engineers Report. This is shown in Table 1.

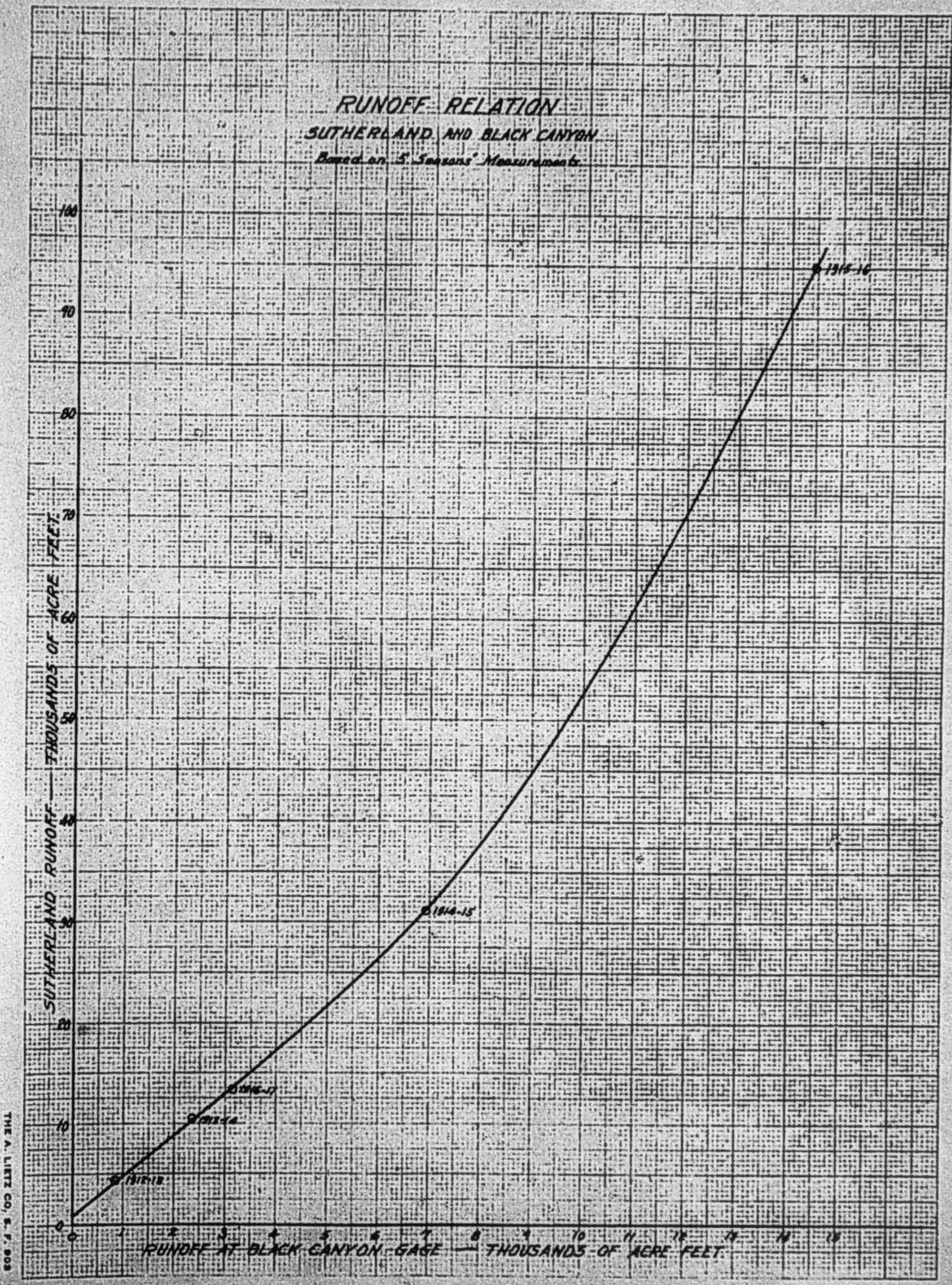
Since the Black Canyon water is to be diverted at two different points on the stream it is necessary to distribute the total runoff over the catchment area as controlled by the points of diversion. This statement is made clear by an inspection of Plates 1 and 2. Isohyetose studies show a uniform variation in rainfall from Area A to Area C, precipitation being greatest at the North end of the drainage area. The topography of Areas B and C is nearly

