WILLIAM S. POST
ASSOC. MEM. A. S. C. E.
FLETCHER BLDG., 924 6TH ST.
SAN DIEGO, CALIFORNIA

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RESULTS

Evaporation Studies of Volcan Land & Water Co.

by William S. Post.

July 15th, 1914.

REPORT ON EVAPORATION STUDIES OF VOLCAN LAND AND WATER COMPANY and CUYAMACA WATER COMPANY

By W. S. Post.

In order to determine the evaporation of the various reservoirs in existence and projected, the Volcan Land and Water Company and the Cuyamaca Water Company began in January, 1913, a series of observations of evaporation at various points which are described hereafter. The observations are of three kinds. The observations noted as being "in air" consist of an insolated pan exposed to air currents and raised somewhat above the ground. Other observations noted as "ground pans" were made in pans imbedded in the surface of the earth, and other pans were floated from booms upon water surfaces. The majority of the pans were of standard size adopted by U. S. Reclamation Service or the Weather Bureau being 3 feet x 3 feet and 18 inches deep. A few of the pans were simply coal oil cans 9x9 inches. In addition a study has been made of what may be called an evaporating pan of the full size, - Cuyamaca Lake - by observing the reservoir gage heights and accounting for inflow and draft and rainfall.

The observations in every case are given as <u>gross</u> evaporation by which is meant the total evaporation from the surface of the pans eliminating rainfall. To obtain <u>net evaporation</u>, rainfall is subtracted from <u>gross evaporation</u>.

Net evaporation would represent the actual amount which would be lost under natural conditions, alternately replenished by rain and loosing by evaporation.

As the object of these observations is to determine the net evaporation for use in predicting the safe yield of various projected reservoirs in San Diego County, the study of the actual conditions as determined at Cuyamaca Lake is very important. During the months of high rainfall, December to April, it is impossible to make any actual determination at Cuyamaca Lake. With the cessation of rains, the inflow from streams can be closely estimated and is of a quantity sufficiently small compared with the large area of the reservoir to be almost negligible.

A rain gage has been placed at each end of the Lake and a floating pan at the west end and a ground pan at the east end. It has been possible, therefore, to determine all of the elements of the problem. The details of the computations are shown in Table . The observations are summarized as follows:

Table No. 1.

SUMMARY OF GROSS EVAPORATION, AS ACTUALLY OBSERVED ON CUYAMACA LAKE.

	1912.	1913.	1914.
Jamary			
February			
March			4.94
April			2.00
May		7.27	7.08
June	9.89	5.24	9.24
July	3.58	4.05	
August	8.39	2.78	
September	6.48	4.39	
October	5.60		
November	0.61		
December	5.00		

Table No. 2.

COMPARISON OF ACTUAL EVAPORATION, EVAPORATION IN WATER AND EVAPORATION IN GROUND AT CUYAMACA LAKE.

1913.	Cuyamaca Lake Actual	Pans - Cuyamaca No. 1 In water		No. 2 In ground	
May	7.27"			8.38	86%
June	5.24"	9.25	57%	8.90	59%
July	4.05"	8.18	50%	8.99	45%
August	2.78"	7.94	35%	8.96	31%
September	4.39"	9.68	55%	9.39	47%
1914.					
March	4.94"	7.20	68%	5.26	94%
April	2.00"	5.60	36%	5.50	36%
May	6.70"	7.53	89%	6.19	108%
June	9.24"	8.82	104%	10.02	91%
Mean			62%		66%

The conclusion from the above is that in a general way the actual evaporation in the reservoirs is 62% of a pan floating in water, and is 66% of a pan in ground.

The above tables are combined in the following table using the percentage obtained to interpellate the actual evaporation for those months during which it can not be observed. Mean monthly temperatures are also shown.

Table No. 5.

