REPORT NO. 19

SUPPLEMENTAL STORAGE REQUIREMENTS

above

BEAR LAKE

1- Segregation of lands
sections & Acreage

2- Ac ft/acre diversions
by Sections

3- G.S. & Bureau Cons. Use
Studies.

4- Pge 21 value of k & efficiency
factor

5- Pge 30 - Storage
req'd at Willard

6- Pge 35 - storage
req'd at [illegible]

7- Smiths Fk - [illegible]
need none for suppl. storage

8- Tho's Fk - not covered

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U. S. Geological Survey

August 9, 1951

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FOREWORD

Additional storage upstream from Bear Lake is one of the major issues facing the negotiators of a compact dividing the waters of Bear River between the States of Idaho, Utah, and Wyoming. Water users above the lake have insisted they are entitled to an equitable share of the storable waters of the river system. On the other hand, water users below Bear Lake maintain there are no storable waters available for new storage above the lake in excess of present rights and uses.

Normally, the major portion of the natural flow runoff in the upper basin occurs in April, May and June, and those dependent on natural flow are practically without water for the balance of the season. The principal crops raised in the upper basin are wild hay and native grasses and for maximum return from this type of crop, adequate water should be available from about May 1, to about mid-July.

Since irrigation supplies are not available throughout the growing period, much early irrigation is practiced before crop growth begins, which is both wasteful of water and harmful to the lands. Upstream water users have indicated that if supplemental storage supplies were available to them they would discontinue the practice of early and excessive irrigation.

The purpose of this report is to present a study and data on supplemental storage requirements of lands above Bear Lake. The study is principally limited to those lands for which storage sites and storable supplies are available. It would be a waste of effort to include lands for which no reasonable storage facilities are available, or for which present natural flow supplies are adequate for most years.

SUPPLEMENTAL STORAGE REQUIREMENTS FOR LANDS
ABOVE BEAR LAKE

SEGREGATION OF LANDS

In order to analyze the supplemental storage requirements of lands above Bear Lake, it is necessary to segregate the lands as to sources of water supply. This segregation can be made in conformity with the State sections as defined in the "Tentative Draft of a Bear River Compact" and the basin divisions as prescribed in the later "Proposed Draft of a Bear River Compact." It is believed such a segregation will avoid confusion and facilitate the study of this report. The land areas are defined as follows:

A. Upper Division

1. Upper Wyoming Section

   Area served by canals diverting from Bear River above the Woodruff Narrows, comprising approximately 39,600 acres. Sometimes referred to as the Evanston area. does not include Francis [illegible] Bear R.

2. Lands Served by major streams tributary to Upper Wyoming Section.

   a. Mill Creek

   b. Sulphur Creek

   c. Yellow Creek

3. Middle Utah Section

   Area served by canals diverting from Bear River between Woodruff Narrows and the Utah-Wyoming State line below Randolph, comprising approximately 37,200 acres. Sometimes referred to as the Woodruff-Randolph area. Includes [illegible]

4. Areas served by West Side streams tributary to Middle Utah Section.

a. Woodruff Creek

b. Big Creek

c. Randolph Creek

d. Otter Creek

5. Middle Wyoming Section

Area served by canals diverting from Bear River between the Utah-Wyoming State line below Randolph and the mouth of Sublette Creek, comprising approximately 8,300 acres.

6. Lands served by streams tributary to Middle Wyoming Section

a. Twin Creek

B. Central Division

1. Lower Wyoming Section

Area served by canals diverting from Smiths Fork and area served by canals diverting from Bear River between the mouth of Sublette Creek and the Wyoming-Idaho State line at Border, comprising approximately 15,200 acres.

2. Lands served by streams tributary to Lower Wyoming Section.

a. Sublette Creek

b. Pine Creek

c. Other small tributaries to Smiths Fork

3. Upper Idaho Section

Area served by canals diverting from Bear River between the Wyoming-Idaho State line at Border and Stewart Dam, comprising approximately 23,300 acres.

4. Lands served by streams tributary to Upper Idaho Section.

a. Thomas Fork

C. Lower Division

All lands served by Bear River and tributaries below Stewart Dam and including Bear Lake.

PREVIOUS REPORT OF ENGINEERING COMMITTEE

In the report titled "Report of Engineering Committee to Bear River Compact Commission" dated June 15, 1949, determinations were made of supplemental water supply needed by water users served by canals diverting from the main stem of Bear River above Bear Lake for 1944, 1946, and 1947. Two different methods of determination, designated as Plan "A" and Plan "B" were used. These two plans and the supplemental requirements thereby determined are as follows:

<u>Plan A:</u>

1. Assumed seasonal requirement in acre-feet per acre for headgate delivery in each river section to be:

   Upper Wyoming Section, 2.80 acre-feet per acre (40,000 acres)
   Middle Utah Section, 3.00 acre-feet per acre (37,200 acres)
   Middle Wyoming Section, 3.00 acre-feet per acre (8,300 acres)
   Lower Wyoming Section, 3.20 acre-feet per acre (15,200 acres)
   Upper Idaho Section, 3.40 acre-feet per acre (23,300 acres)

2. The type of crop pattern to be served shall be based on the indicated average monthly percent of total seasonal diversions (May to September) of the Lower Wyoming and Upper Idaho Sections for 1944, 1946 and 1947. In those three years, the supply for these sections for the most part, exceeded the demand. The 1945 season was omitted because of the effect of the abnormally high precipitation which occurred during the irrigation season. In general, this plan would serve a more diversified crop pattern than now exists.

Distribution in Percent of Total Requirement

Month		Percent of Total Requirement	1967
April		0	0
May		20	16
June		30	39
July		30	23
August		15	11
September		5	11
	Season	100	

3. The division of natural flow waters during periods of low flow shall be as set forth in the tentative draft.

4. Supplemental requirement to be determined only for the years 1944, 1946, and 1947.

Plan B:

1. Assumed seasonal requirement to be that necessary to furnish an estimated full diversion demand through July 31 in each year.

2. Type of crop pattern to be served shall be predominately wild hay as now exists. Rate of diversion shall be limited to a maximum of one cubic foot per second for each fifty acres. Pattern of diversion shall begin May 1, follow actual diversion, until maximum rate is reached, then continue at maximum rate until July 31, after which canals would cut down to natural flow supply for balance of season.

3. The present natural flow supply is assumed to correspond to the division of natural flow waters as set forth in the tentative draft.

4. Supplemental requirement to be determined only for the years 1944, 1946, and 1947.

TABLE 1

Summary of Supplemental Requirement
Acre-Feet

	PLAN A			PLAN B		
Section	1944	1946	1947	1944	1946	1947
Upper Wyoming	31,200	46,800	21,600	24,820	47,220	23,300
Middle Utah	31,900	46,700	21,400	24,820	47,220	23,300
Middle Wyoming	5,560	8,780	1,595	1,520	6,140	730
Lower Wyoming	1,520	1,520	340	5,130	6,560	3,170
Upper Idaho	0	0	0	0	0	0

It is to be kept in mind that these determinations are headgate requirements and do not take into account acreage limitations because of available storage sites and return flows. Storage water return flows would probably decrease the total requirement by as much as 30 to 50 percent.

BUREAU OF RECLAMATION DIVERSION REQUIREMENT STUDIES

The Logan Project Office of the Bureau of Reclamation, in connection with storage project investigations, has made consumptive use studies in the basin, using the Lowry-Johnson method. These studies were based on climatological data available at various locations in the basin and would be applicable to the lands in the general vicinity of the climatological station. Table 2 shows the data furnished by the Bureau, summarizing these studies. It is to be kept in mind that the resultant figures shown in the table are for an irrigation season extending from May through September, for a more efficient class of irrigation than is currently practiced, and with canal losses of about 40 percent.

TABLE 2

CONSUMPTIVE USE DATA BASED ON LOWRY-JOHNSON METHOD (a)

Climatological Station	Growing Period			Computed Consump. Use af/ac	Effective Precip. Ft.	Net Consmp. Use af/ac	Monthly Distribution Percent of Total Requirement							Average Divers. Reqmt. (b) af/ac
	Beginning Date	Ending Date	Length Days				Apr.	May	June	July	Aug.	Sept.	Oct.	
Evanston, Wyo.	5-29	9-20	115	1.61	.22	1.39	0	3	22	30	29	16	0	2.4
Woodruff, Utah	5-25	9-10	109	1.60	.19	1.41	0	4	25	33	29	9	0	2.6
Lifton, Idaho	5-6	9-26	144	1.90	.43	1.47	0	12	21	29	27	11	0	2.5
Grace, Idaho	5-2	9-30	151	1.98	.40	1.58	2.4	10.1	15.4	27.2	25.4	17.1	2.4	2.8
Preston, Idaho	5-2	10-4	156	1.74	.41	1.33	2.1	11.6	15.8	26.3	24.7	16.9	2.6	3.2
Logan, Utah	4-7	10-31	208	1.90	.50	1.40	3.5	10	15	24.5	23	15	9	3.3

(a) Data furnished by Bureau of Reclamation.

(b) Includes estimated conveyence losses and farm waste.

ACTUAL DIVERSIONS 1944 to 1947

During the irrigation seasons in the water years 1944 to 1947, discharge records were obtained for all canals diverting from Bear River. In addition, records were collected on Lower Wyoming and Upper Idaho canals in 1948 and the Middle Utah canals in 1950. The following tabulations show May to September monthly diversions in acre-feet per acre and percentage distributions in river sections:

TABLE 3

Upper Wyoming Section Diversions - 39,600 acres
Acre-Feet per Acre

Year	May	June	July	Aug.	Sept.	Total
1944	0.39	0.93	0.57	.10	.05	2.04
1945	.40	.99	.74	.27	.08	2.48
1946	.64	.91	.30	.09	.04	1.98
1947	.70	.93	.60	.23	.14	2.60
Average	.54	.94	.55	.17	.08	2.28

TABLE 4

Middle Utah Section Diversions - 37,200 acres
Acre-Feet per Acre

Year	May	June	July	Aug.	Sept.	Total
1944	0.97	1.25	.46	.01	.01	2.70
1945	1.02	1.20	.58	.12	.03	2.95
1946	.92	.86	.08	.02	.02	1.90
1947	1.13	1.12	.49	.08	.05	2.87
1950	.82	1.54	.59	.05	.08	3.08
Average	.97	1.19	.44	.06	.04	2.70

TABLE 5

Middle Wyoming Section Diversions - 7,800 Acres
Acre-Feet per Acre

Year	May	June	July	Aug.	Sept.	Total
1944	.95	2.14	.22	0	0	3.31
1945	1.29	2.09	.38	0	0	3.76
1946	1.77	1.26	.04	0	0	3.07
1947	1.17	1.45	0	0	0	2.62
1948	.98	1.01	.01	0	0	2.00
Average	1.23	1.59	.13	0	0	2.95

TABLE 6

Lower Wyoming Section Diversions - 15,600 Acres
Acre-Feet per Acre

Year	May	June	July	Aug.	Sept.	Total
1944	0.39	1.42	1.36	0.69	0.55	4.41
1945	.53	1.68	1.37	.76	.29	4.63
1946	.63	1.69	1.25	.55	.28	4.40
1947	.57	1.58	1.27	.70	.27	4.39
1948	.62	2.00	1.30	.80	.60	5.32
Average	.55	1.67	1.31	.70	.40	4.63

TABLE 7

Upper Idaho Section Diversions - 23,300 Acres
Acre-Feet per Acre

Year	May	June	July	Aug.	Sept.	Total
1944	.92	1.24	.63	.37	.30	3.46
1945	.61	1.13	.70	.31	.14	2.89
1946	.94	1.22	.64	.36	.22	3.38
1947	.87	1.36	.55	.28	.25	3.31
1948	.56	1.17	.66	.35	.33	3.07
Average	.78	1.22	.64	.33	.25	3.22

TABLE 8

Summary of Average Diversions
Acre-Feet per Acre

Section	May	June	July	Aug.	Sept.	Total
Upper Wyo.	.54	.94	.55	.17	.08	2.28
Middle Utah	.97	1.19	.44	.06	.04	2.70
Middle Wyo.	1.23	1.59	.13	0	0	2.95
Lower Wyo.	.55	1.67	1.31	.70	.40	4.63
Upper Ida.	.78	1.22	.64	.33	.25	3.22

TABLE 9

Diversion Percentage by Months

Section	May	June	July	Aug.	Sept.	Total
Upper Wyo.	24	41	24	8	3	100
Middle Utah	36	44	16	2	2	100
Middle Wyo.	42	54	4	0	0	100
Lower Wyo.	12	36	28	15	9	100
Upper Idaho	24	38	20	10	8	100

Tables 8 and 9 illustrate the pattern of the water supply available in each river section. In the upper three sections, practically all of the seasons runoff is concentrated in May and June and the supply usually decreases very rapidly about July 1. As a result, these three sections divert excessive amounts in May and June and suffer a deficiency thereafter, especially in July. In the lower two sections, the supply is more uniformly distributed throughout the irrigation season, because of the peculiar natural controlled runoff characteristics of the Smiths Fork drainage.

CONSUMPTIVE USE STUDIES IN UPPER BEAR RIVER BASIN

A study of stream flow depletions and consumptive use has been made for the period May 1 to September 30 in 1944, 1946, 1947 and 1948 and presented in a report by the author titled "Stream Flow Depletions and Consumptive Use in Bear River Basin above Border, Wyoming" dated Dec. 14, 1950. In that study constants were derived for the Blaney-Criddle equation for determining Consumptive use. The derived equations and definitions of terms used are as follows:

<u>Equations</u>

Upper Wyoming Section

$$U = 0.855\ F + 2.90$$

Headgate efficiency coeff. = 0.52

Middle Utah Section

$$U = 0.614\ F + 9.06$$

Headgate efficiency coeff. = 0.51

<u>Definition of Terms</u>

U = Consumptive use in inches depth of water from irrigation and rainfall on cropped lands during the period May 1 to Sept. 30.

F = $\frac{\Sigma tp}{100}$ = Sum of monthly use factors = Sum of the products of the mean monthly temperatures and monthly percent of annual day time hours for that portion of the "irrigation-growing period" between the day following the end of extreme freezing or May 1, whichever is the later and the day major irrigation from Bear River source ceases plus 14 days or the day of the first hard freeze, whichever is the earlier.

t = Monthly mean temperature in degrees Fahrenheit.

p = Monthly percent of daylight hours of the year.

Precipitation is assumed to be one-hundred percent beneficial.

A comparison of the total consumptive use and total water applied in irrigation (headgate diversions ≁ precipitation supply), indicated that total consumptive use averaged about 50 percent of the water applied in irrigation. This comparison expressed as a ratio is called the headgate efficiency coefficient.

These equations provide means for determining seasonal consumptive use for irrigation periods of different lengths in the designated river sections and should be reasonably applicable to portions of each section as well as the whole. With consumptive use known, the headgate irrigation requirement can be computed after applying the efficiency coefficient and allowing for precipitation. It is to be kept in mind that the derived equations of consumptive use include other valley losses in addition to losses from irrigated lands. — Valley Cons. Use —

Native hay and grasses are the principal crops raised in the upper division of the basin. This type of vegetation begins growing when extreme freezing ceases and is ready for harvesting late in July. For maximum growth, a full irrigation supply is needed from about May 1 to mid-July. The average seasonal consumptive use and irrigation water requirement can be determined by substituting average monthly values of temperature and precipitation in the equations. Climatological data at Evanston, Wyoming will serve for the Upper Wyoming Section and like data at Woodruff, Utah will serve for the Middle Wyoming Sections. Consumptive use in the Middle Wyoming Section should be practically the same as that for the Middle Utah Section.