PLATE 2

BLACK CANYON

DRAINAGE AREAS

PLATE 3



THE A. LIETZ CO. S. F. 988

the same - being slightly in favor of Area B as regards runoff. The topography of Area A has much gentler slopes than Area B and comprises more cultivated land thereby losing more by evaporation.

From the foregoing conditions the following relations have been assumed.

Runoff per square mile from Areas A & B is the same.

Runoff per square mile from Area C is one-half that of B.

The Areas and distribution of runoff are -

Area	Sq. Miles	Weight	% Total
A	10.0	1	67.6
B	4.0	1	27.0
C	1.5	½	5.4
	15.5	2½	100.0

The total runoff is then distributed over the total area for the 29 year period as shown in Table 2.

Diversion

On account of the limited capacity of the diversion conduits and the great variation of stream flow, it is necessary to allow for wastage of a certain portion of the runoff during flood periods.

To determine this waste a study has been made of the Sutherland discharge by days over a 5 year period and the results noted in Table 3.

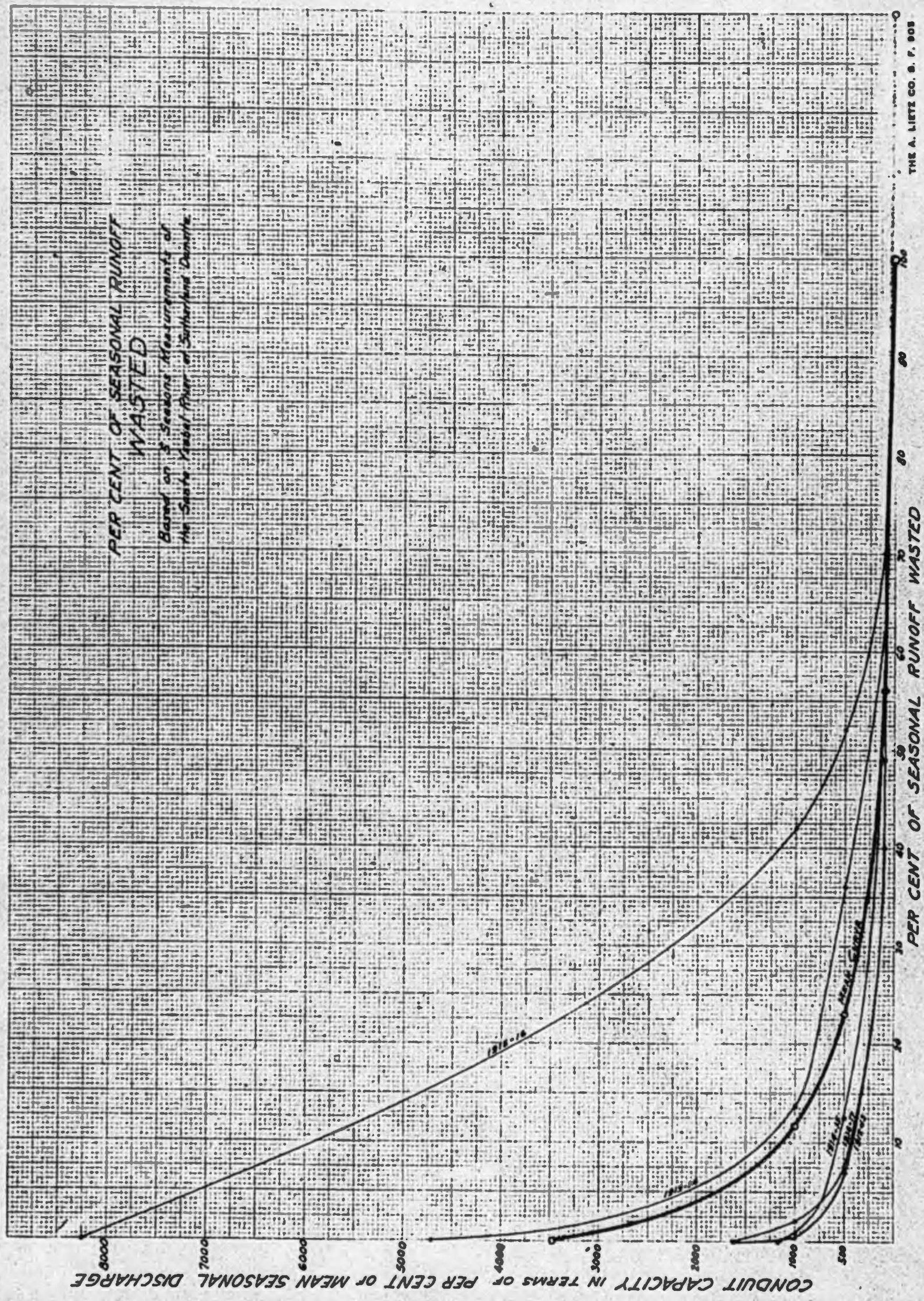
The Sutherland discharge was studied because the records are more complete than those of Black Canyon, while the regimen is nearly the same.