GROSS EVAPORATION AT CUYAMACA

Month	1912. Temp.	1912. Actual Evap.	1912. Pan 1 in water	1912. Pan 2 in ground	1913. Temp.	1913. Actual Evap.	1913. Pan 1 in water	1913. Pan 2 in ground	1914. Temp.	1914. Actual Evap.	1914. Pan 1 in water	1914. Pan 2 in ground	Mean Actual
January					35°		--	--		+ 1.52	--	2.30	1.52
February					38°		--	--		# 2.20	--	3.32	2.20
March					39°		--	--		4.94	7.20	5.26	4.94
April					49°	# 4.05	--	6.15		2.00	5.60	5.50	3.02
May					56°	7.27	--	8.38		7.08	7.53	6.19	7.18
June	65°	9.89	--	--	59°	5.24	9.25	8.90		9.24	8.82	10.02	8.12
July	63°	3.58	--	--	67°	4.05	8.18	8.99					3.81
August	67°	8.39	--	--	68°	2.78	7.94	8.96					5.59
September	63°	6.48	--	--	65°	4.39	9.68	9.39					5.43
October	54°	5.60	--	--	54°	# 4.60	6.86	7.49					5.10
November	54°	0.61	--	--	45°	# 3.20	5.63	4.40					1.91
December	42°	5.00	--	--	38°	# 1.65	2.85	2.30					3.32
												Total	52.14

+ # Pan No. 2 x 66%.

EVAPORATION ON WARNER RESERVOIR.

Similar Pans are installed on the site of Warner Reservoir.

Pan No. 3 - 9" x 9" x 12" Pan is installed in air at the Engineer's House at Warner's Dam Site. The sides of the pan are insulated with wood, but subject to direct rays of the sun.

Pan No. 4 - 3' x 3' x 1½' deep - is located in pond along side concrete wall of dam floating in water.

Pan No. 5 - 3' x 3' x 1½' deep - is located 5 miles east floating on Big Lake, in the center of Warners Ranch. This pan and the preceding are on opposite sides of the future Reservoir.

Pan No. 6 - 3' x 3' x 1½' deep - is in marsh ground adjoining Big Lake and near Pan No. 5. A rain gage is also installed here.

Table 4 exhibits the result of observations on these pans. The observed evaporation in pans is multiplied by 46% in the case of air, 62% floating in water and 66% for ground pans, - to derive "actual evaporation."

TABLE 4.

EVAPORATION

WARNER DAM - BIG LAKE

Drawing No 433
File No A-80

Year and Month	WARNER DAM: No 3 Air	WARNER DAM: No 3 x 46%	WARNER DAM: No 4 Water	WARNER DAM: No 4 x 62% = Actual	BIG LAKE: No 5 Water	BIG LAKE: No 5 x 62% = Actual	BIG LAKE: No 6 Ground	BIG LAKE: No 6 x 66% = Actual	BIG LAKE: Mean actual Big Lake	Average Warner & Big Lake Actual
1912										
Jan	-									-
Feb	-									-
Mar	1.57	.72								.72
Apr	4.26	1.96								1.96
May	6.26	2.88								2.88
June	8.42	3.88	11.30	7.00)	Small pan					5.44
July	8.62	3.92	10.30	6.40)	in shallow		N O N E			5.16
Aug	9.06	4.15	9.20	5.70)	water					4.92
Sept	7.22	3.32	9.45	5.80)						4.56
Oct	3.95	1.82	-							1.82
Nov	2.88	1.32	-							1.32
Dec	4.97	2.29	-							2.29
1913										
Jan	4.12	1.90	-		-		-			1.90
Feb	3.01	1.38	4.12	2.55	-		-			1.38
Mar	5.93		3.79	2.36	4.31	2.66	3.58	2.35	2.50	2.43
Apr	5.77		4.17	2.58	5.71	3.44	4.97	3.29	3.37	2.98
May	7.15		3.89	2.41	6.03	3.75	4.96	2.48	3.12	2.76
June	7.40		4.41	2.73	5.76	3.56	4.66	2.35	2.95	2.84
July	10.07		4.42	2.73	6.51	4.04	6.67	4.40	4.22	3.47
Aug	9.62		3.72	2.31	5.53	3.44	5.85	3.86	3.65	2.98
Sept	9.04		4.01	2.49	6.18	3.81	6.73	4.45	4.13	3.31
Oct	6.68		4.93	3.06	6.29	3.89	4.90	3.25	3.57	3.32
Nov	5.36		3.30	2.05	3.67	2.28	2.82	1.87	2.08	2.06
Dec	2.77		3.40	2.10	2.79	2.54	1.93	1.28	1.81	1.95
1914										
Jan	3.05		2.76	1.72	1.69	1.05	1.70	1.12	1.08	1.40
Feb	3.38		-	-	3.50	2.17	2.67	1.76	1.94	1.94
Mar	5.55		4.11	2.55	4.60	2.85	3.49	2.30	2.58	2.57
Apr	5.70		4.24	2.64	4.98	3.09	3.07	2.03	2.56	2.60
May	6.23		4.87	3.02	5.23	3.24	3.30	2.18	2.71	2.86
June	-		6.31	4.93	6.61	4.10	4.34	2.85	3.47	4.20