Average Temperature and Precipitation Data

TABLE 10

Monthly Mean Temperatures and Precipitation - Evanston, Wyoming

Month	Temperature °F	Precipitation Inches
May	46.8	1.36
June	53.9	1.00
July	62.2	.96
August	60.7	1.10
September	52.4	1.01

TABLE 11

Monthly Mean Temperatures and Precipitation - Woodruff, Utah

Month	Temperature °F	Precipitation Inches
May	47.3	1.04
June	54.9	.85
July	61.8	.82
August	60.1	.98
September	51.5	.87

TABLE 12

Monthly Percent of Daytime Hours of the Year

Month	Daytime Hours Monthly Percent
May	10.14
June	10.21
July	10.35
August	9.62
September	8.40

Computation of Consumptive Use and Headgate Requirement

A full water supply from May 1 to mid-July is needed for the type of crops common in the upper basin areas. The definition of "irrigation-growing period" specifies that 14 days is to be added to the irrigation period in determining the consumptive use factor. For all practical purposes, the irrigation-growing period would then be from May 1 to July 31 and the factor determined for this period. Application of equations by sections is as follows:

Upper Wyoming Section

$$U = 0.855\,F + 2.90$$

$$U = 0.855\left[\frac{46.8 \times 10.14}{100} + \frac{53.9 \times 10.21}{100} + \frac{62.2 \times 10.35}{100}\right] + 2.90$$

U = 17.16 inches depth per acre

Headgate efficiency coefficient = 0.52

Precipitation May 1 to Sept. 30 = 5.43 inches

$$\text{Headgate Requirement} = \frac{17.16}{.52} - 5.43 = 27.57 \text{ inches depth per acre}$$

$$= 2.30 \text{ ac.-ft. per acre}$$

Middle Utah and Middle Wyoming Sections

$$U = 0.614\,F + 9.06$$

$$U = 0.614\left[\frac{47.3 \times 10.14}{100} + \frac{54.9 \times 10.21}{100} + \frac{61.8 \times 10.35}{100}\right] + 9.06$$

U = 19.38 inches depth per acre

Headgate efficiency coefficient = 0.51

Precipitation May 1 to Sept. 30 = 4.56 inches

$$\text{Headgate Requirement} = \frac{19.38}{.51} - 4.56 = 33.44 \text{ inches depth per acre}$$

$$= 2.78 \text{ ac.-ft. per acre}$$

Lower Wyoming and Upper Idaho Sections

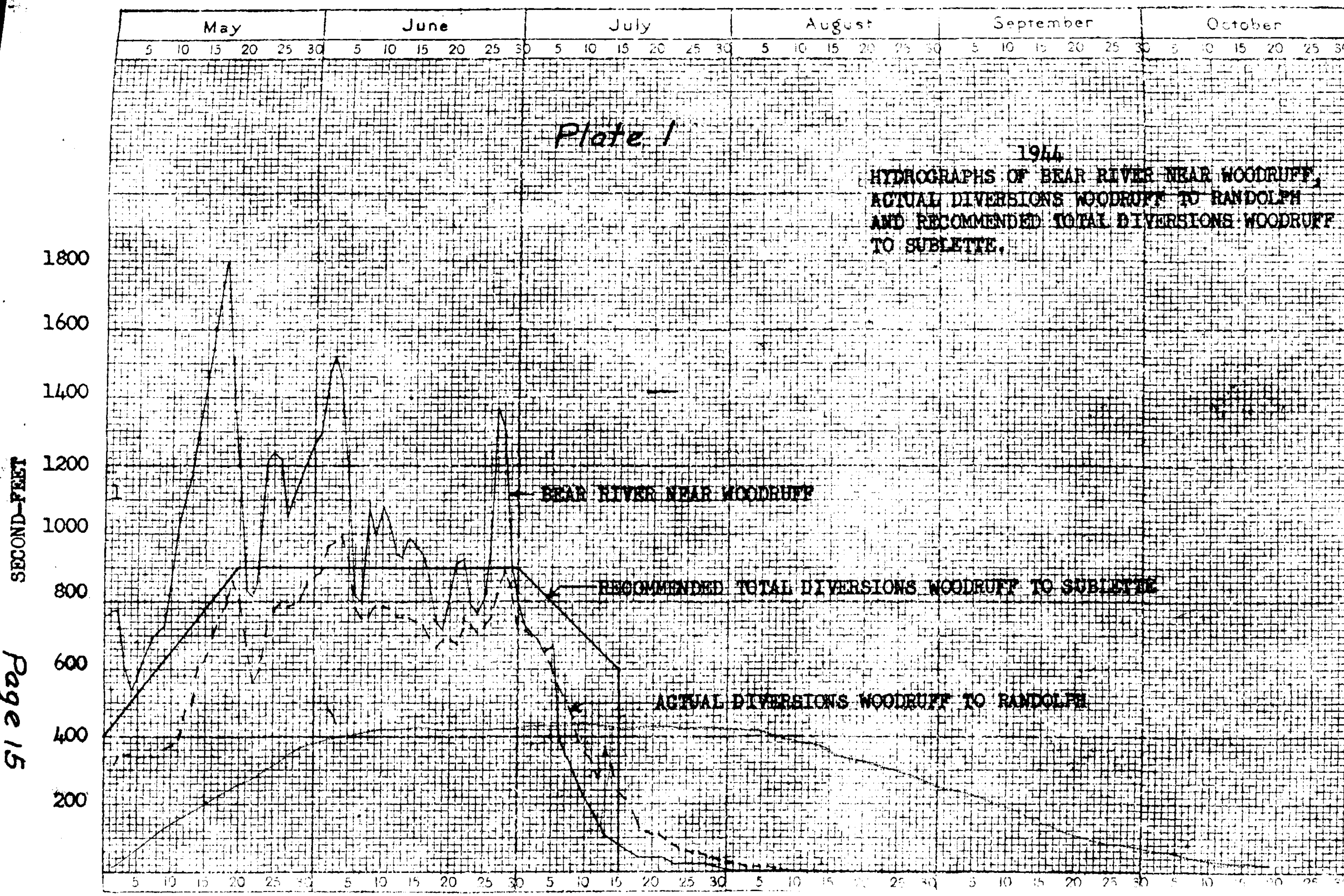
In the consumptive use study it was impossible to determine equations for the Lower Wyoming and Upper Idaho Sections because the gaging stations had not been operated at all control points necessary for the determination of total inflows and total outflows. However, it is believed that because of type of crops grown and a better sustained seasonal distribution of water supply, that these two sections will have greater consumptive use than found for the upstream sections.

A RECOMMENDED METHOD
of
DETERMINING HEADGATE IRRIGATION WATER REQUIREMENT

A review of the previously described consumptive use and water requirement determinations places some doubt on the reliability of the equations in supplying a reasonably exact answer of the amount of water needed in an average year to meet crop requirements. The Lowry-Johnson method is for delivery of water May to September. The Blaney-Criddle equations used show consumptive use May to September, but with the factor computed on a much shorter irrigation-growing period. In the latter method, water use and return flows, after major irrigation ends, may have large effect on the factor "K" and/or the headgate efficiency coefficient.

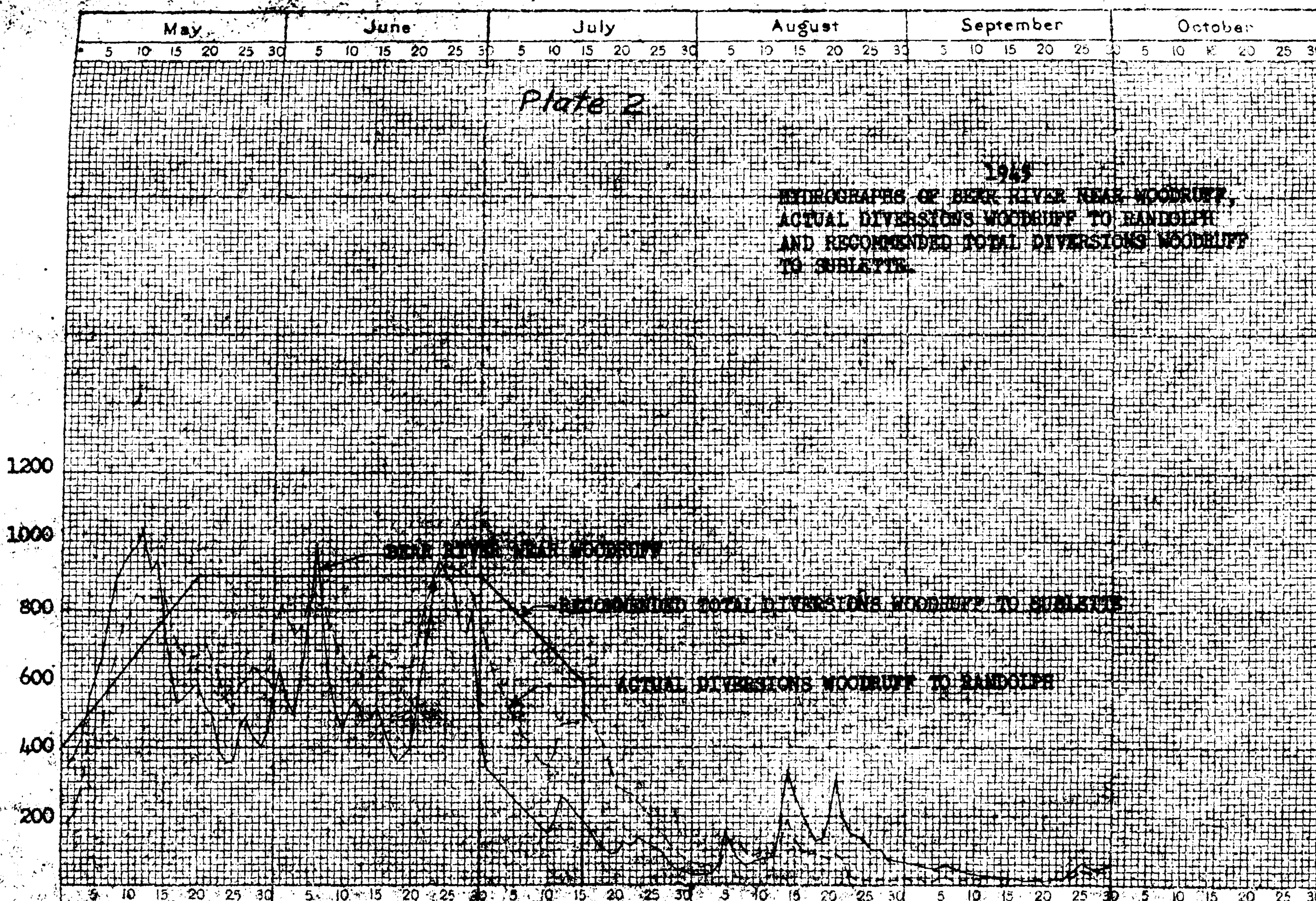
If in the Blaney-Criddle method the consumptive use, consumptive use factor, and headgate efficiency coefficient were all restricted to the irrigation-growing period, there should result a more accurate and usable determination. In the years 1944, 1945 and 1950, the water supplies were adequate and the pattern of irrigation closely coincides with that thought to be needed for the Middle Utah Section. This section can therefore be used as a basis for deriving constants in the Blaney-Criddle equation.

There are 44,000 acres irrigated between Woodruff Narrows and the Randolph control line from Bear River and the West Side creeks. In the tabulations on Pages 18, 19, and 20, the data and derived constants are shown for the years 1944, 1945 and 1950. The "irrigation-growing" period is from May 1 to July 31. Application of irrigation water begins May 1 and ends in mid-July. All quantities are in acre-feet unless otherwise noted. On Plates 1, 2, and 3, pages 15, 16, and 17, are shown the hydrographs of Bear River at Woodruff Narrows and the total Bear River diversions for the years under study. An examination of these hydrographs show how the water supply and pattern of total diversions matches that believed necessary for all years.



May
June
July
August
September
October
Plate 1
1944
HYDROGRAPHS OF BEAR RIVER NEAR WOODRUFF, ACTUAL DIVERSIONS WOODRUFF TO RANDOLPH AND RECOMMENDED TOTAL DIVERSIONS WOODRUFF TO SUBLETTE.
BEAR RIVER NEAR WOODRUFF
RECOMMENDED TOTAL DIVERSIONS WOODRUFF TO SUBLETTE
ACTUAL DIVERSIONS WOODRUFF TO RANDOLPH
SECOND-FEET
1800
1600
1400
1200
1000
800
600
400
200

Plate 2



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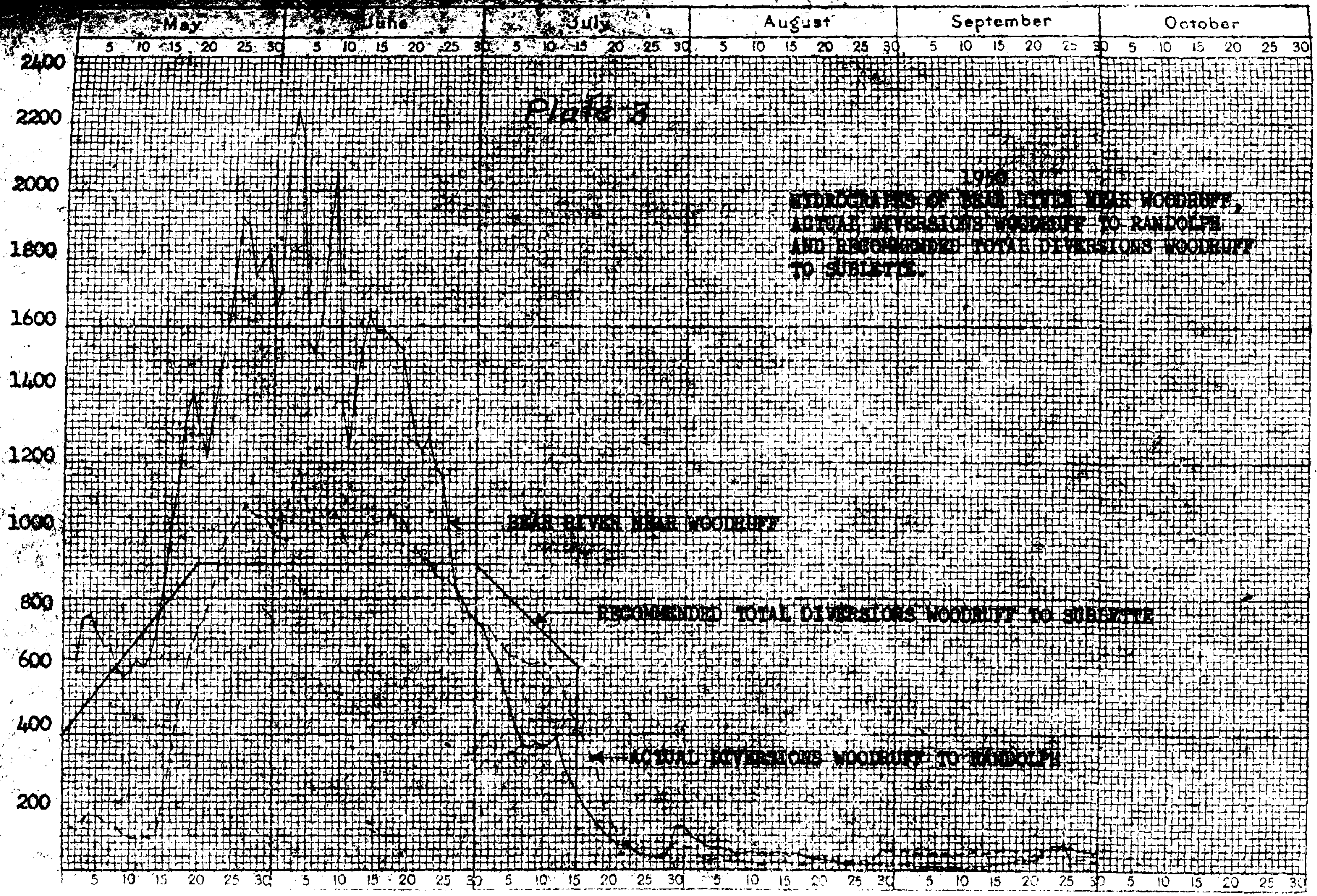


Plate 3
HYDROGRAPHS OF BEAR RIVER NEAR WOODRUFF,
ACTUAL DIVERSIONS WOODRUFF TO RANDOLPH
AND RECOMMENDED TOTAL DIVERSIONS WOODRUFF
TO SUBLETTE.
BEAR RIVER NEAR WOODRUFF
RECOMMENDED TOTAL DIVERSIONS WOODRUFF TO SUBLETTE
ACTUAL DIVERSIONS WOODRUFF TO RANDOLPH
SECOND-FEET
May
June
July
August
September
October

1944 Determination - Middle Utah Section

Total Inflow	May	June	July	Total
Bear River near Woodruff	64,260	59,390	12,150	135,800
Woodruff Creek	8,518	3,656	976	13,150
Big Creek	938	520	410	1,868
Randolph Creek	100	340	475	915
Otter Creek	740	720	740	2,200
Total Inflow	74,556	64,626	14,751	153,933
Total Outflow				
Bear River near Randolph	45,350	43,660	8,670	97,680
B.Q. West Side at Control Line	4,859	3,760	545	9,164
Total Outflow	50,209	47,420	9,215	106,844
Depletion (Inflow minus Outflow)	24,347	17,206	5,536	47,089
Water Applied in Irrigation				
Bear River	31,157	42,758	16,519	90,434
Tributaries	10,296*	5,236*	2,601*	~~18,133~~* 23,851
Total	41,453	47,994	19,120	~~108,567~~ 114,284

* Taken as total Inflow from tributaries.
Will be greater than this because of return flow within section

	May	June	July	Total
Precipitation at Woodruff (inches)	.76	2.41	.87	4.04
Precipitation Supply on 44,000 Acres (ok)	2,780	8,830	3,190	14,800
Total Consumptive Use (Dep. + Precip.)	27,127	26,036	8,726	61,889
Total Consumptive Use Ac.-Ft. per Ac.	.62	.59	.20	1.41
Total Consumptive Use inches per Acre	7.4	7.1	2.4	16.9

~~Should have added prior storage~~

	May	June	July	Total
Monthly Mean Temperature °F (t)	48.6	52.4	60.6	-
Monthly Percent of Daytime Hours (p)	10.14	10.21	10.35	-
Monthly Con. Use Factor $\left[\frac{t \times p}{100}\right]$	4.94	5.35	6.28 (Rep. 12)	16.57 (15.00)

This is only variant from previous study.

$$U = KF \text{ or } K = \frac{U}{F}$$

$$K = \frac{16.9}{16.57} = 1.02$$

Criddle ... = 0.75 for Upper Bear ...