The underlined values determined in Table 3 were plotted and curves drawn through them showing the percent of yearly runoff wasted for various conduit capacities. (Plate 4)

PLATE 4

PER CENT OF SEASONAL RUNOFF WASTED

Based on 3 Seasons' Measurements of the Santa Ynez River at Santa Ynez Dam Site.



Applying this curve to the Black Canyon runoff values, there is left an average flow available for use of 4 second feet.

POWER OUTPUT & CAPACITY

The safe yield of the three streams and the effective heads are -

	Sec.ft.	Effective Head
San Luis Rey ----------	34.0	1558.
Santa Ysabel ----------	15.5	856.
Black Canyon A B ----------	4.0	856.
Black Canyon A ----------	2.85	1558.
Black Canyon B ----------	1.15	856.

Plan No. 1. Only one diversion from Black Canyon.

The total power output is calculated for 70% plant efficiency, as follows:

$$\frac{34 \text{ s.f.} \times 1558' \times 62.4}{550} \times .70 = 4210 \text{ H.P.}$$

$$\frac{15.5 \text{ s.f.} \times 856' \times 62.4}{550} \times .70 = 1054 \text{ H.P.}$$

$$\frac{4 \text{ s.f.} \times 856' \times 62.4}{550} \times .70 = 272 \text{ H.P.}$$

Total ------- 5536 H.P. = 4125 K.W.

Plan No. 2. Two diversions from Black Canyon.

Same as No. 1 = 5536 H.P.

and $\frac{2.85 \text{ s.f.} \times 702' \times 62.4}{550} \times .70 = 159$ H.P.

Total ------- 5695 H.P. = 4250 K.W.

In order to care for hourly fluctuations in load upon the power plant, the conduits and penstocks must be designed to carry the maximum amount of water necessary for the peak load and in the absence of pondage facilities at the head of the penstocks, the