TABLE NO. 5.

THE MEAN "ACTUAL" EVAPORATION,

averaged between Warner Dam and Big Lake, is given below - 3 years - Values derived from air, ground and water pans.

January	1.65
February	1.66
March	1.91
April	2.51
May	2.83
June	4.16
July	4.32
August	3.95
September	3.93
October	2.57
November	1.69
December	2.14
	33.32 Inches.

TABLE NO. 6.

LA MESA RESERVOIR

Observed Evaporation in Pan in Water

	Cuyamaca Water Company La Mesa Reservoir Pan No. 7.			La Mesa Mean x 62% = Actual
	1913	1914	Mean	
January	1.59	2.37	1.98	1.23
February	4.23	2.94	3.58	2.22
March	4.51	6.76	5.64	3.50
April	6.19	7.45	6.82	4.24
May	7.54	5.79	6.66	4.13
June	6.98	7.95	7.47	4.63
July	9.64		9.64	5.98
August	8.45		8.45	5.25
September	8.21		8.21	5.10
October	6.48		6.48	4.02
November	3.42		3.42	2.13
December	2.70		2.70	1.68
	69.94"		71.05"	44.11"

TABLE NO. 7.

SUMMARY OF ACTUAL EVAPORATION.

Month.	Cuyamaca Lake	Warner Reservoir	La Mesa Reservoir	Sweetwater Reservoir	Salton Sea
Elev.	4600	2700	500	250	- 250
Jamuary	1.52	1.65	1.23	1.51	
February	2.20	1.66	2.22	1.28	
March	4.94	1.91	3.50	1.98	
April	3.02	2.51	4.24	2.89	
May	7.18	2.83	4.13	3.44	
June	8.12	4.16	4.63	4.13	NO DETAILS
July	3.81	4.32	5.98	4.68	
August	5.59	3.95	5.25	5.08	
September	5.43	3.93	5.10	4.06	
October	5.10	2.57	4.02	3.22	
November	1.91	1.69	2.13	2.97	
December	3.32	2.14	1.68	1.15	
	62.14"	33.32"	44.11"	36.39"	69.00"

O.K

6-7% more in 90%

6-7% more in 90

← Average of these two →

CONCLUSIONS

No clear rule for the relation of temperature to evaporation has been discovered in these observations; although the weight of authority would seem to require it. An exception is the La Mesa Reservoir series which shows a variation with temperature.