Rep 12 — K = 1.19

Headgate efficiency coefficient = $\frac{61,889}{108,567 + 14,800}$ = .50 = .48

Aug 5.75 Sept

1945 Determination - Middle Utah Section

Total Inflow	May	June	July	Total
Bear River near Woodruff	37,470	36,480	10,140	84,090
Woodruff Creek	7,395	5,185	1,346	13,926
Big Creek	665	729	472	1,866
Randolph Creek	201	243	297	741
Otter Creek	740	720	740	2,200
Total Inflow	46,471	43,357	12,995	102,823
Total Outflow				
Bear River near Randolph	13,630	22,860	6,610	43,100
B.Q. West Side at Control Line	4,959	3,659	687	9,305
Total Outflow	18,589	26,519	7,297	52,405
Depletion (Inflow minus Outflow)	27,882	16,838	5,698	50,418
Water Applied in Irrigation				
Bear River	33,225	41,135	20,962	95,322
Tributaries	~~9,001*~~	~~6,877*~~	~~2,855*~~	~~18,733*~~
Actual tributary diversions	*10,981*	*8,986*	*3,545*	*23,532*
Total	42,226	48,012	23,817	~~114,055~~ *118,854*
* Taken as total inflow from tributaries.				
Precipitation at Woodruff (inches)	1.57	1.37	1.37	4.31
Precipitation Supply on 44,000 Acres	5,750	5,020	5,020	15,790
Total Consumptive Use (Dep. + Precip.)	33,632	21,858	10,718	66,208
Total Consumptive Use Ac.-Ft. Per Ac.	.76	.50	.24	1.50
Total Consumptive Use inches per Acre	9.1	6.0	2.9	18.0

	May	June	July	Total
Monthly Mean Temperature °F (t)	48.4	50.2	62.5	-
Monthly Percent of Daytime Hrs. (p)	10.14	10.21	10.35	-
Monthly Consumptive Use Factor $\left[\frac{t \times p}{100}\right]$	4.91	5.13	6.47	16.51

$$U = KF \text{ or } K = \frac{U}{F}$$

$$K = \frac{18.0}{16.51} = 1.09$$

Headgate efficiency coefficient = $\frac{66,208}{\sout{114,055}\ 118,854 + 15,790}$ = ~~0.51~~ *0.49*

1950 Determination - Middle Utah Section

Total Inflow	May	June	July	Total
Bear River near Woodruff	67,380	86,210	15,600	169,190
Woodruff Creek	18,920	12,390	2,826	34,136
Big Creek	5,270	3,560	2,480	11,310
Randolph Creek	211	370	290	871
Otter Creek	1,230	1,070	922	3,222
Total Inflow	93,011	103,600	22,118	218,729
Total Outflow				
Bear River near Randolph	68,990	74,390	13,400	156,780
B.Q. West Side at Control Line	4,798	6,660	1,600	13,058
Total Outflow	73,788	81,050	15,000	169,838
Depletion (Inflow minus Outflow)	19,223	22,550	7,118	48,891
Water Applied in Irrigation				
Bear River	25,512	50,840	20,350	96,702
Tributaries	10,000*	10,000*	5,700*	25,700*
Total	35,512	60,840	26,050	122,402
* Estimated				
Precipitation at Woodruff (inches)	1.34	.51	.80	2.65
Precipitation Supply on 44,000 Acres	4,910	1,870	2,930	9,710
Total Consumptive Use (Dep. + Precip.)	24,133	24,420	10,048	58,601
Total Consumptive Use Ac.-Ft. Per Ac.	.55	.55	.23	1.33
Total Consumptive Use inches per Ac.	6.6	6.6	2.8	16.0

	May	June	July	Total
Monthly Mean Temperature °F (t)	42.3	52.0	57.6	-
Monthly Percent of Daytime Hrs. (p)	10.14	10.21	10.35	-
Monthly Consumptive Use Factor $\left[\frac{t \times p}{100}\right]$	4.29	5.31	5.96	15.56

$$U = KF \text{ or } K = \frac{U}{F}$$

$$K = \frac{16.0}{15.56} = 1.03$$

$$\text{Headgate efficiency coefficient} = \frac{58,601}{122,402 + 9,710} = .44$$

Summary of Derived Constants, Efficiency Factors and Recommended Values

Year	Total Consumptive Use Ac.-Ft. per Acre	Constant "K"	Headgate efficiency coefficient
1944	1.41	1.02	.50
1945	1.50	1.09	.51
1950	1.33	1.03	.44

The pattern of water supply and use for 1945 was not as ideal as in the other two years, which would affect the constant "K" and consequently its derivation for that year should be discounted to some degree. Because of excessive supplies in 1950 more than usual amounts were believed diverted from the tributaries, which resulted in a low efficiency coefficient. It is felt that the efficiency factor for 1944 and 1945 are nearer a correct value.

The following values are recommended for use in determining water requirements for average years:

K = 1.03 Valley

Headgate efficiency coefficient = 0.50

The use of these values in the Blaney-Criddle equation for consumptive use result in average headgate water requirement figures for the valley area. The headgate water requirement of any individual canal may vary considerably from this average valley area figure.

In Tables 10, 11, and 12, on Page 12, are shown the mean monthly temperatures, precipitation and other data for Woodruff. Substituting these values with the recommended constants and headgate efficiency coefficient, results in the following determination of average consumptive use and average headgate requirement for the Woodruff-Randolph area.

$$U = KF$$

$$K = 1.03$$

Headgate efficiency coefficient = 0.50

$$U = 1.03 \left[\frac{47.3 \times 10.14}{100} + \frac{54.9 \times 10.21}{100} + \frac{61.8 \times 10.35}{100} \right]$$

U = 17.3 inches depth per acre

Precipitation May 1 to July 31 = 2.7 inches

$$\text{Headgate requirement} = \frac{17.3}{.50} - 2.7$$

$$= 31.9 \text{ inches depth per acre}$$

$$= 2.66 \text{ acre-feet per acre}$$

This headgate requirement was determined to be 2.78 acre-feet per acre by the other derived equation (see page 13).

Since the results obtained by both methods are practically the same, it can be assumed that the equation derived for the Upper Wyoming Section, in the report "Stream Flow Depletions and Consumptive Use," would also result in a reliable determination for that section.

SUPPLEMENTAL STORAGE REQUIREMENTS OF UPPER WYOMING SECTION

In a previous report by the author titled "Available Water Supplies and Potential Reservoir Sites above Bear Lake," dated July 6, 1951, the Hilliard Reservoir with a maximum capacity of 10,000 acre-feet was listed as the only apparent storage possibility for the Upper Wyoming Section. About 15,000 acres of the 31,800 acres (excludes Chapman Canal lands in Utah) irrigated from the main stem of the river in this section are situated below this reservoir site. This 15,000 acres includes all lands (except Chapman Canal lands in Utah), irrigated from the river between Myers Narrows and Woodruff Narrows.

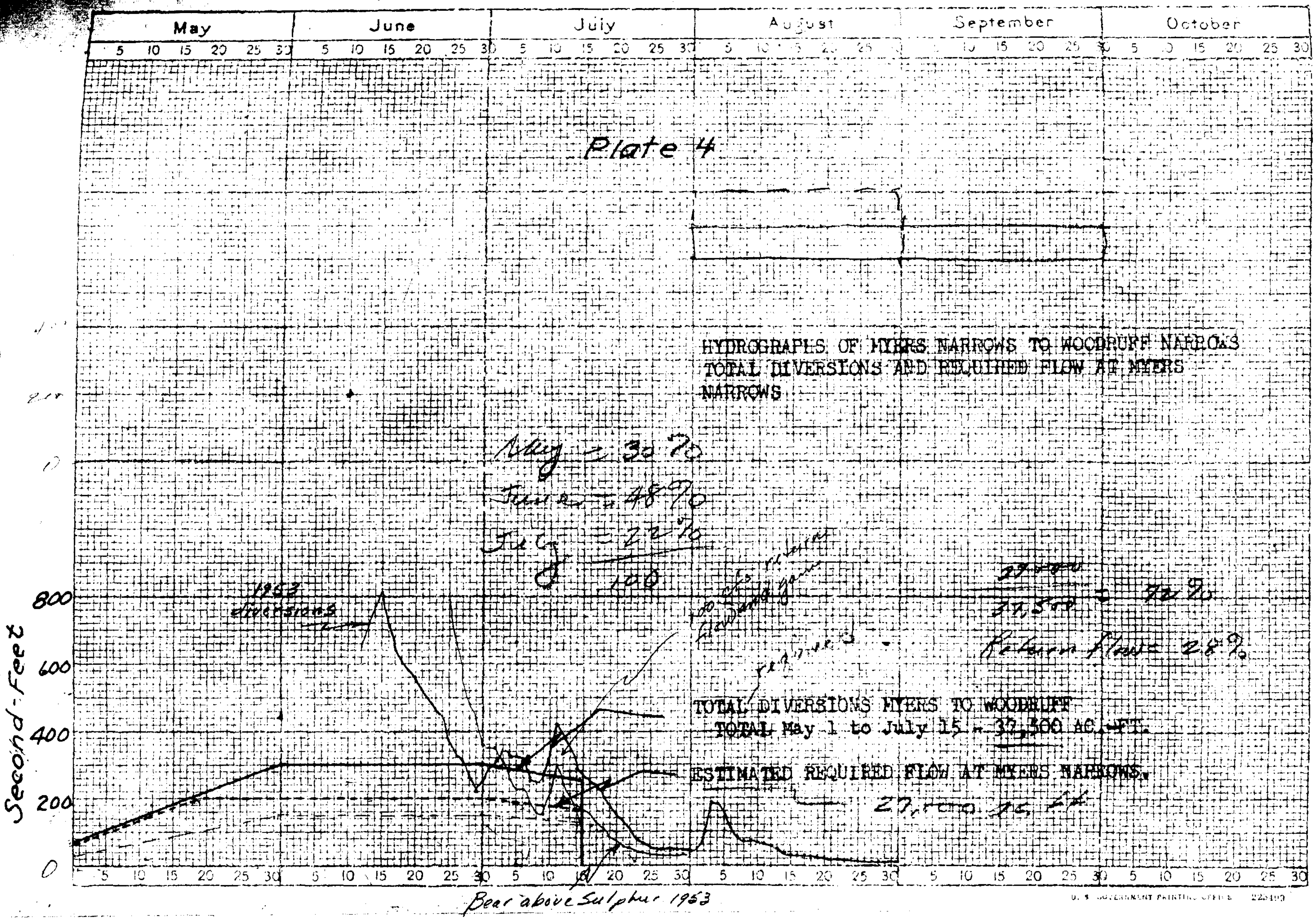
A stream flow gaging station, Bear River above Sulphur Creek near Evanston, was installed in Myers Narrows in October 1946 and records are available since that date. Priority of rights have never been enforced and the recorded flow at this station would represent the maximum natural flow supply available for lands below the Narrows after the maximum amount of storage exchange were effected should priorities be enforced. The deficiency of this supply in fulfilling headgate requirements, taking into account return flows, would be a measure for the supplemental storage required sofar as a reservoir at the Hilliard site is concerned.

On Page 13 it was computed that 2.3 acre-feet per acre is the average headgate requirement for delivery of a full water supply between May 1 and July 15 in the Upper Wyoming Section. It could be expected that the average requirement above Myers Narrows would be less than the average and the requirement below Myers Narrows would be greater than the average. It is estimated that 2.5 acre-feet per acre would be a safe figure to use for the 15,000 acres located below Myers Narrows and on this basis the requirement May 1 to July 15 for 15,000 acres would be 37,500 acre-feet. The monthly

15,439 38,600

Myers — Woodruff

Plate 4


May
June
July
August
September
October
HYDROGRAPHS OF MYERS NARROWS TO WOODRUFF NARROWS TOTAL DIVERSIONS AND REQUIRED FLOW AT MYERS NARROWS
May = 30%
June = 48%
July = 22%
100
1953 diversions
800
600
400
200
0
Second-Feet
Return flow = 28%
TOTAL DIVERSIONS MYERS TO WOODRUFF
TOTAL May 1 to July 15 - 37,300 AC.-FT.
ESTIMATED REQUIRED FLOW AT MYERS NARROWS.
Bear above Sulphur 1953

average distribution of 37,500 acre-feet as indicated by diversion records, would be approximately as follows:

Month	Acre-Feet	Mean Daily Second-Feet
May	11,400	185
June	17,800	300
July 1-15	8,300	280

This distribution is graphically shown by the hydrograph on Plate 4, page 24.