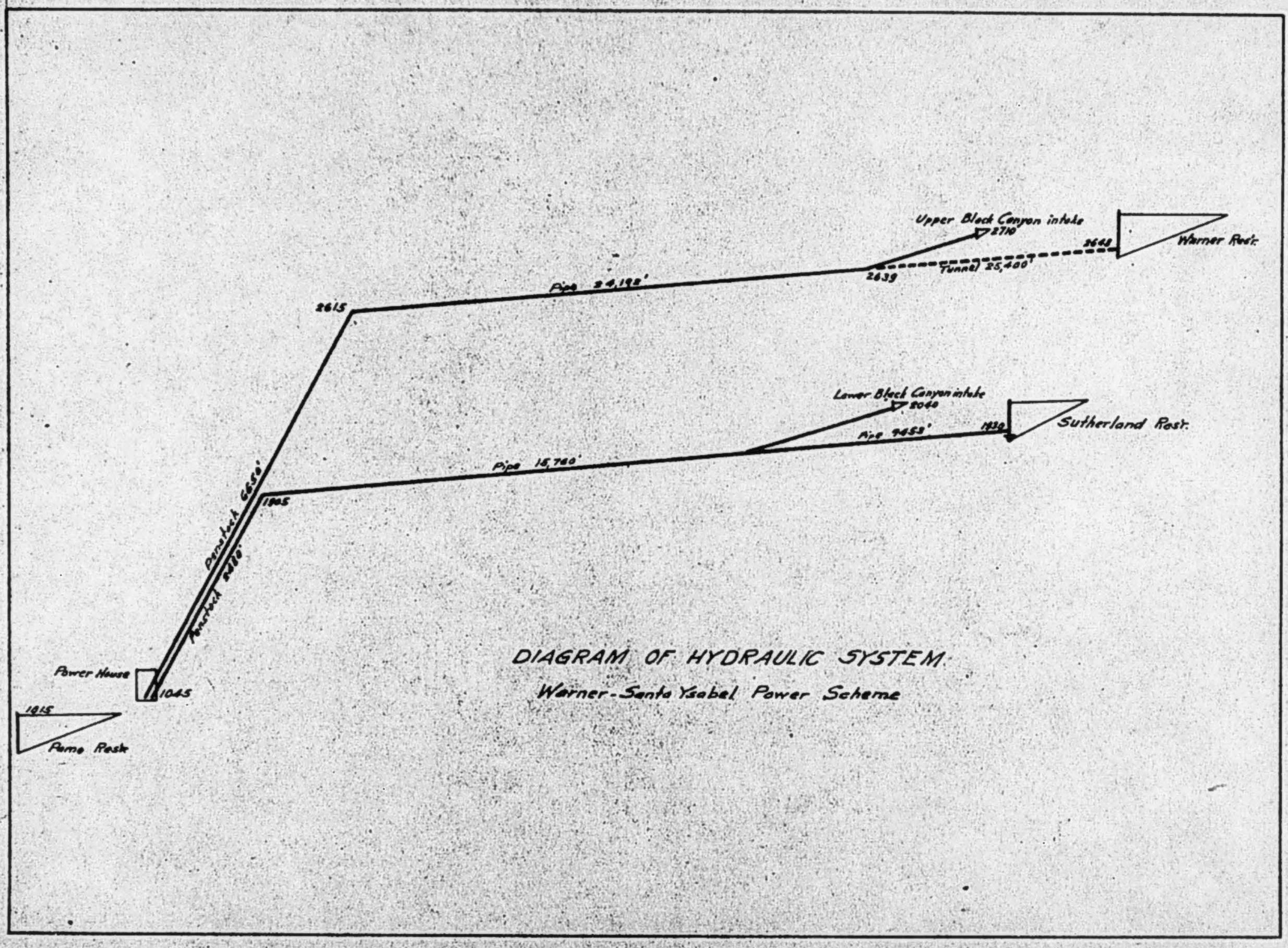


DIAGRAM OF HYDRAULIC SYSTEM.

Warner-Santa Ysabel Power Scheme

PLATE 5

entire hydraulic transmission system must be under pressure.

In this report a load factor of 50% is used as representing average practice, and being well on the side of safety.

The hourly load curve is shown in Plate 6.