It is suggested that the local topography and effect of the ocean winds decidedly interfere with pure evaporation due to temperature. One element is the well known morning fog blanket of May and June along the coast and even reaching Warner's Reservoir. Another element is the Sonora winds sweeping from the south east in the Fall. These winds are dry and of high velocity, and presumably explain the sustained evaporation on Cuyamaca Reservoir in the late Fall. On the other hand, the topography of Smith Mountain appears to deflect these dry winds in the case of Warner's Reservoir, so as to go through the passes near Oak Grove, Temecula and beyond to where these winds are actually called Santa Anas. Another element is the summer thunder storms at Cuyamaca and Warner's Reservoirs, bringing high humidity and sudden variations of temperature. These storms are probably of Gulf of Mexico origin and appear along with the summer cloudburst period of Arizona. They do not reach the Coast; and the coast pans at La Mesa and Sweetwater could not be affected by them.

USE OF THESE DATA

In applying these results of "gross actual evaporation" to mass curves the following method will be used.

From gross evaporation will be deducted about 90% of the rainfall to determine net or practical evaporation - the theory being that stream measurements indicate a run-off of say 10% of the rainfall. In the case of a reservoir, the rainfall is clear gain, and therefore should be allowed. But 10% has already been accounted for in stream flow, and therefore only the balance, say 90%, should be used in net evaporation.

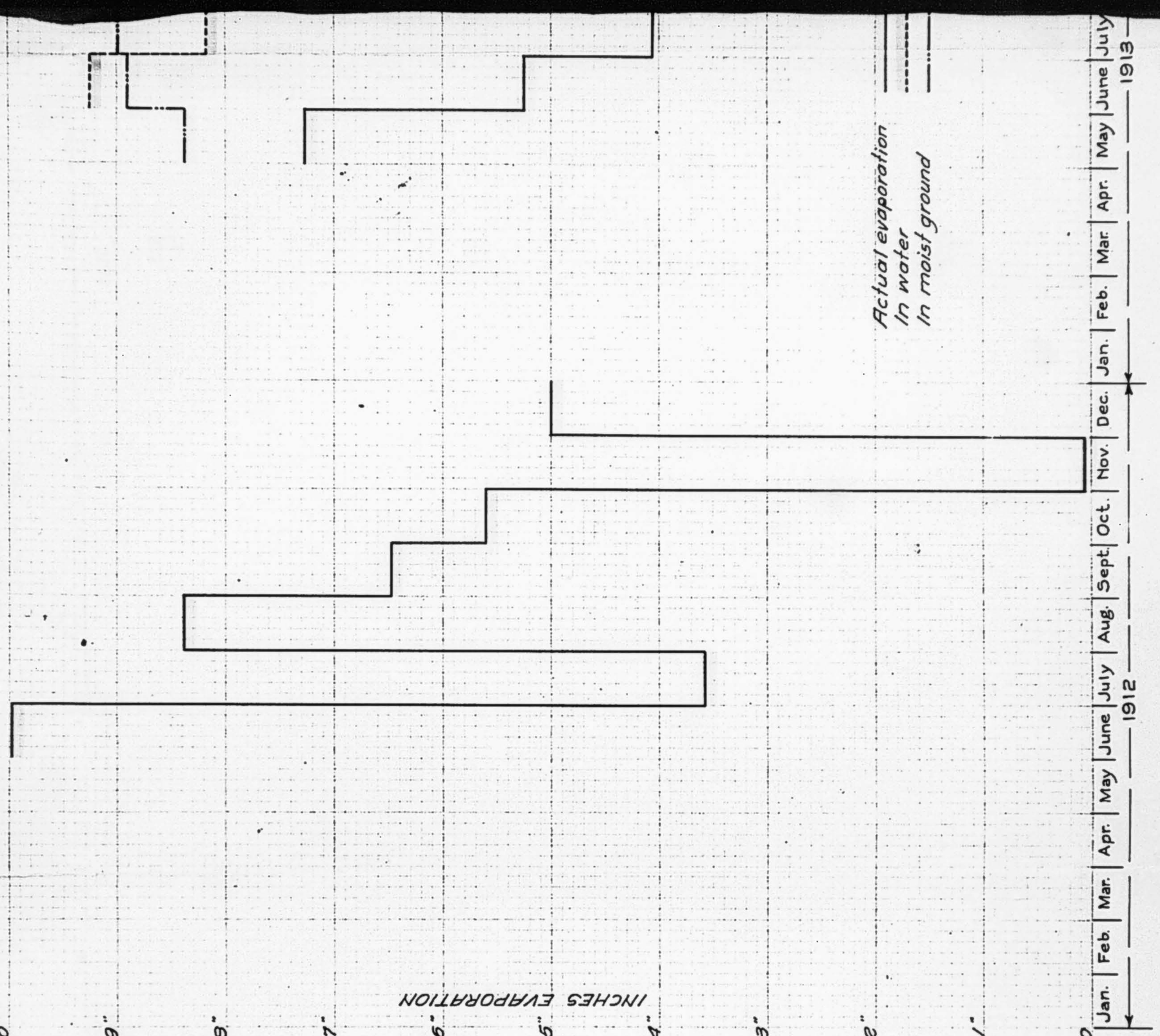
This makes net evaporation vary decidedly from year to year. Further where mass curves are studied month by month, net evaporation (as defined) may be negative or a gain to the reservoir. However, to avoid complicating monthly mass curves in such case, the net evaporation will be simply made equal to zero.