Because of the large part return flows play in filling total headgate requirements, it is impossible to compute mathematically the total flow of new supply required at Myers Narrows to fill total headgate requirements for all canals diverting from the main stem of the river between Myers Narrows and Woodruff Narrows. However, with information available, this new supply can be approximately determined. The following general rule is indicated by depletion studies:

$$\text{Depletion} = \text{Inflow} - \text{Outflow}$$
or
$$\text{Inflow} - \text{Depletion} = \text{Outflow}$$

If outflow is reduced to a point approaching zero, then

$$\text{Inflow} = \text{Depletion}$$

Previous computations have indicated that

$$\text{Depletion} = 1/2 \text{ water applied (approximately)}$$

Therefore:

$$\text{Inflow} = 1/2 \text{ water applied (approximately)}$$

From this general relation and a careful study of the hydrographs of gain and return flows, water supplies, and water diverted, an estimated hydrograph of required flow at Myers Narrows was drawn on Plate 4, page 24. If this hydrograph were superimposed on the hydrograph of actual discharges at Myers Narrows, the area lying below the estimated required flow hydrograph

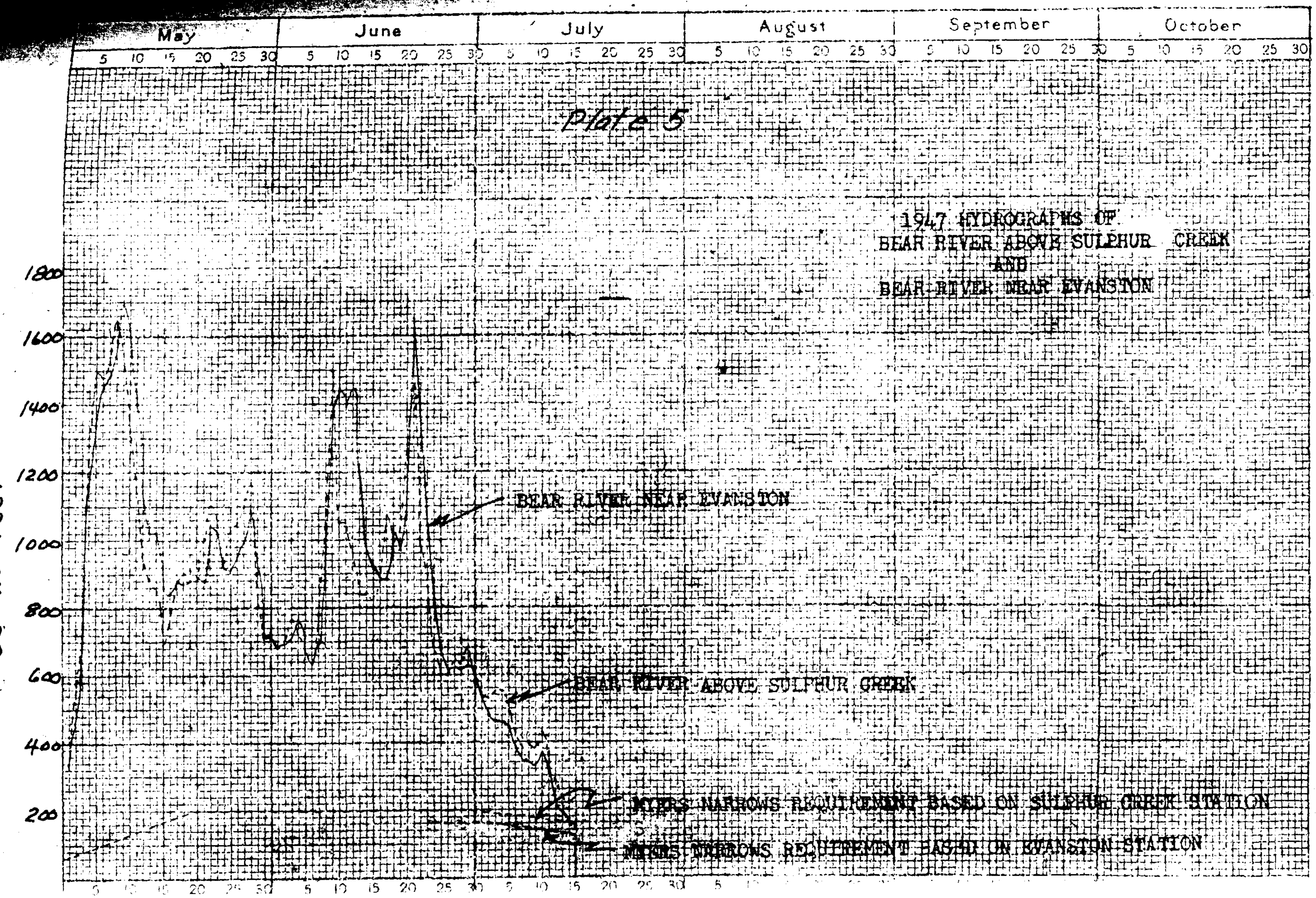
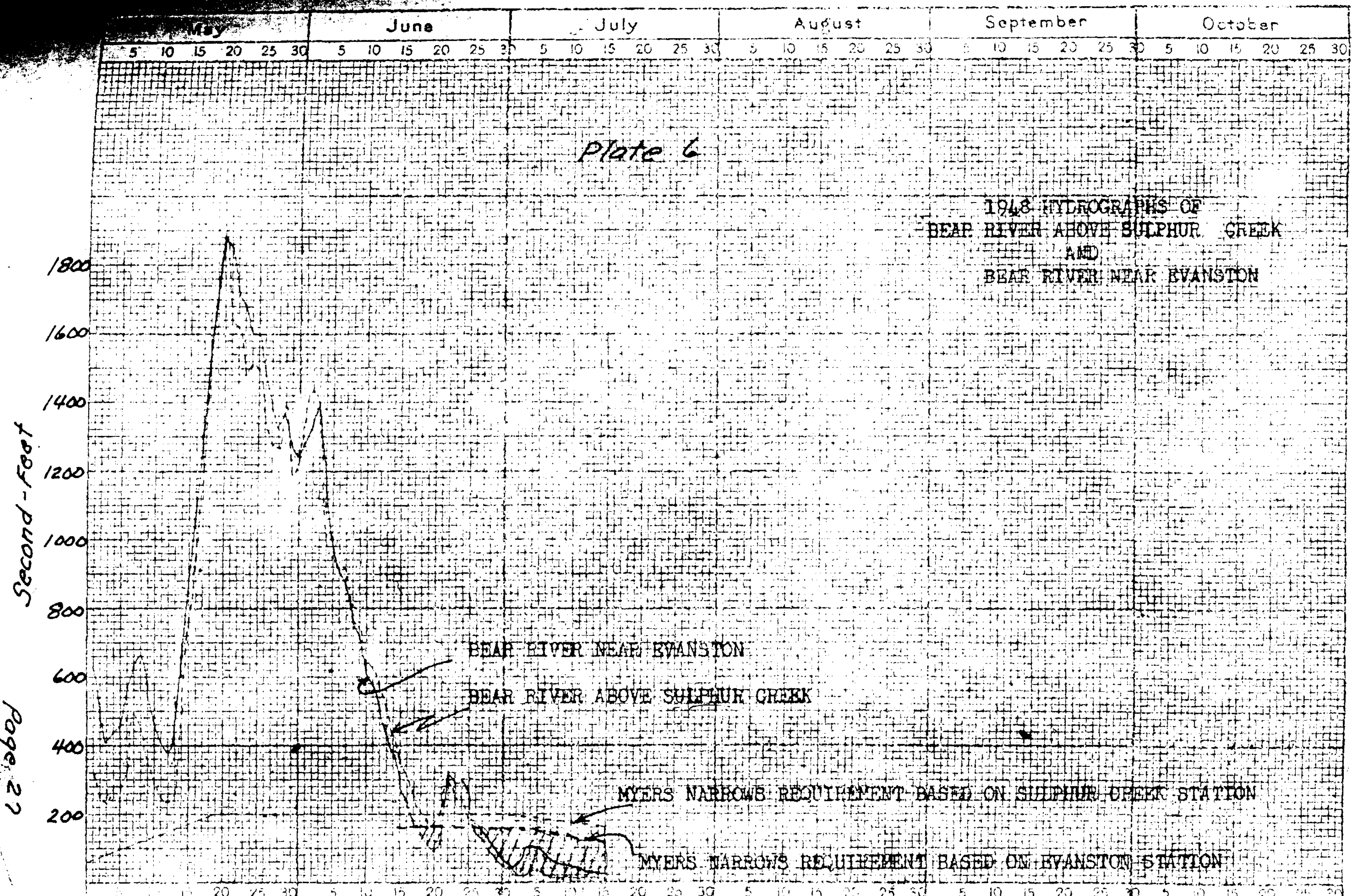
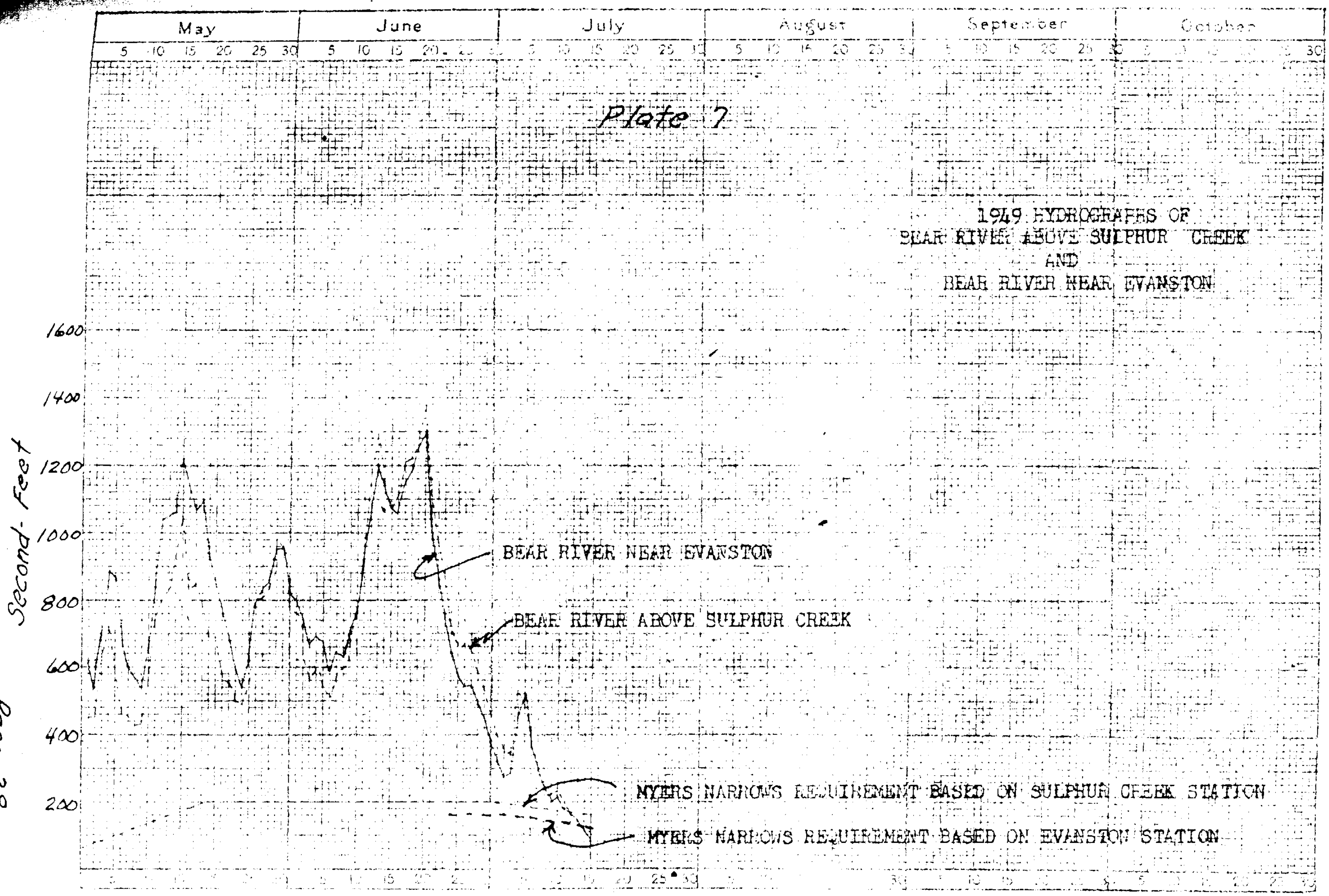


Plate 5
1947 HYDROGRAPHS OF
BEAR RIVER ABOVE SULPHUR CREEK
AND
BEAR RIVER NEAR EVANSTON
BEAR RIVER NEAR EVANSTON
BEAR RIVER ABOVE SULPHUR CREEK
MYERS NARROWS REQUIREMENT BASED ON SULPHUR CREEK STATION
MYERS NARROWS REQUIREMENT BASED ON EVANSTON STATION
May
June
July
August
September
October
Second - Feet
1800
1600
1400
1200
1000
800
600
400
200


May
June
July
August
September
October
Plate 6
1948 HYDROGRAPHS OF
BEAR RIVER ABOVE SULPHUR CREEK
AND
BEAR RIVER NEAR EVANSTON
BEAR RIVER NEAR EVANSTON
BEAR RIVER ABOVE SULPHUR CREEK
MYERS NARROWS REQUIREMENT BASED ON SULPHUR CREEK STATION
MYERS NARROWS REQUIREMENT BASED ON EVANSTON STATION
Second-Feet
1800
1600
1400
1200
1000
800
600
400
200

GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

Plate 7



and above the actual discharge hydrograph would represent the amount of supplemental storage required to meet the sections total headgate requirement.

Records are only available at Myers Narrows since October 1946 and it is desired to extend the study to include the years 1924 to 1948. The relation of daily discharges at the Bear River above Sulphur Creek (Myers Narrows) gaging station and the discharges at the Bear River near Evanston gaging station may be used in extending the record. Shown on Plates 5, 6 and 7, pages 26, 27 and 28, are hydrographs of these two stations with the Myers Narrows estimated required flow hydrograph superimposed thereon.

The three year comparison indicates that the supply as measured at the upper station is 30 to 50 second-feet more than the supply as measured at the Evanston station. By decreasing the required flow of the Myers Narrows hydrograph by about 40 second-feet, an adjustment would be effected whereby the Bear River near Evanston hydrograph would give practically the same storage requirement as the Myers Narrows hydrograph. This has been done on Plates 13 to 37, pages 41 to 65, by using the area between bottom dashed line and the Evanston hydrograph in determining the storage requirement. The following tabulation shows computed annual storage requirement in a reservoir at the Hilliard site as determined by the above described method:

(See table 13, next page)

TABLE 13

Suppl. Headgate Req't Report B

Water Year Ending Sept. 30	Plan A	Plan B	Storage Required at Hilliard acre-feet	increase for regulation
1924			5,000	100
1925			0	200
1926			2,800	400
1927			400	400
1928			1,600	500
1929			0	300
1930			3,000	700
1931			6,600	1500
1932			400	300
1933			3,000	500
1934			14,200	800
1935			1,600	400
1936			2,000	500
1937			1,200	300
1938			1,000	300
1939			4,400	1200
1940			8,600	2000
1941			400	200
1942			2,200	600
1943			200	~~200~~
1944	31,200	24,800	0	400
1945			0	0
1946	46,800	47,200	4,600	900
1947	21,600	23,360	0	0
1948			4,400	900
Average			2,700	600 average

Note:- Above figures do not include space requirement for evaporation loss.

For 15,000 acres between Myers & Woodruff Narrows.

Based on a total headgate requirement of 2.5 acre-feet per acre.

1949	0	0
1950	0	0
1951	0	0
1952	0	0
1953	0	0
1954	7100	2,900

SUPPLEMENT STORAGE REQUIREMENT
for
MIDDLE UTAH AND MIDDLE WYOMING SECTION

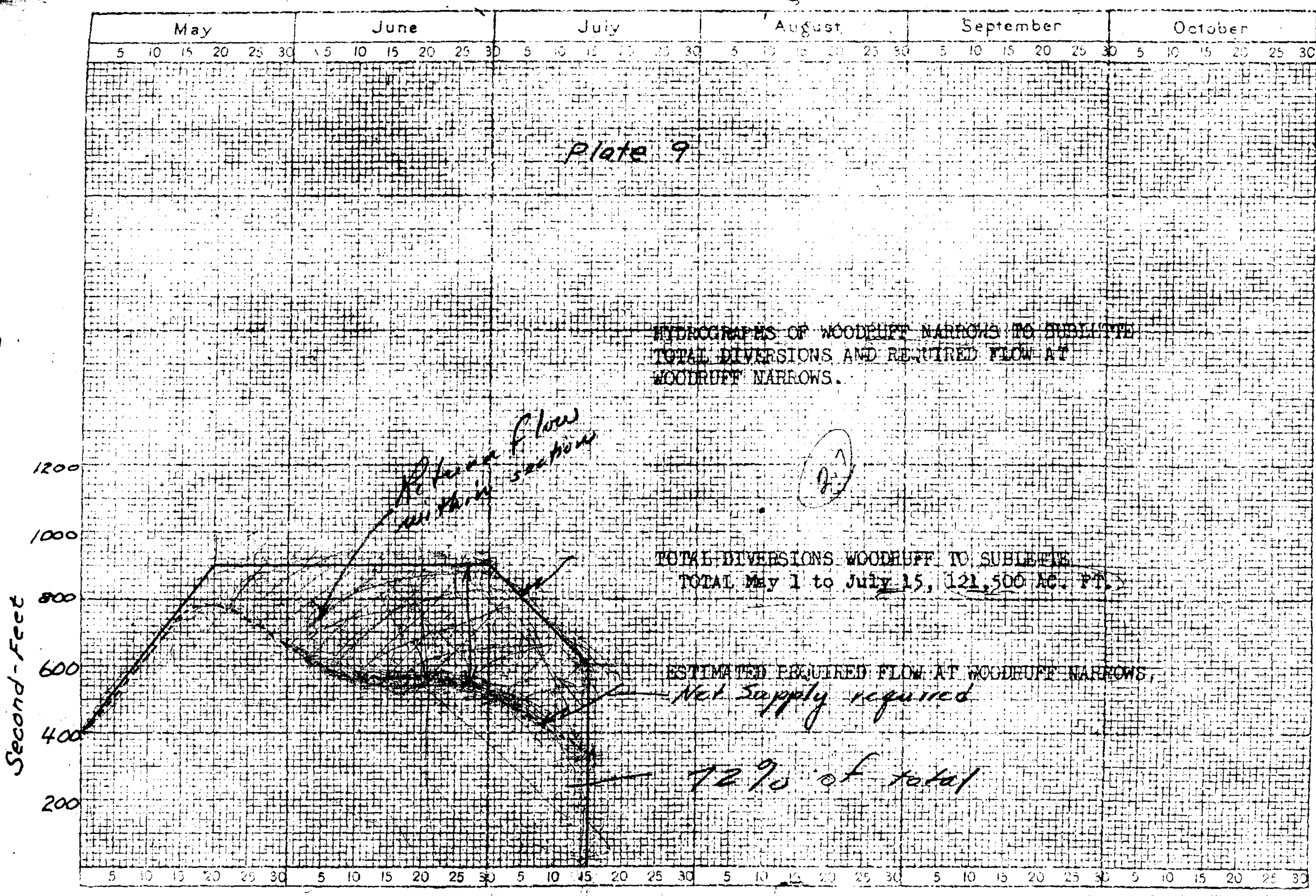
A reservoir at Woodruff Narrows would serve both the Middle Utah and Middle Wyoming sections. Approximately 37,200 acres are irrigated in the Middle Utah Section and 7,800 acres are irrigated in the Middle Wyoming Section. The principal source of water supply for these lands, totalling 45,000 acres, is the water passing Woodruff Narrows.