The electrical power capacities are computed as follows for a 50% load factor:

Plan No. 1:

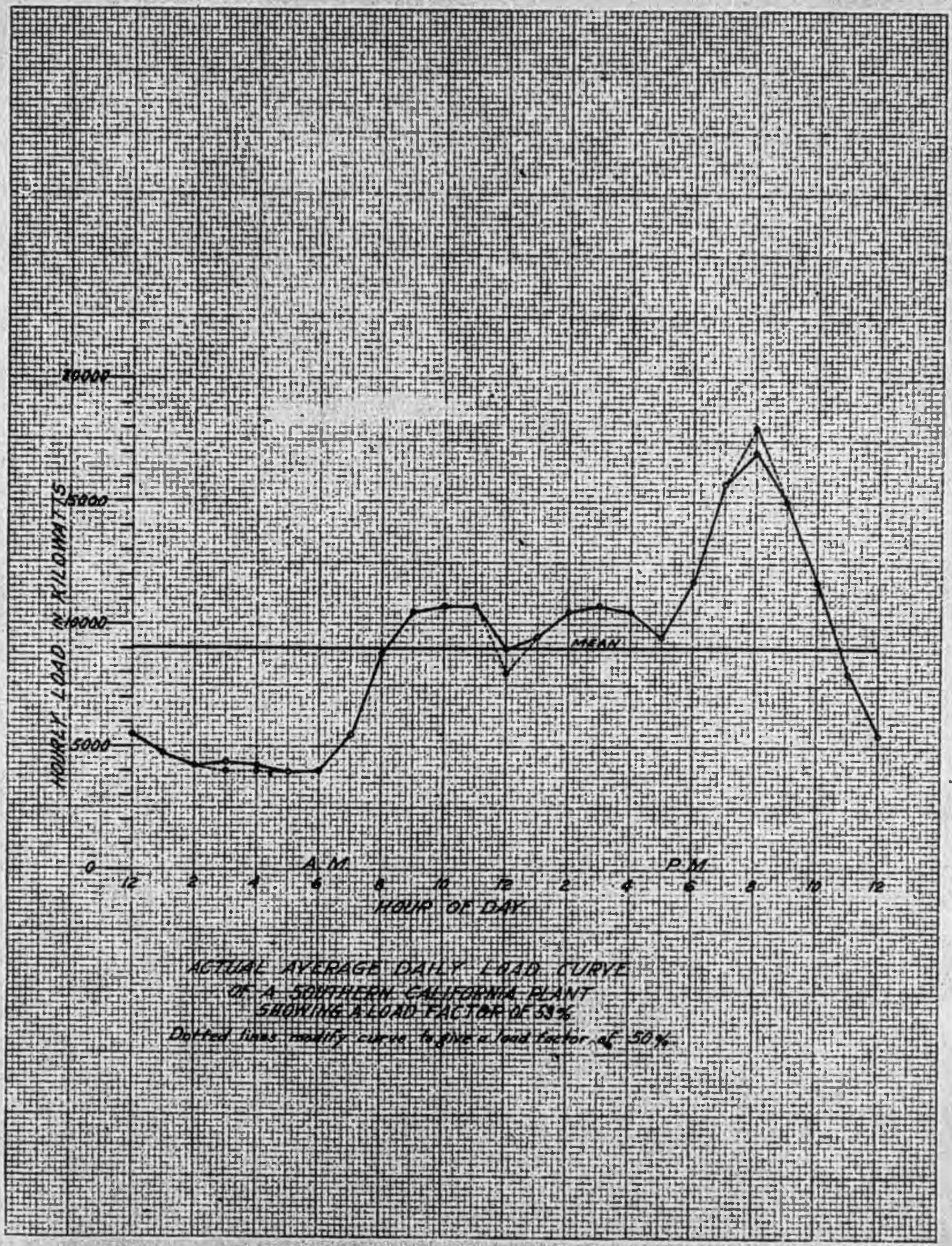
$$\frac{5536 \text{ H.P.}}{0.50} \times .746 = 8250 \text{ K.W.}$$

Plan No. 2:

$$\frac{5695 \text{ H.P.}}{0.50} \times .746 = 8500 \text{ K.W.}$$

IMPORTANT DETAILS OF HYDRAULIC TRANSMISSION SYSTEM

Structure	Capacity Sec.ft.	Dimensions Feet	Length Feet	Grade	Head Lost
Warner Tunnel	92	6½ x 8.	25,400	.00035	9
Warner-Pamo Pipe	92	d. 5½	24,192	.001	24
Warner-Pamo Penstock	92	d. 5	6,650		12
Suth.-Pamo Pipe	167	d. 7	25,213	.001	25
Suth.-Pamo Penstock	167	d. 6	2,480		4
Blk Can.Pipe (Upper) Plan 2	75	d. 2½	1,500	.047	70
Blk Can.Pipe (Lower) Plan 2	31	d. 2	5,000	.024	119
Blk Can.Pipe (Lower) Plan 1	163	d. 3.8	5,000	.024	119