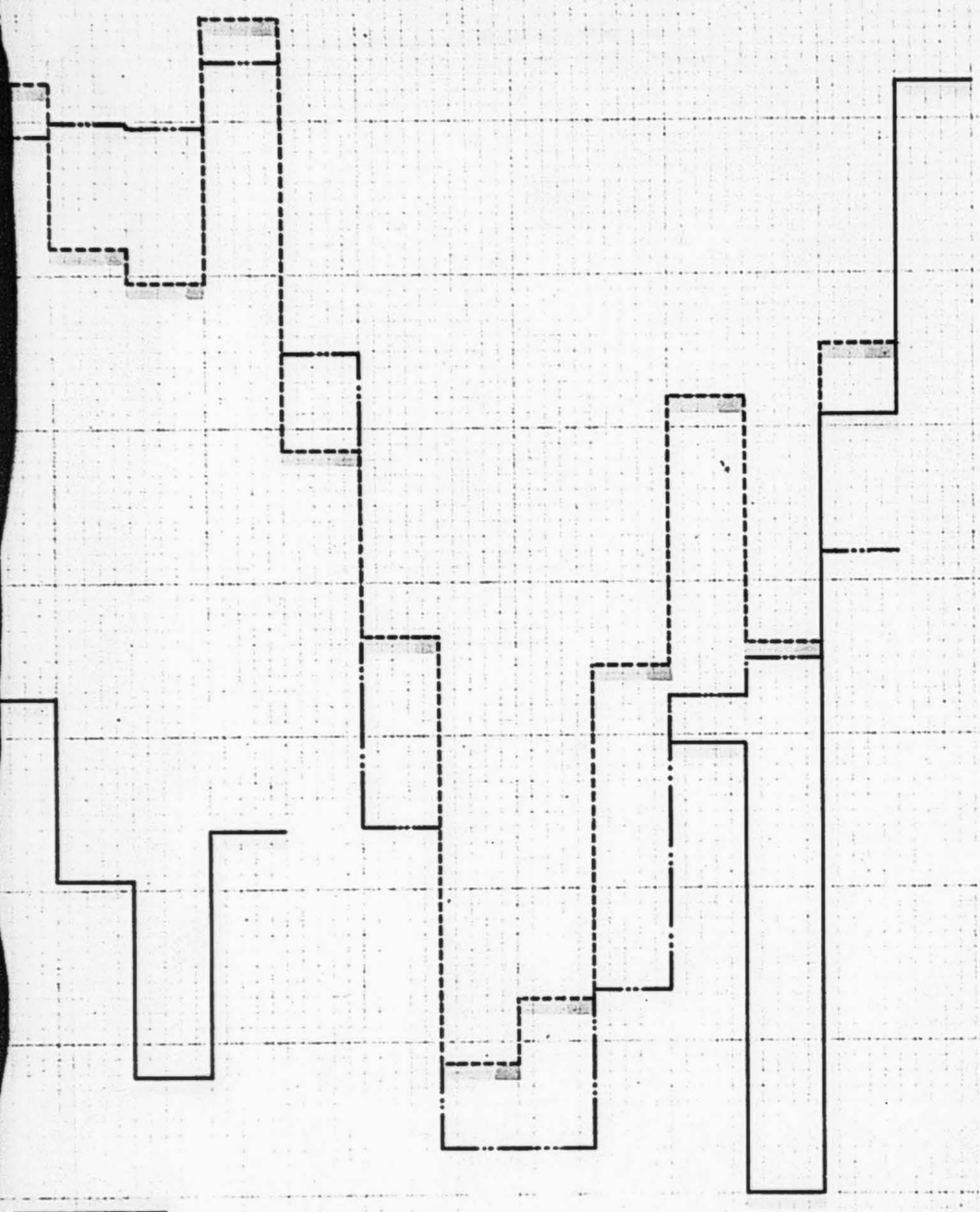
July 15th, 1914.