On Pages 13 and 22, it was computed that the average headgate requirement for crop needs between May 1 and July 31, was about 2.7 acre-feet per acre. At this rate the 45,000 acres need a total of 121,500 acre-feet (headgate diversions) between May 1 and July 15. A study of average seasonal demand distribution indicates the seasonal delivery would be distributed about as follows:

Month	Acre-Feet	Average Flow in Second-Feet
May 1-20	25,800	650
May 21-31	19,700	900
June 1-30	53,600	900
July 1-15	22,400	750

This distribution is graphically shown on Plate 9, page 33.

A study of the discharge required at Woodruff Narrows in order to meet headgate deliveries was made using the 1944 to 1947 stream flow records. This study took into account return flows, location of points of diversion, and probable natural gains in the reach. The hydrograph of the estimated required flow at Woodruff Narrows is shown on Page 33. While a good portion of this hydrograph is based on an evaluation of observed data and knowledge of the stream's characteristics, it is believed that it furnishes a reasonable foundation on which to determine supplemental storage needed for these two sections.


May
June
July
August
September
October
Plate 9
HYDROGRAPHS OF WOODRUFF NARROWS TO SUBLETTE
TOTAL DIVERSIONS AND REQUIRED FLOW AT
WOODRUFF NARROWS.
TOTAL DIVERSIONS WOODRUFF TO SUBLETTE
TOTAL May 1 to July 15, 121,500 AC. FT.
ESTIMATED REQUIRED FLOW AT WOODRUFF NARROWS,
Net Supply required
72% of total
Second-Feet
1200
1000
800
600
400
200

A gaging station, "Bear River near Woodruff," was established in Woodruff Narrows in April, 1942. If the hydrograph of required flow at Woodruff Narrows (Page 33), is superimposed on the hydrographs of this gaging station, the area lying below the estimated required flow hydrograph and above the actual discharge hydrograph, would represent the amount of supplemental storage required to meet the section's total headgate requirement. On Plates 38 to 44, pages 66 to 72, the cross-hatched areas show the computed storage for the water years 1942 to 1948.

To extend this storage requirement study through the years 1924 to 1941, the records of discharge at the Bear River near Evanston gaging station may be utilized. Hydrographs for a number of years of the Woodruff and Evanston gaging stations were plotted and it was found that the Evanston record was quite similar, but there was not indicated a consistent average correction which could be applied to the requirement hydrograph. However, it is believed reasonable to assume that like years of runoff pattern, during the storage delivery period, will have like corrections which can be applied to the storable requirement as computed from the Evanston record to show the equivalent requirement at Woodruff Narrows. The estimated required flow at Woodruff Narrows hydrograph was superimposed on the Bear River near Evanston hydrograph, Plates 13 to 37, pages 41 to 65, and the cross-hatched areas planimetered. These quantities are unadjusted figures of the Woodruff requirement. The cross-hatched areas were then matched as nearly as possible with the years of duplicate record and approximate corrections applied to the unadjusted Evanston hydrograph determinations to produce the estimated requirement at Woodruff Narrows. The actual planimetered quantities and estimated quantities are shown in the following Table:

TABLE 14

Water Year Ending Sept. 30	Plan A	Plan B	Annual Storage Requirement based on Evanston station Acre-Feet	Annual Storage Requirement based on Woodruff station Acre-Feet	
1924			26,400	28,000*	25,000
1925			8,400	11,000*	10,000
1926			21,400	24,000*	21,500
1927			7,000	11,000*	9,000
1928			17,600	20,000*	18,000
1929			4,000	5,000*	4,300
1930			16,200	20,000*	18,500
1931			56,400	60,000*	55,000
1932			5,200	8,000*	7,500
1933			16,000	20,000*	18,500
1934			75,600	80,000*	75,000
1935			11,000	15,000*	13,500
1936			16,400	20,000*	18,000
1937			19,200	22,000*	20,000
1938			10,400	14,000*	13,000
1939			40,200	44,000*	41,000
1940			38,800	43,000*	39,000
1941			9,200	11,000*	9,800
1942			11,000	15,200	13,700
1943			6,200	10,200	9,500
1944	31,900	24,800	2,800	3,200	3,200
1945			3,000	5,400	5,400
1946	46,700	47,200	22,000	23,200	20,900
1947	21,400	23,300	2,600	4,000	4,600
1948			23,600	26,000	23,700
1949					19,900

* Estimated from Evanston station as explained in text.

Suppl. Headgate Requit. Middle Utah Rep. 8

2200 = 8 yrs; 25000 = 8 yrs shortage

18,850

1951 21,200 - 1924-48

Headgate req't = 2.7 ac.ft/acre

45000 acres - Middle Utah & Lower Wyoming section.

1949	6,300	5,000
1950	1,000	1,000
1951	5,200	5,200
1952	4,000	4,000
1953	11,300	9,300
1954	58,600	50,200

12,[illegible] = 57%

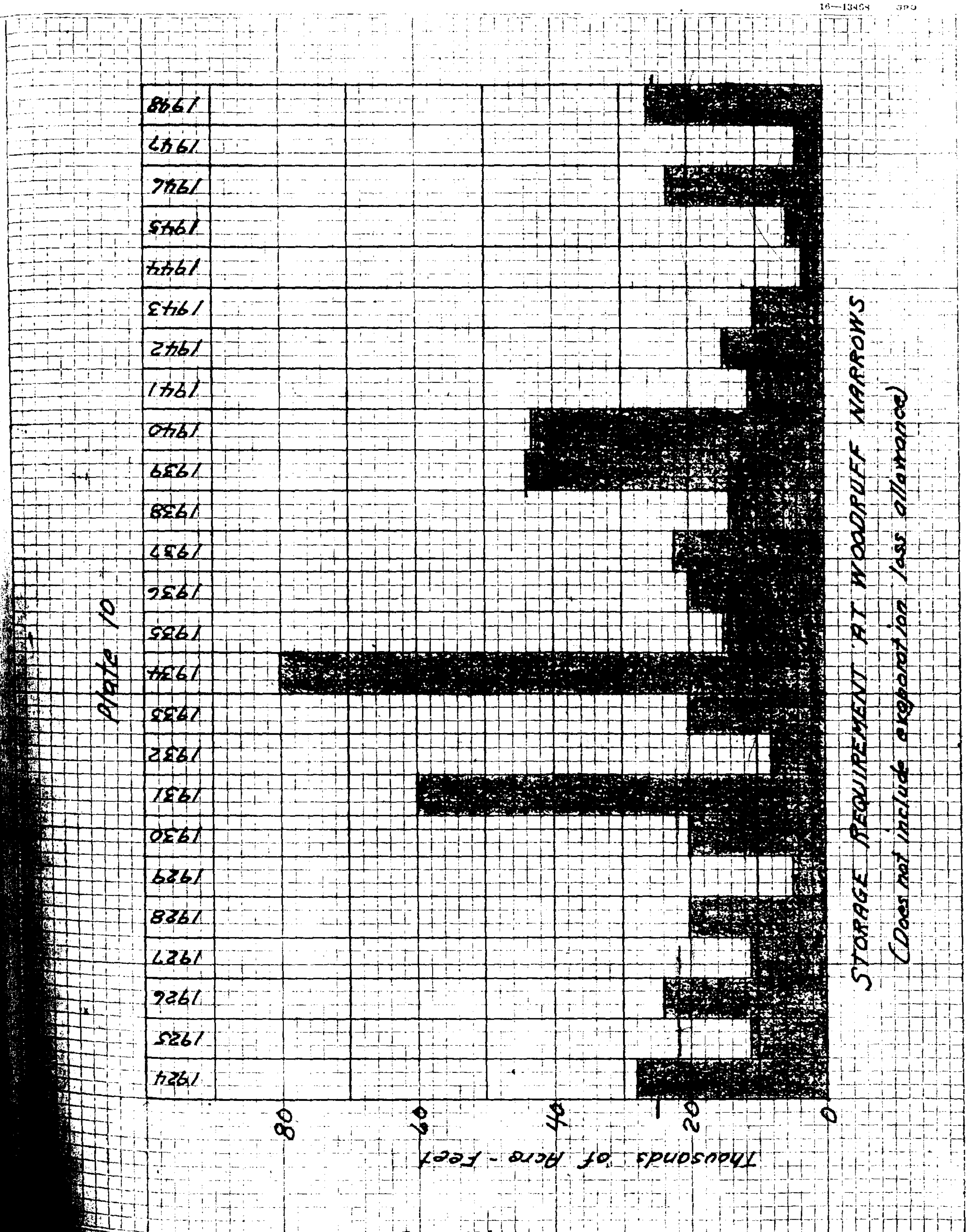
21 800

13-A
(ber 1930)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

File Number { Washington .... District ....

16—13458



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COMBINED TOTAL STORAGE REQUIREMENTS AT AND
ABOVE WOODRUFF NARROWS AND COMPARISON
WITH STORABLE SUPPLIES

In the report on available storable supplies above Bear Lake, it was pointed out that irrigation storage requirements and reservoir storage capacities for reservoirs above Woodruff Narrows must be taken into account in considering storage requirements and capacities for a reservoir at Woodruff Narrows. This should also take into account return flows from upstream irrigation with storage water and evaporation losses from the reservoirs.

It is indicated from the requirements of the 15,000 acres above Woodruff Narrows that the probable capacity of a reservoir at the Hilliard site would be about 5,000 acre-feet. (average requirements are only 1/2 of this amt) Return flows from the application of this storage which reach Woodruff Narrows would add somewhat to the water available at that point. However, in short water years this amount would probably not be very large and consequently, it may be disregarded in this study.

The evaporation from the reservoirs should be taken into account and added to the supplemental storage requirement in arriving at the total storage capacity required. However, it should be kept in mind that such evaporation losses may not constitute an equivalent loss of water to the river system as evaporation and transpiration losses already are occurring on much of the land which would be flooded. Such losses to the river system may possibly be as large as the evaporation from the prospective reservoirs.

The probable evaporation rate from reservoirs at Woodruff Narrows can be computed from the Weather Bureau land pan located at Lifton, Idaho by applying the proper coefficients.

Under the considered plan of storage, the reservoirs will be at full capacity on April 30 of each year and storage would be all applied before the end of July. Additional space should therefore be provided in the

plying the proper coefficients.

reservoirs to offset evaporation losses in May, June and July. For approximate computation purposes, precipitation during this period can be disregarded and the reservoir area for full capacity used. An examination of Plates 8 and 10 indicate that approximately 5,000 acre-feet would be the probable capacity needed at Hilliard and 20,000 acre-feet the probable capacity at Woodruff.

Total monthly evaporation averages from the land pan at Lifton are May 6.52 inches, June 7.61 inches, and July 9.27 inches. This totals 23.40 inches for the three months. The two reservoirs under consideration are at an elevation about 1,000 feet higher than Lifton, which introduces an altitude coefficient of about 90 percent. The evaporation pan to lake coefficient is about 70 percent. Applying the coefficients to this total results in a net figure of 14.8 inches. The water surface area of Hilliard Reservoir for 5,000 acre-feet is about 500 acres. The water surface area of Woodruff Narrows reservoir for 20,000 acre-feet is about 1,700 acres. Hilliard Reservoir evaporation loss would require 600 acre-feet of reservoir capacity and the Woodruff Narrows Reservoir would require 2,100 acre-feet of space for evaporation loss.

In Table 15 page 39, are shown the supplemental storage requirements and storable supplies at and above Woodruff Narrows. These are graphically represented on Plates 11 and 12, pages 40 and 41. These graphs of requirements and available supplies indicate the maximum limitation of the feasible and economically beneficial storage capacity needed sofar as storage at and above Woodruff Narrows is concerned.

Report II 19

TABLE 15

STORAGE REQUIREMENTS AND AVAILABLE SUPPLIES
AT AND ABOVE WOODRUFF NARROWS

Water Year Ending Sept.30	Annual Storage Rqmt. Upper Wyo. Acre-Feet	Annual Storage Rqmt. Middle Utah & Middle Wyo.. Acre-Feet	Reservoir Evaporation Loss May to July (a) Acre-Feet	Total Storage Space at & Above Woodruff Narrows Acre-Feet	Storable Supply Oct.1 to Apr.15 Acre-Feet	Storable Supply Oct.1 to Apr.30 Acre-Feet
1924	5,000	28,000	2,700	35,700	64,500	78,200
1925	0	11,000	2,700	13,700	22,500	37,000
1926	2,800	24,000	2.700	29,500	47,000	63,300
1927	400	11,000	2,700	14,100	25,400	38,400
1928	1,600	20,000	2,700	24,300	50,700	62,200
1929	0	5,000	2,700	7,700	29,500	47,100
1930	3,000	20,000	2,700	25,700	41,400	54,800
1931	6,600	60,000	2,700	69,300	40,600	45,200
1932	400	8,000	2,700	11,100	28,400	41,400
1933	3,000	20,000	2,700	25,700	22,300	30,500
1934	14,200	80,000	2,700	96,900	17,300	24,600
1935	1,600	15,000	2,700	19,300	16,200	22,900
1936	2,000	20,000	2,700	24,700	12,700	43,400
1937	1,200	22,000	2,700	25,900	30,900	55,600
1938	1,000	14,000	2,700	17,700	27,500	50,300
1939	4,400	44,000	2,700	51,100	41,100	52,800
1940	8,600	43,000	2,700	54,300	17,200	23,400
1941	400	11,000	2,700	14,100	24,100	28,200
1942	2,200	15,200	2,700	20,100	50,700	63,700
1943	200	10,200	2,700	13,100	31,600	49,500
1944	0	3,200	2,700	5,900	30,600	44,000
1945	0	5,400	2,700	8,100	24,100	38,400
1946	4,600	23,200	2,700	30,500	45,800	71,400
1947	0	4,000	2,700	6,700	49,400	57,400
1948	4,400	26,000	2,700	33,100	35,100	63,400
Ave.	2,700	21,800	2,700	27,100		47,500

(a) Estimated on basis of Hilliard Reservoir 5,000 acre-feet and Woodruff Narrows Reservoir 20,000 acre-feet.

Storage requirements based on consumptive use and headgate requirement studies.