ACTUAL AVERAGE DAILY LOAD CURVE
OF A SOUTHERN CALIFORNIA PLANT
SHOWING A LOAD FACTOR OF 59%
Dotted lines modify curve to give a load factor of 50%

CONCLUSIONS

1. The total flow available for power development at Pamo is 34.0 sec. ft. from Warner
15.5 sec. ft. from Sutherland
and 4.0 sec. ft. from Black Canyon.

2. While Black Canyon affords no storage sites for any considerable quantity of water, a dam should be provided which will impound at least 20 acre feet in order to regulate the flow for one day in accordance with the demand for power.

3. The used water from the power plant can be regulated in Pamo reservoir for other uses by a dam 210 feet high.

4. The average Hydro-electric power output available will be 5695 continuous Horse Power.

5. The possible electrical power capacity of the power plant, at a 50% daily Load Factor is 8500 K.W.

6. There are no surveys from which to determine the practicability of building an economical pipe line and diversion dam at the upper Black Canyon intake referred to in this report, which would net 159 additional Horse Power. The canyon is favorable for a diversion dam and the length of pipe would probably be less than 1500 feet as estimated in the last preceding tabulation, so that, considering the reduction in size of pipe at the lower intake if this Plan No. 2 is adopted, the scheme appears attractive.

Respectfully submitted,

McC:BK

D. A. McClung.

Table No. 1

SEASONAL RUNOFF OF BLACK CANYON AT GAGING STATION.
COMPUTED FROM PLATE 3 AND SEASONAL RUNOFF AT SUTHERLAND.
Quantities in Acre Feet.

Season	Sutherland runeff from Board of Engineers Report	Black Canyon runoff Measured	Black Canyon runoff Computed
1888-89	13,000		3,000
1889-90	24,500		5,600
1890-91	27,500		6,200
1891-92	10,100		2,300
1892-93	16,000		3,700
1893-94	8,000		1,800
1894-95	52,400		9,960
1895-96	5,000		1,050
1896-97	11,700		2,700
1897-98	3,000		550
1898-99	2,500		400
1899-1900	2,000		300
1900-01	7,200		1,600
1901-02	5,600		1,200
1902-03	8,900		2,000
1903-04	4,300		900
1904-05	14,000		3,250
1905-06	36,000		7,700
1906-07	20,600		4,750
1907-08	6,900		1,500
1908-09	27,800		6,300
1909-10	19,400		4,500
1910-11	10,700		2,450
1911-12	7,000		1,550
1912-13	4,370	820	
1913-14	10,450	2,359	
1914-15	31,130	6,926	
1915-16	95,040	14,458	
1916-17	13,314	3,137	

Table No. 2.

DISTRIBUTION OF BLACK CANYON RUNOFF (See Plate 2)