WSP-BK

File No. E-60
Drawing No. 431

Evaporation Curve, Chatsworth Reservoir





VOLCAN LAND & WATER CO.

EVAPORATION CURVE

FOR

CUYAMACA RESERVOIR

—SCALES—

Horizontal: $\frac{1}{2}$" = 1 Month

Vertical: 1" = 1" Evaporation

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Drawing No 431

File No F-60

431. Evaporation curve
F-60, Cuyamaca Reservoir

EVAPORATION IN INCHES

INCHES EVAPORATION

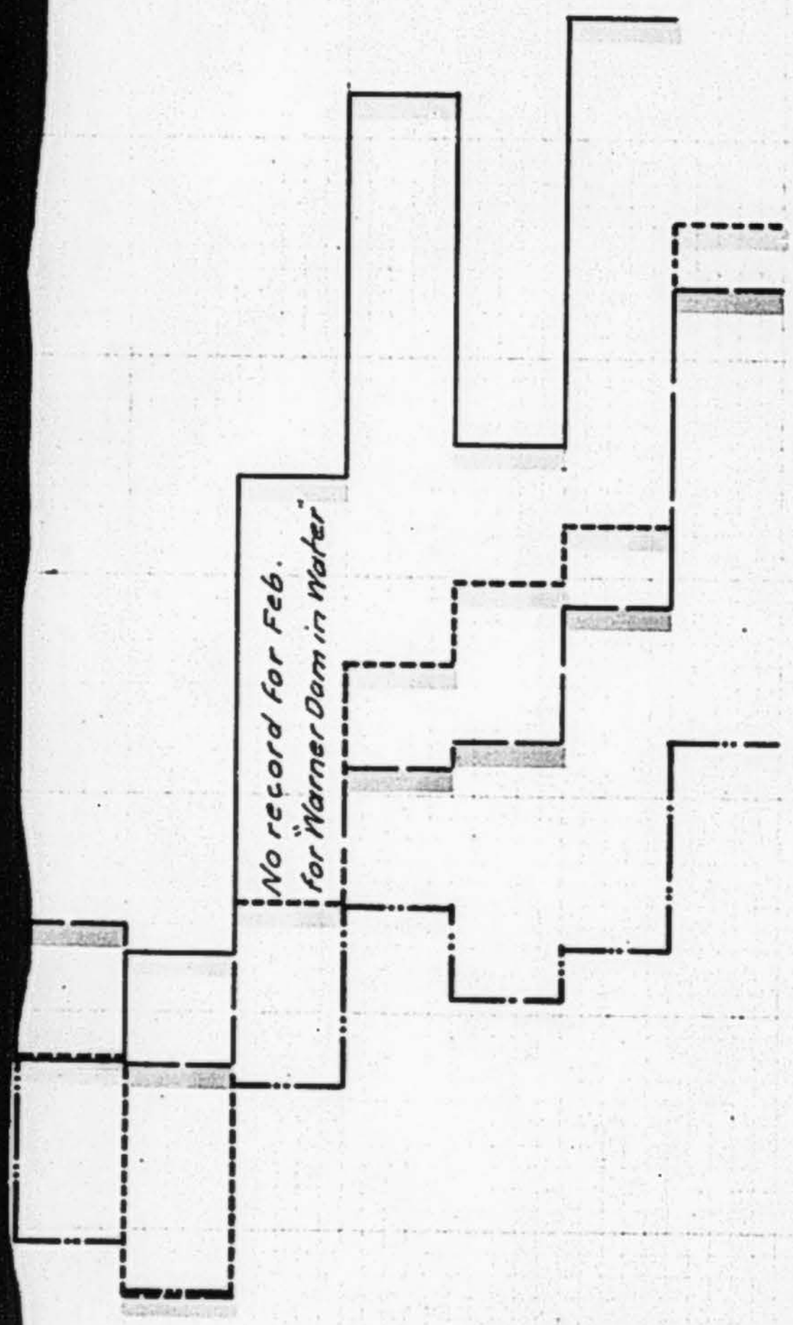
10
9
8
7
6
5
4
3
2
1
0

11.30"
10"
9"
8"
7"
6"
5"
4"
3"
2"
1"
0"

—LEGEND—
Warner Dam in air
" " in water
Big Lake in water
" " ground

Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan.

1912 — 1913



VOLCAN LAND & WATER CO.