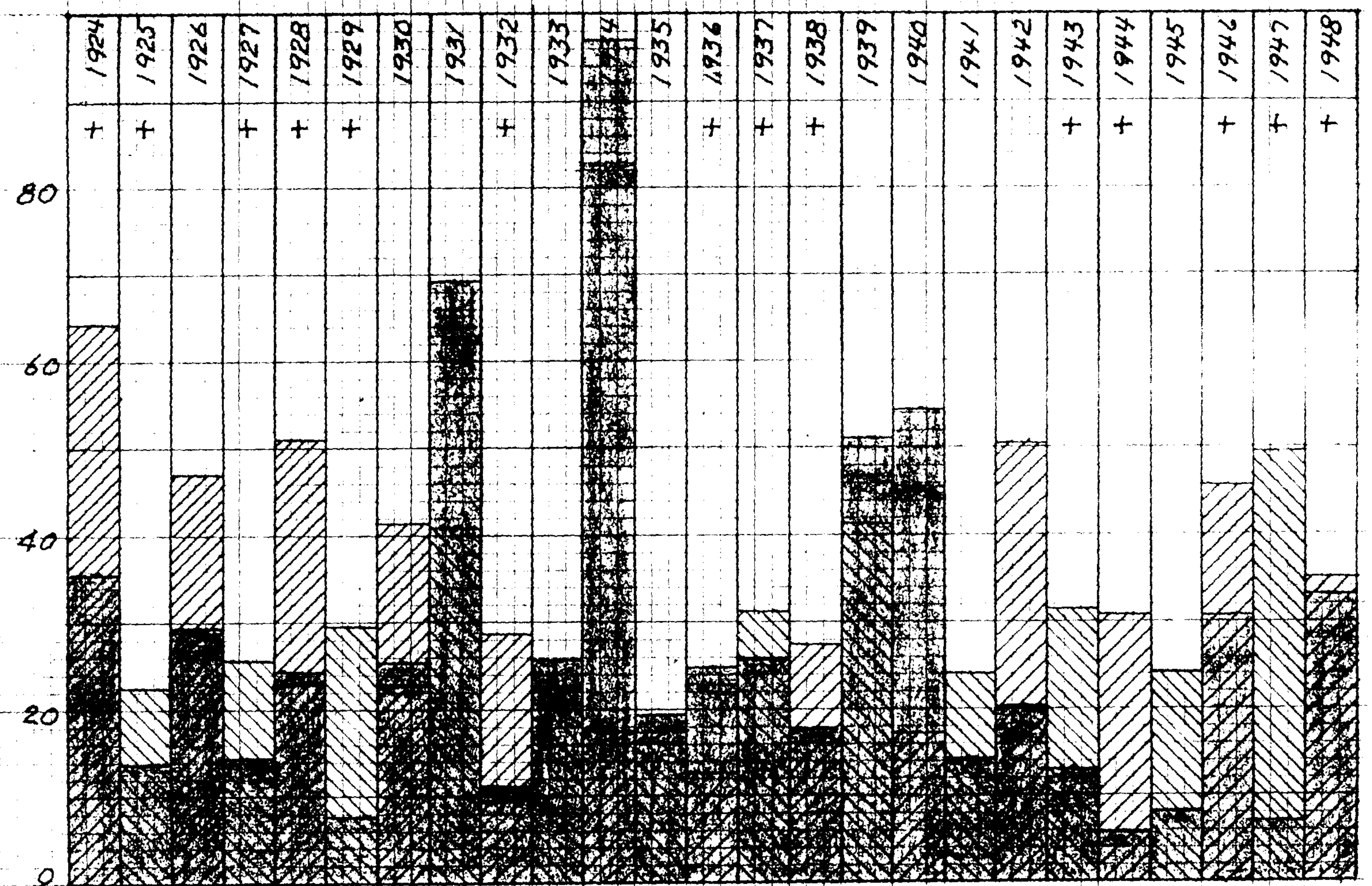
SUPPLEMENTAL STORAGE REQUIREMENTS
in
CENTRAL DIVISION

Smiths Fork is the principal reliable source of water supply for the Lower Wyoming and Upper Idaho sections. The flow of this stream is, to a remarkable extent, naturally regulated by the geological character of its drainage area. The summer flow of the stream is principally from springs which are fed from many small lakes scattered over the headwaters.

It is to be noted on Page 5, under Plan A and Plan B, that only relatively small amounts of storage was needed. A study was made to extend records of this stream through the years 1924 to 1941. It was impossible to obtain sufficiently consistent results by stream flow correlation with other neighboring drainage areas having long time stream flow records, on which to base a storage requirement study. On the basis of stream flow records that are available only since 1942, it is believed that there would be little need for supplemental storage except in drought years such as 1931, 1934 and 1940. However, if the compact should place extensive limitations on use in the Lower Wyoming Section, there may be need for a moderate amount of supplemental storage by a few of the canals having late dated priorities.

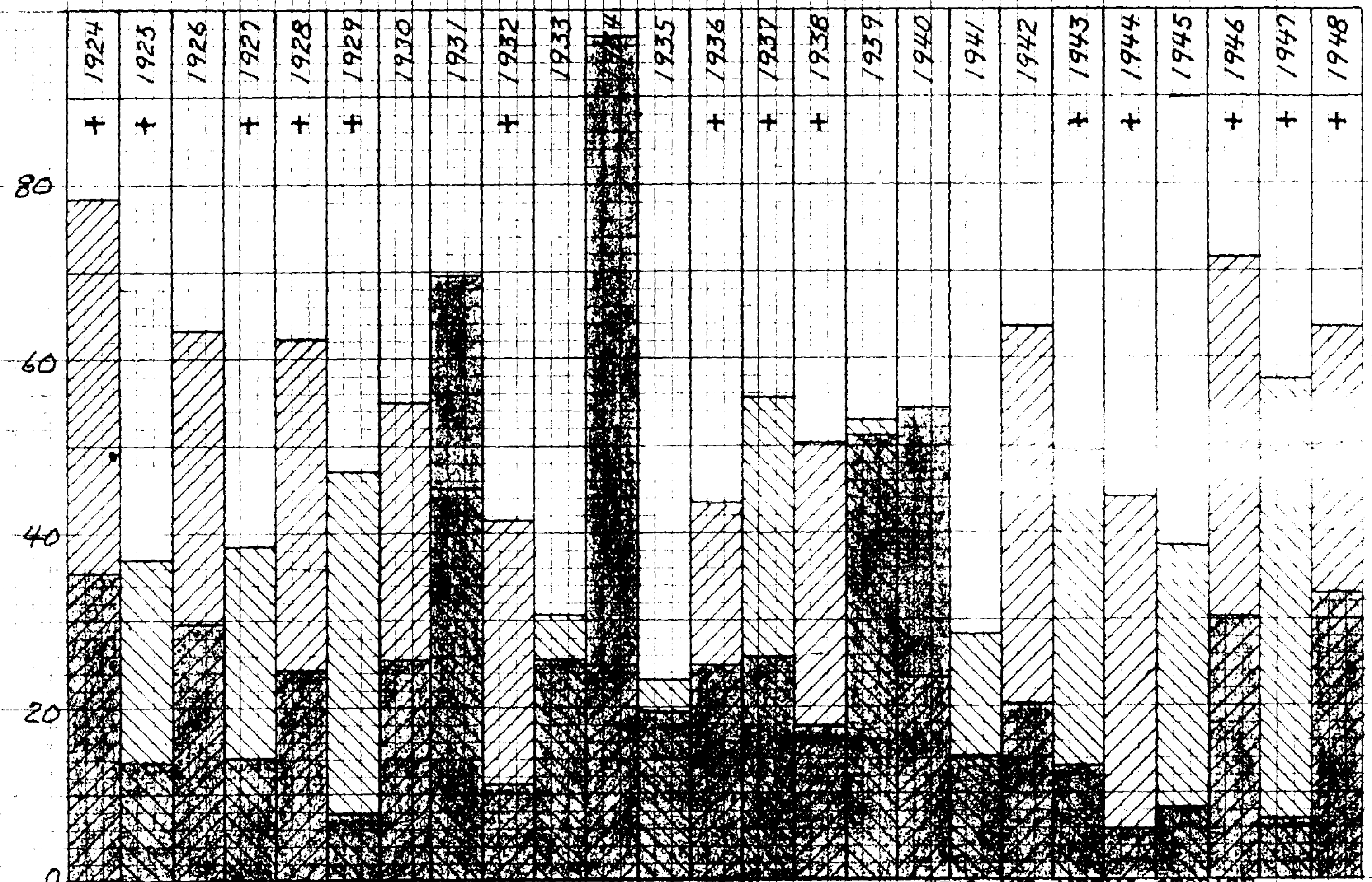
On Thomas Fork there has been some agitation for supplemental storage. Time available for the preparation of this report has not permitted an investigation of the needs of this stream.

Plate II



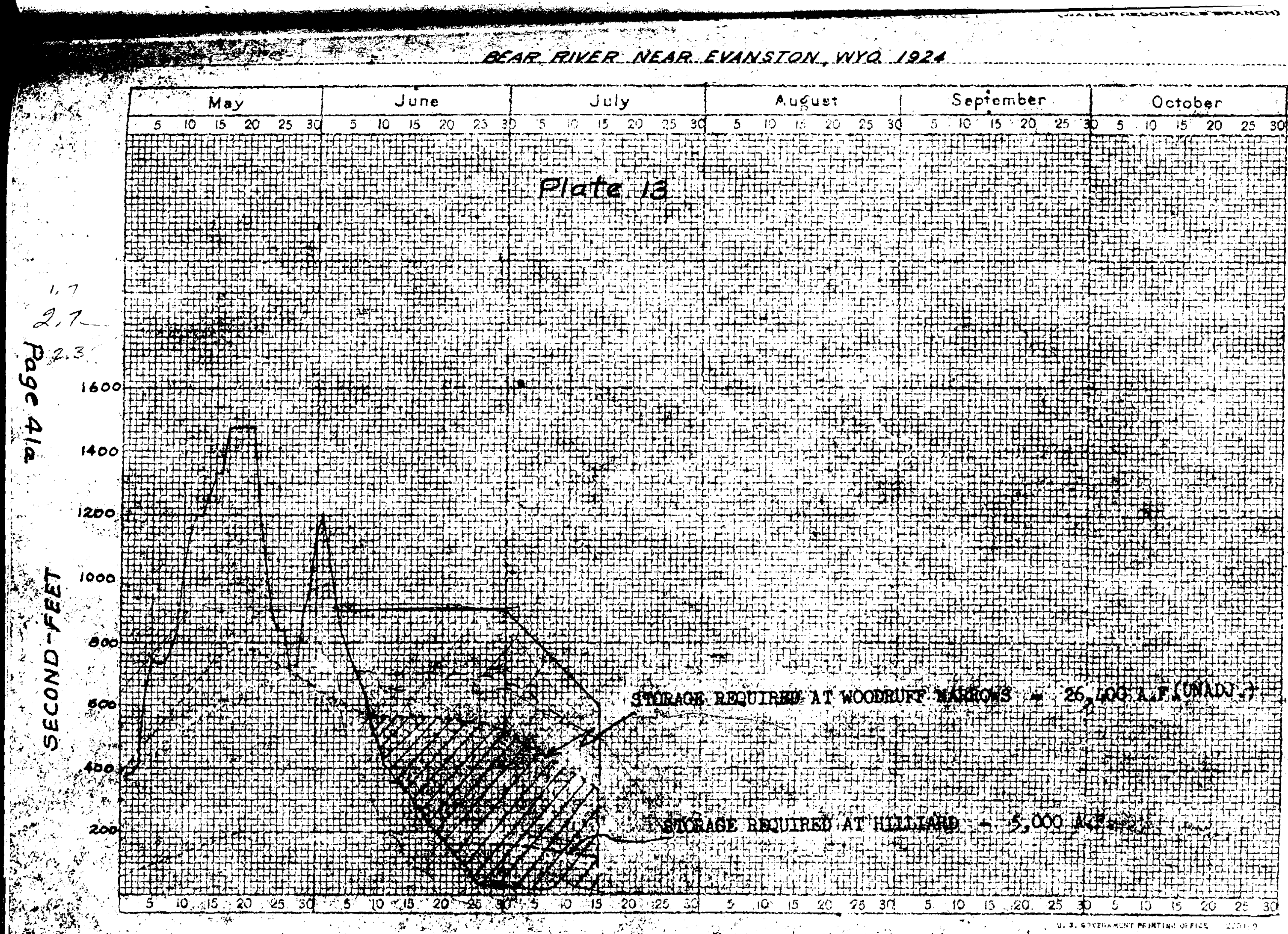
STORABLE SUPPLIES Oct. 1 to Apr. 15 OF EACH WATER YEAR AND ANNUAL STORAGE REQUIREMENT AT AND ABOVE WOODRUFF NARROWS FOR WATER YEARS 1924 to 1948.
Cross Hatched Area indicates Storable Supply Oct. 1 to Apr. 15;
Shaded Area indicates Irrigation Season Storage Requirement and
+ Mark indicates Years in which Additional Water could be stored while Border above 750 second-feet.

Plate 12



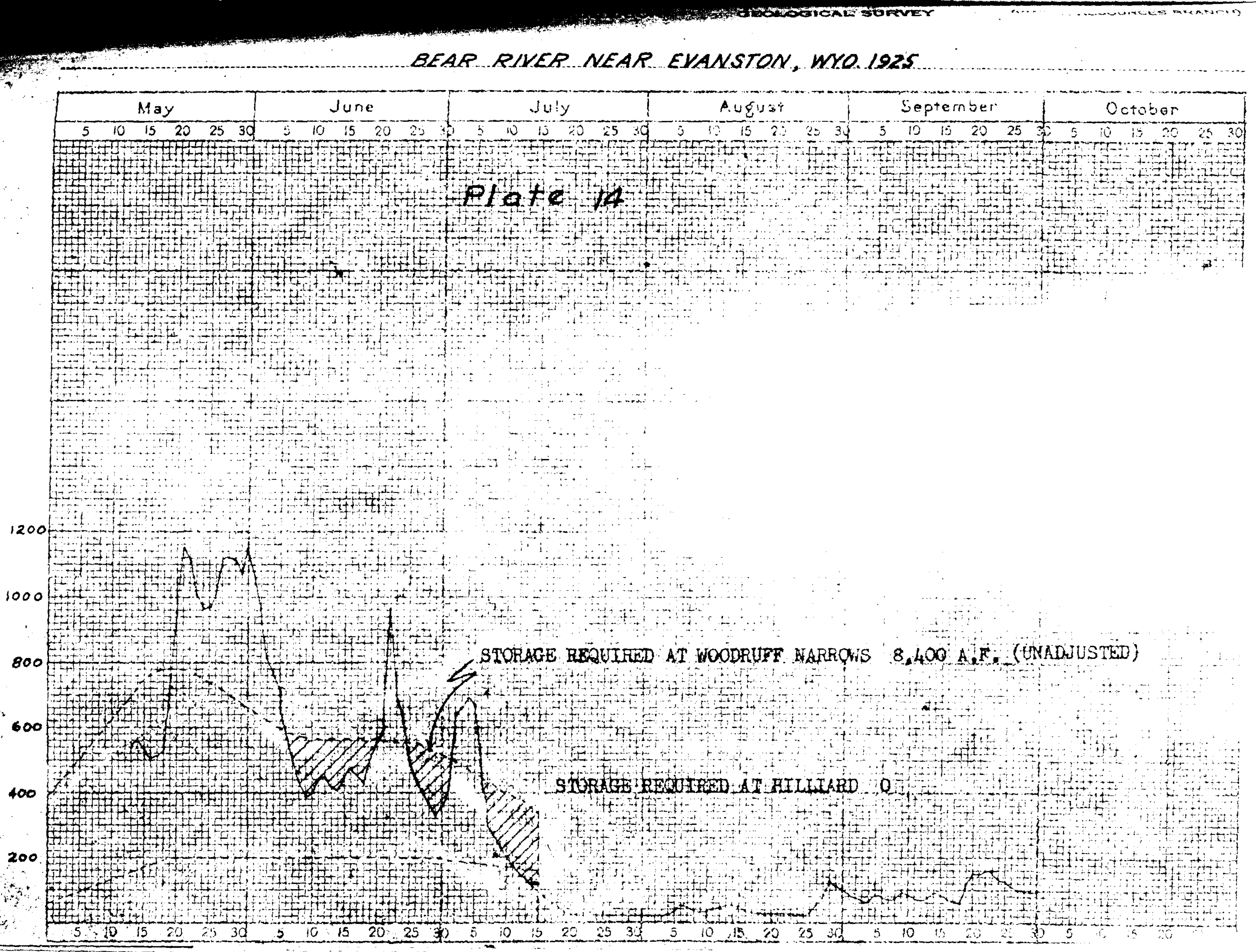
STORABLE SUPPLIES Oct. 1 to Apr. 30 OF EACH WATER YEAR AND ANNUAL STORAGE REQUIREMENT AT AND ABOVE WOODRUFF NARROWS FOR WATER YEARS 1924 to 1948.
Cross Hatched Area indicates Storable Supply Oct. 1 to Apr. 30;
Shaded Area indicates Irrigation Season Storage Requirement and
+ Mark indicates Years in which Additional Water could be stored while Border above 750 second-feet.