Quantities in Acre Feet

Season	Total runoff	Area C 5.4%	Area B 27.0%	Area A 67.6%	Area A & B
1888-89	3,000	160	810	2,030	2,840
1889-90	5,600	300	1,610	3,690	5,300
1890-91	6,200	330	1,670	4,200	5,870
1891-92	2,300	120	620	1,560	2,180
1892-93	3,700	200	1,000	2,500	3,500
1893-94	1,800	100	490	1,210	1,700
1894-95	9,960	540	2,680	6,740	9,420
1895-96	1,050	60	280	710	990
1896-97	2,700	150	730	1,820	2,550
1897-98	550	30	150	370	520
1898-99	400	20	110	270	380
1899-1900	300	15	80	205	285
1900-01	1,600	90	430	1,080	1,510
1901-02	1,200	65	325	810	1,135
1902-03	2,000	110	540	1,350	1,890
1903-04	900	50	240	610	850
1904-05	3,250	180	880	2,190	3,070
1905-06	7,700	420	2,080	5,200	7,280
1906-07	4,750	260	1,280	3,210	4,490
1907-08	1500	80	400	1,020	1,420
1908-09	6,300	340	1,700	4,260	5,960
1909-10	4,500	240	1,210	3,050	4,260
1910-11	2,450	130	660	1,660	2,320
1911-12	1,550	80	420	1,050	1,470
1912-13	820	45	220	555	775
1913-14	2,359	129	640	1,590	2,230
1914-15	6,926	376	1,870	4,680	6,550
1915-16	14,458	788	3,900	9,770	13,670
1916-17	3,137	167	840	2,130	2,970
Total	102,960	5,575	27,865	69,520	97,385
Mean	3,550	192	961	2,397	3,358
Sec.ft.	4.90	.26	1.33	3.31	4.64

Table No. 3.

CHARACTER OF SEASONAL DISCHARGE AT SUTHERLAND IN RELATION TO MEAN SEASONAL DISCHARGE.

Season	Runoff	Mean Sec.ft.	Maximum Sec. ft.	Maximum % of mean	% Of Seasonal Runoff above Mean	1000% M.	500% M.
1912-13	4,370	6.04	95	1,570	49	.4	7.
1913-14	10,450	14.43	680	4,700	62	13.7	36.
1914-15	31,130	43.0	500	1,165	58	.8	12.5
1915-16	95,040	131.3	10,800	8,250	70	42.	52.
1916-17	13,314	18.4	300	1,630	40	2.	7.5
Means				3,463	56	11.8	23.

Results plotted on Plate 4.

Table No. 4.

COMPUTATION OF BLACK CANYON WASTE ON ACCOUNT OF LIMITED CAPACITY OF DIVERSION CONDUIT (From Plate 4)
Conduit Capacity = 82 sec. ft. = 59,400 acre feet per year.

Season	Runoff of Area A & B: Acre Feet	Percent conduit capacity: to Mean Discharge for Season	Percent season's runoff wasted from curve	Waste Ac. Ft.	Runoff available for diversion Acre Feet
1888-89	2,840	2,090	4	114	2,726
1889-90	5,300	1,120	10	530	4,770
1890-91	5,870	1,010	12	700	5,170
1891-92	2,180	2,720	2	44	2,136
1892-93	3,500	1,700	6	210	3,290
1893-94	1,700	3,490	0	0	1,700
1894-95	9,420	630	19	1,790	7,630
1895-96	990	6,000	0	0	990
1896-97	2,550	2,330	3	77	2,473
1897-98	520	11,400	0	0	520
1898-99	380	15,600	0	0	380
1899-1900	285	20,800	0	0	285
1900-01	1,510	3,930	0	0	1,510
1901-02	1,135	5,230	0	0	1,135
1902-03	1,890	3,110	1	20	1,870
1903-04	850	7,000	0	0	850
1904-05	3,070	1,940	4	123	2,947
1905-06	7,280	817	15	1,100	6,180
1906-07	4,490	1,320	8	360	4,130
1907-08	1,420	4,180	0	0	1,420
1908-09	5,960	995	12	720	5,240
1909-10	4,260	1,390	8	340	3,920
1910-11	2,320	2,560	2	47	2,273
1911-12	1,470	4,040	0	0	1,470
1912-13	775	7,670	0	0	775
1913-14	2,230	2,660	3	67	2,163
1914-15	6,550	908	13	850	5,700
1915-16	13,670	435	45	6,150	7,520
1916-17	2,970	2,000	0	0	2,970
Total	97,385			13,242	84,143
Mean	3,358			457	2,901
Sec.Ft.	4.64			.63	4.01

Ed Fletcher Papers

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Business Records - Reports - McClung, D.A. - "Report on the Possible Development of Hydro-Electric Power on the Santa Ysabel Creek"