EVAPORATION CURVE

FOR

WARNER DAM

AND

BIG LAKE

—SCALES—

Horizontal: 1" = 1 Month
Vertical: 1" = 1" Evaporation

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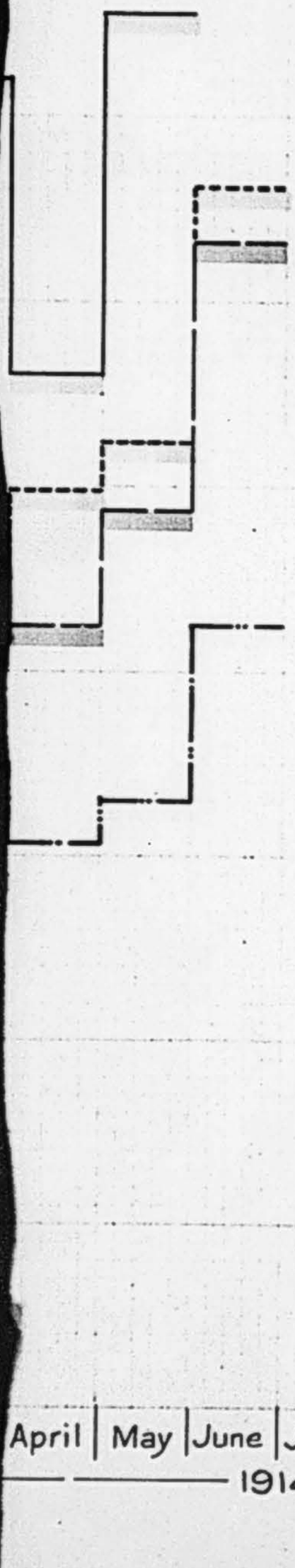
YAO

Drawing Nº 430

File Nº F-60



VOLCAN LAND & WATER CO.

EVAPORATION CURVE

FOR

WARNER DAM

AND

BIG LAKE

—SCALES—

Horizontal: 1" = 1 Month
Vertical: 1" = 1" Evaporation

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Drawing No 430

File No F-60

430 Evaporation Canyon

F-60 Warner Dam & Big Lake

Ed Fletcher Papers

1870-1955

MSS.81

Box: 41 Folder: 5

Business Records - Reports - Post, W.S - "Report: Results from Evaporation Studies of Volcan Co."