Page 41


(WATER RESOURCES BRANCH)
BEAR RIVER NEAR EVANSTON, WYO. 1924
May
June
July
August
September
October
Plate 13
1600
1400
1200
1000
800
600
400
200
SECOND-FEET
STORAGE REQUIRED AT WOODRUFF NARROWS = 26,400 A.F. (UNADJ.)
STORAGE REQUIRED AT HILLIARD = 5,000 AC-FT
1.7
2.7
2.3
Page 41a
U. S. GOVERNMENT PRINTING OFFICE

Page 42

Plate 14



BEAR RIVER NEAR EVANSTON, WYO. 1926

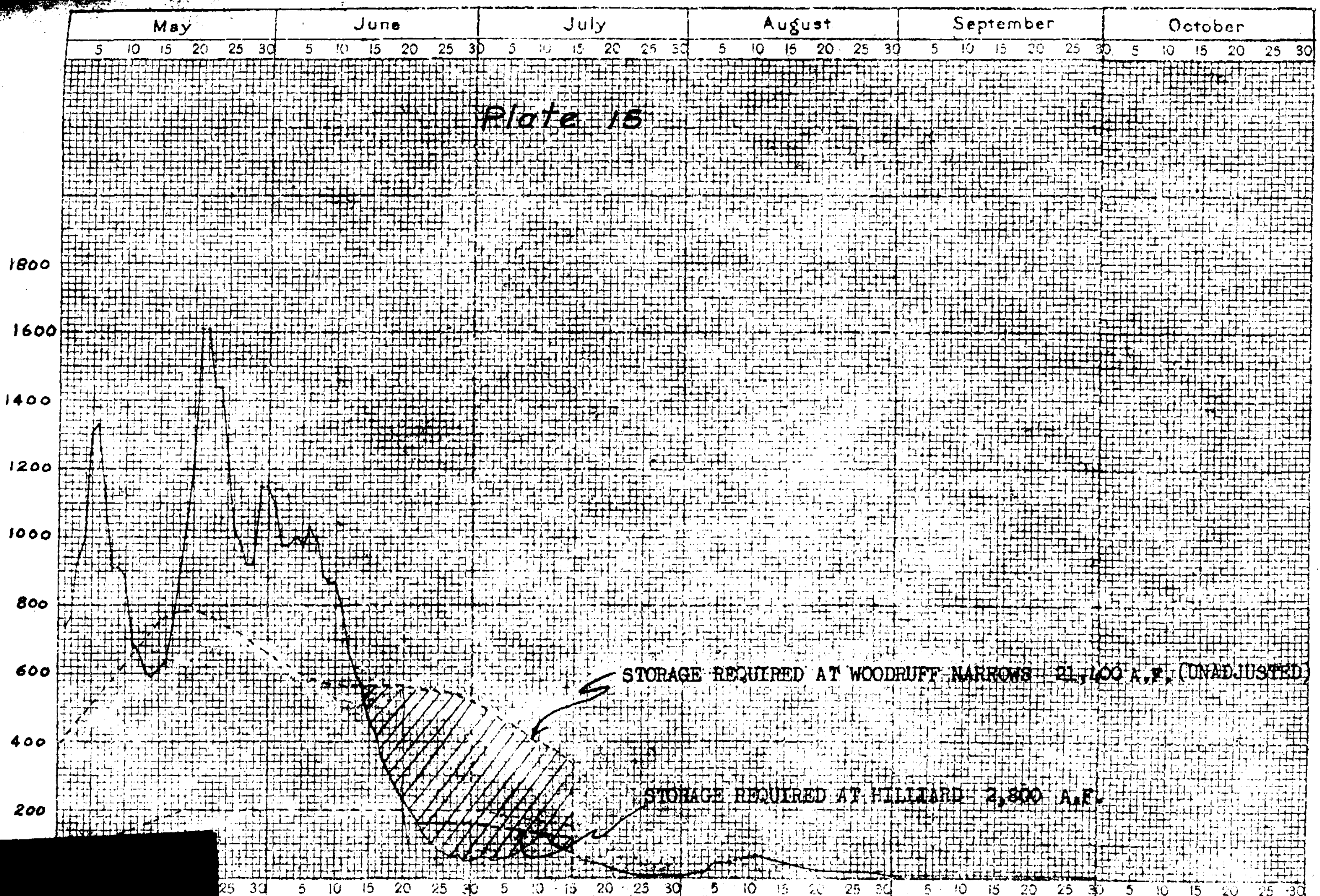


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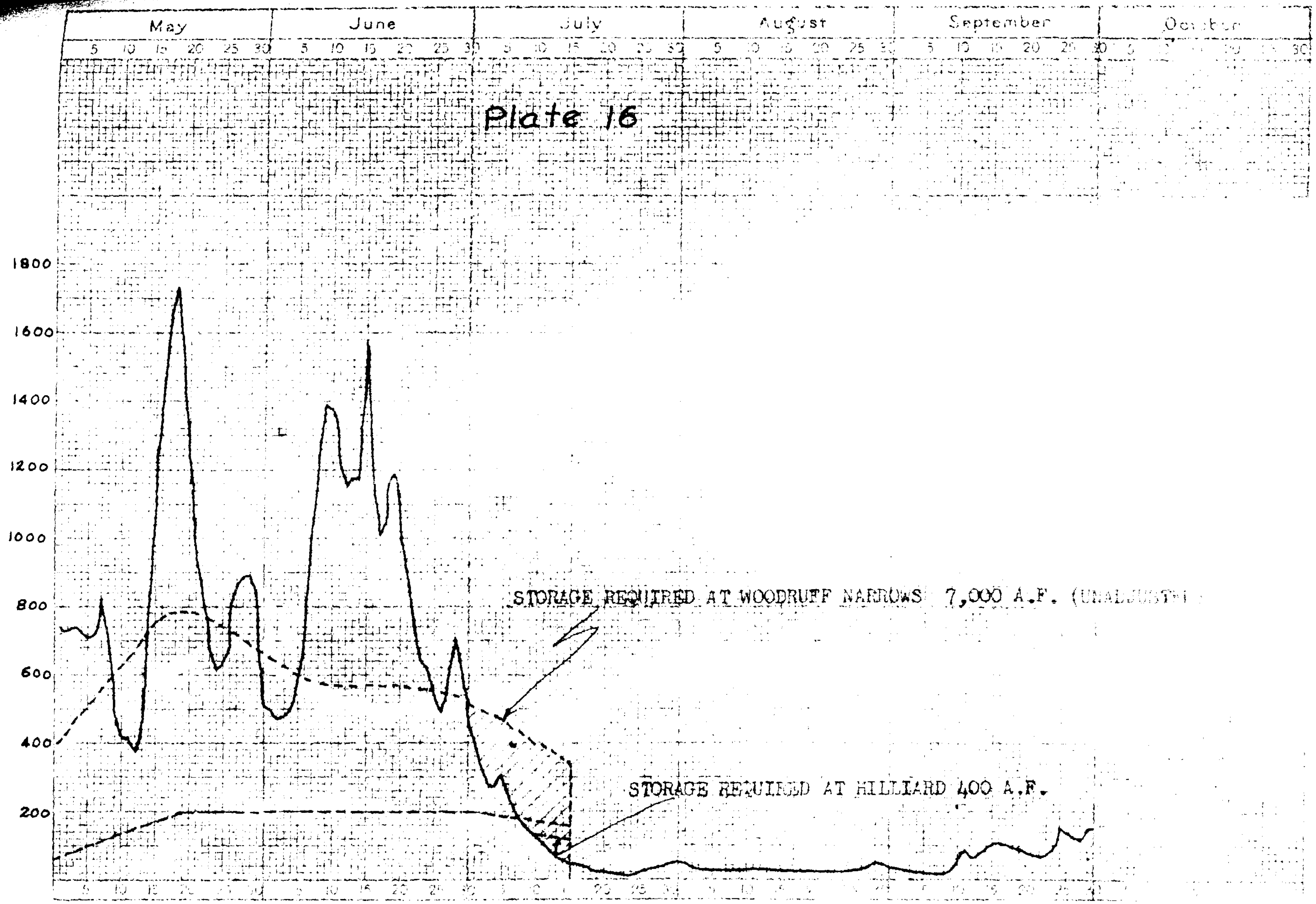
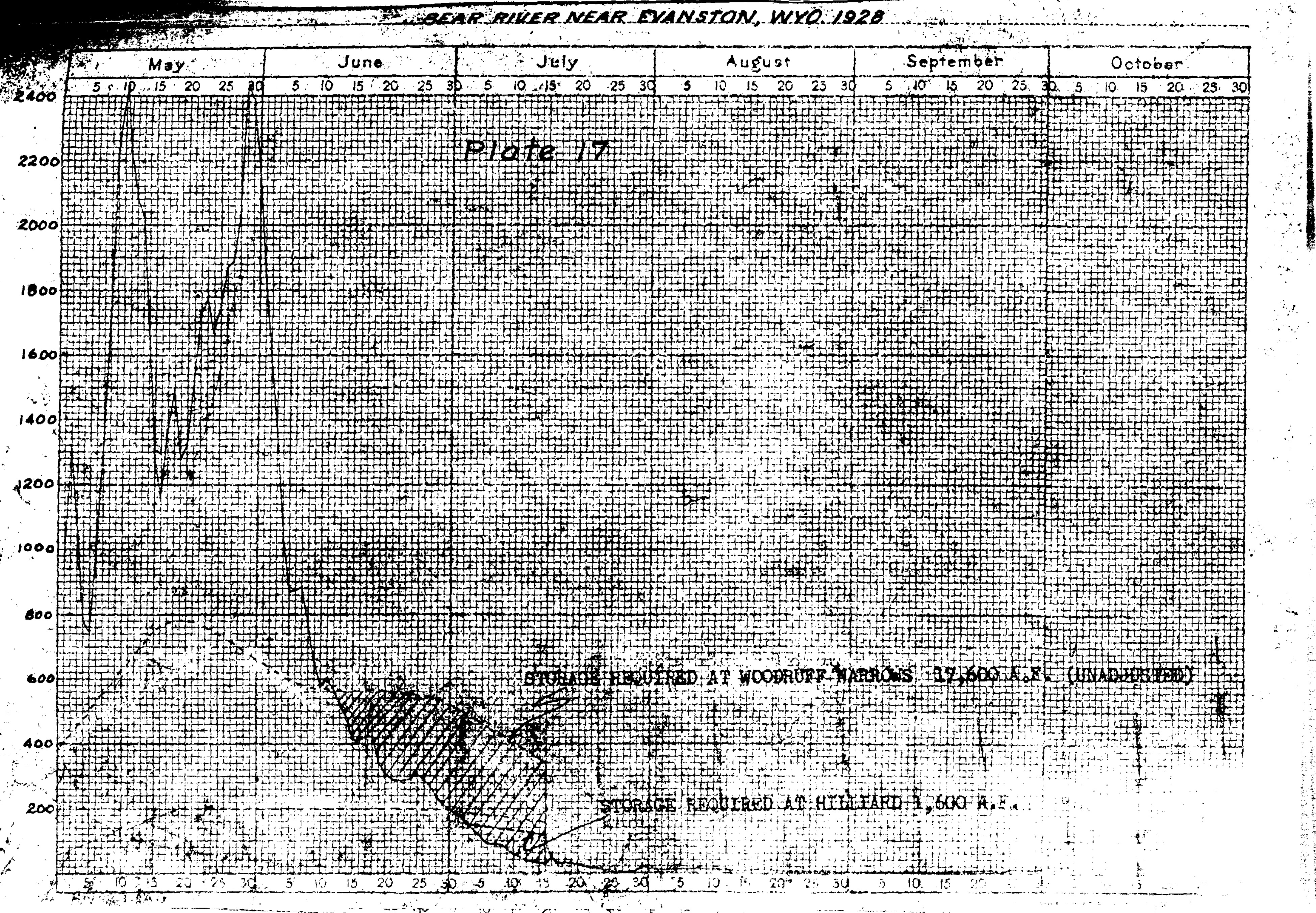
Plate 16

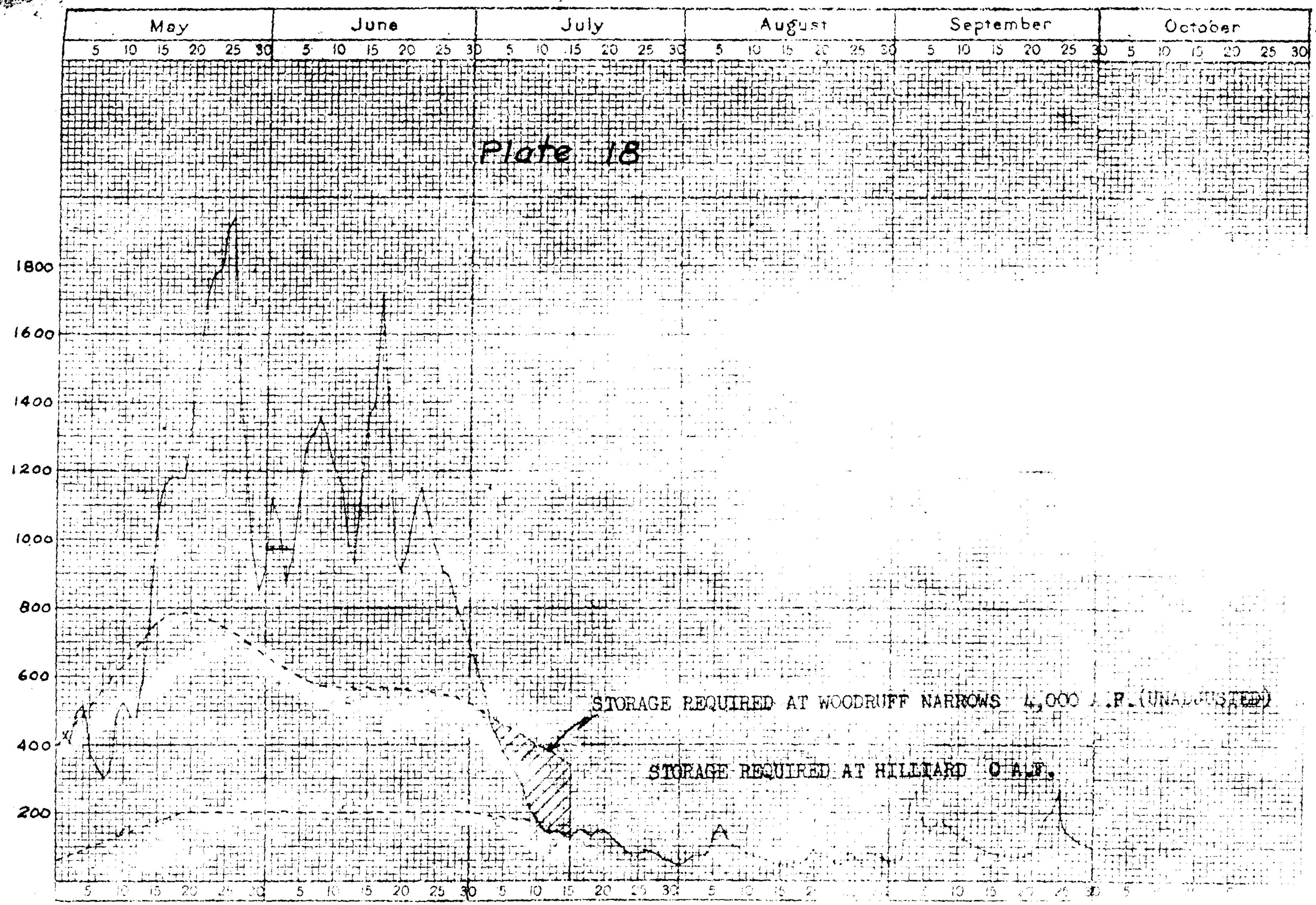
BEAR RIVER NEAR EVANSTON, WYO. 1927

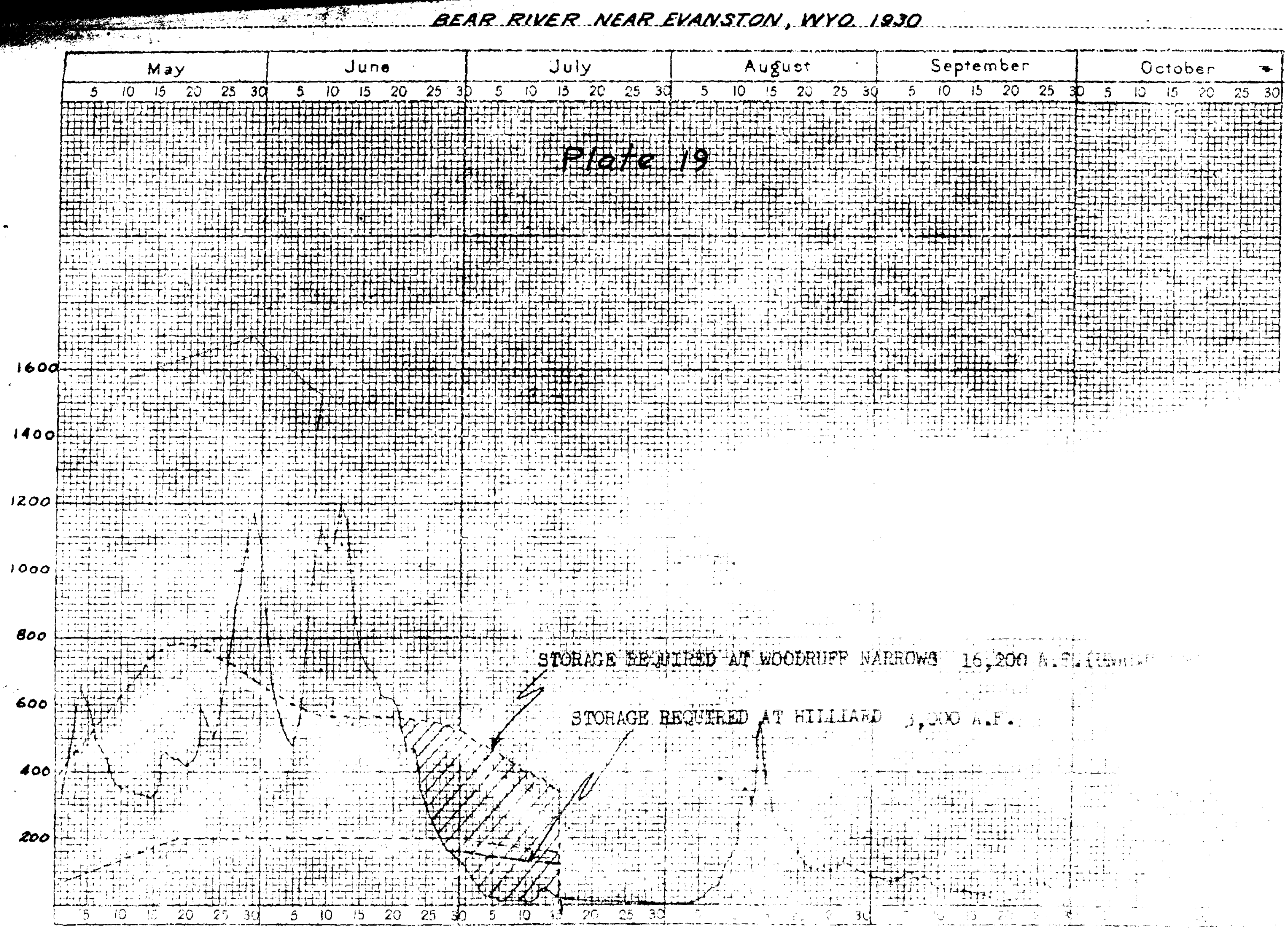


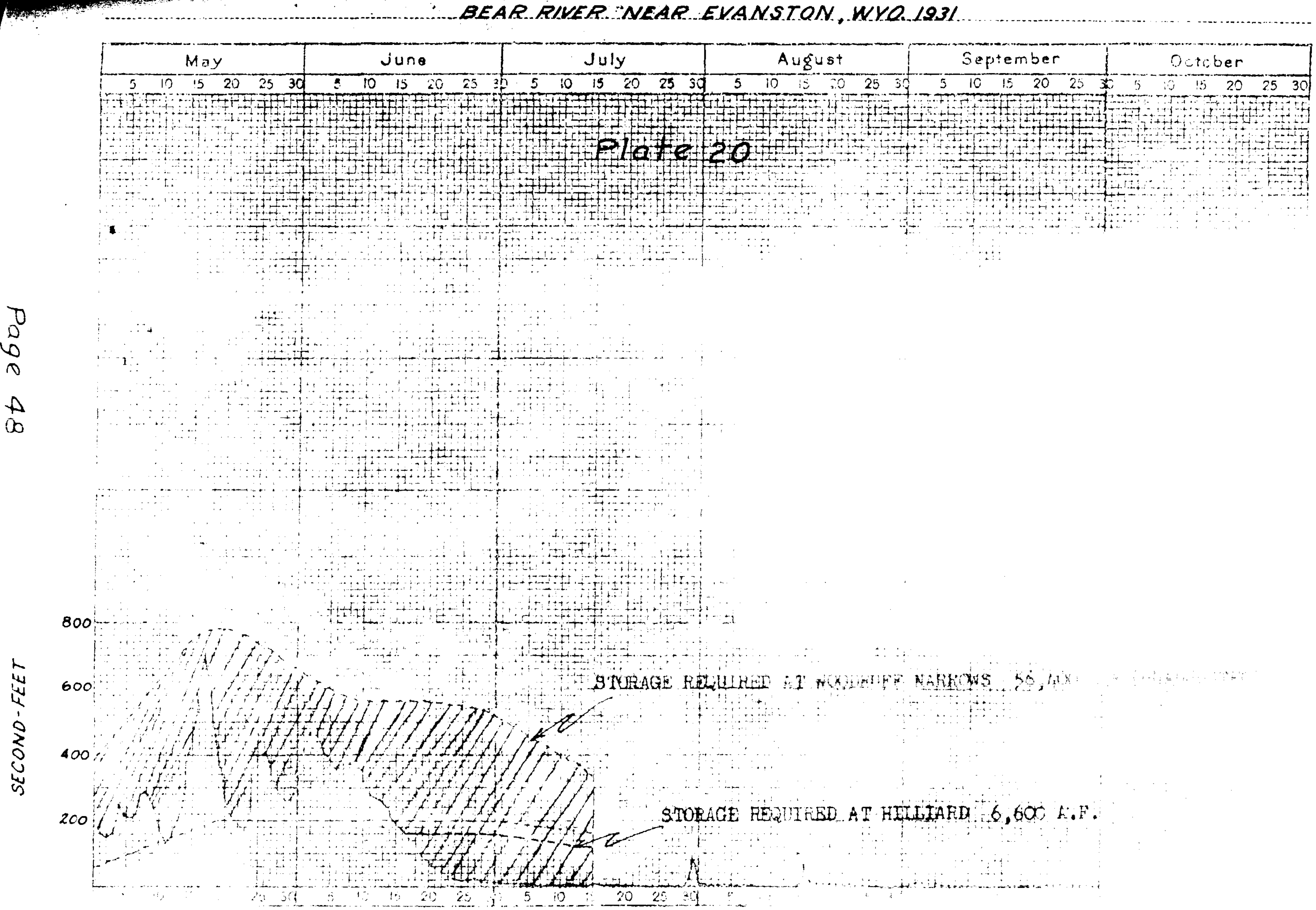

BEAR RIVER NEAR EVANSTON, WYO. 1928
Plate 17
May
June
July
August
September
October
SECOND-FEET
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
STORAGE REQUIRED AT WOODRUFF NARROWS 17,600 A.F. (UNADJUSTED)
STORAGE REQUIRED AT HILLIARD 1,600 A.F.

BEAR RIVER NEAR EVANSTON, WYO. 1929

Plate 18

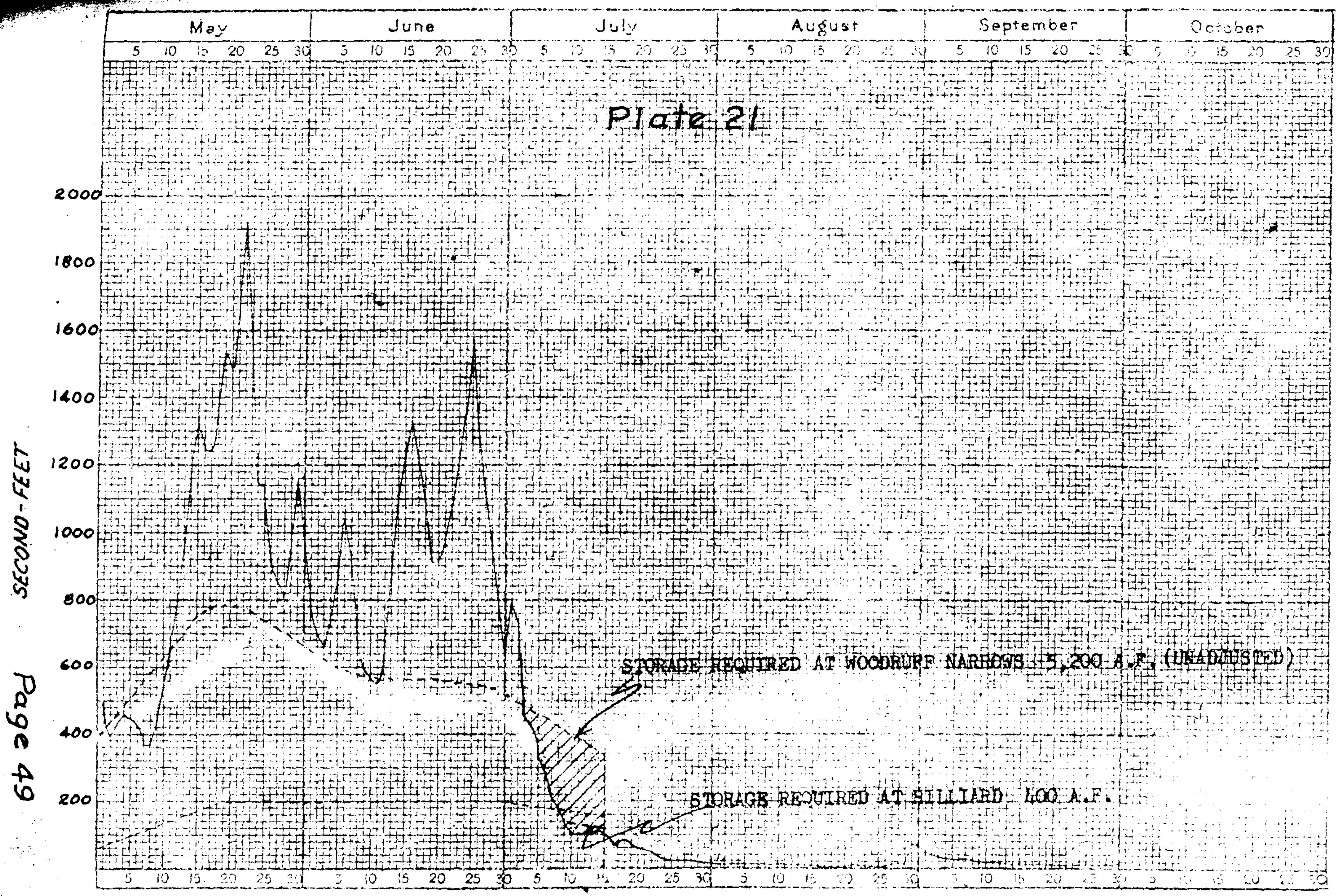



BEAR RIVER NEAR EVANSTON, WYO. 1930
Plate 19
May
June
July
August
September
October
SECOND-FEET
1600
1400
1200
1000
800
600
400
200
STORAGE REQUIRED AT WOODRUFF NARROWS 16,200 A.F.
STORAGE REQUIRED AT HILLIARD


BEAR RIVER NEAR EVANSTON, WYO. 1931
May
June
July
August
September
October
Plate 20
800
600
400
200
SECOND-FEET
STORAGE REQUIRED AT HELLIARD 6,600 A.F.

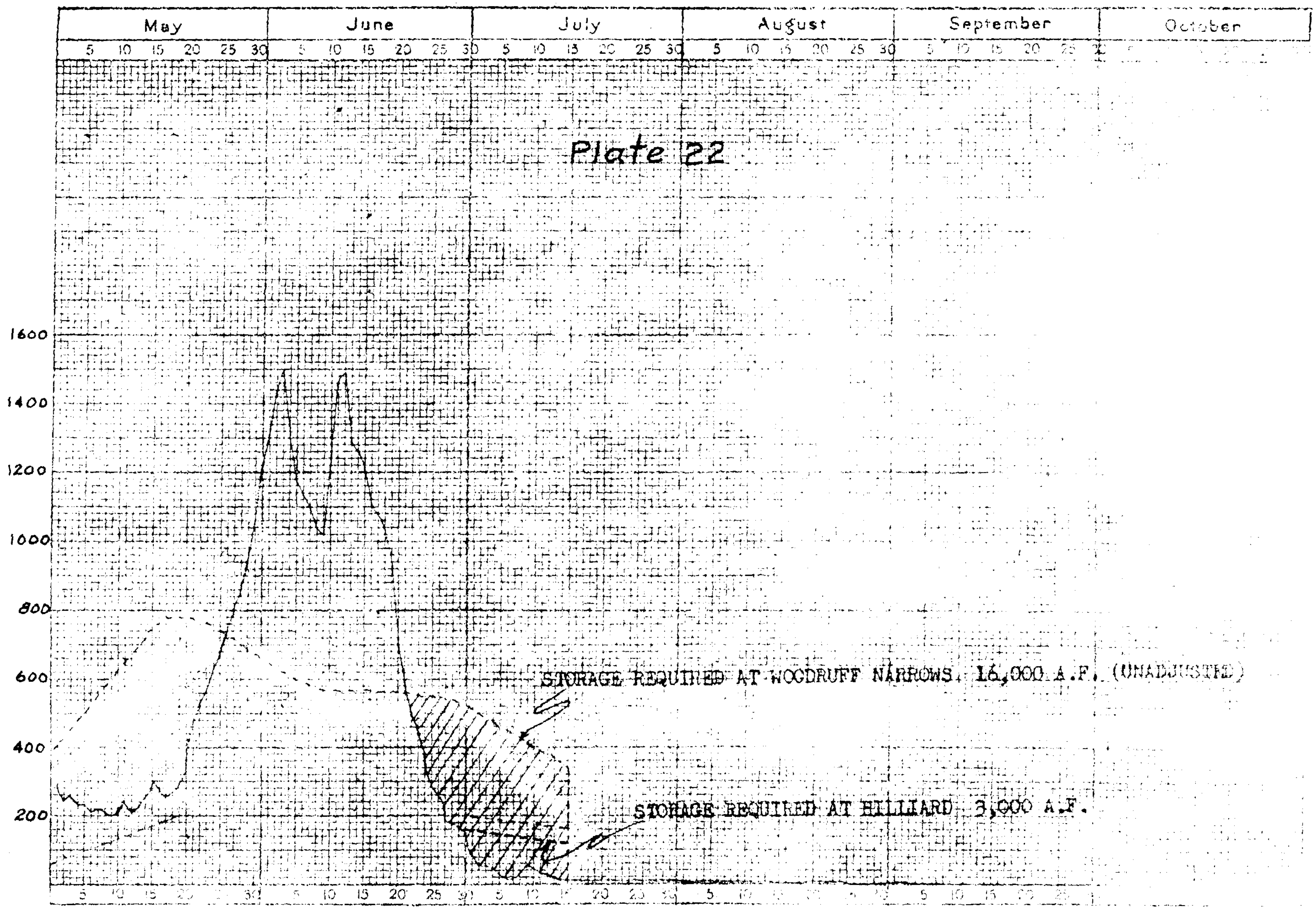
(WATER RESOURCES BRANCH)

BEAR RIVER NEAR EVANSTON, WYO. 1932



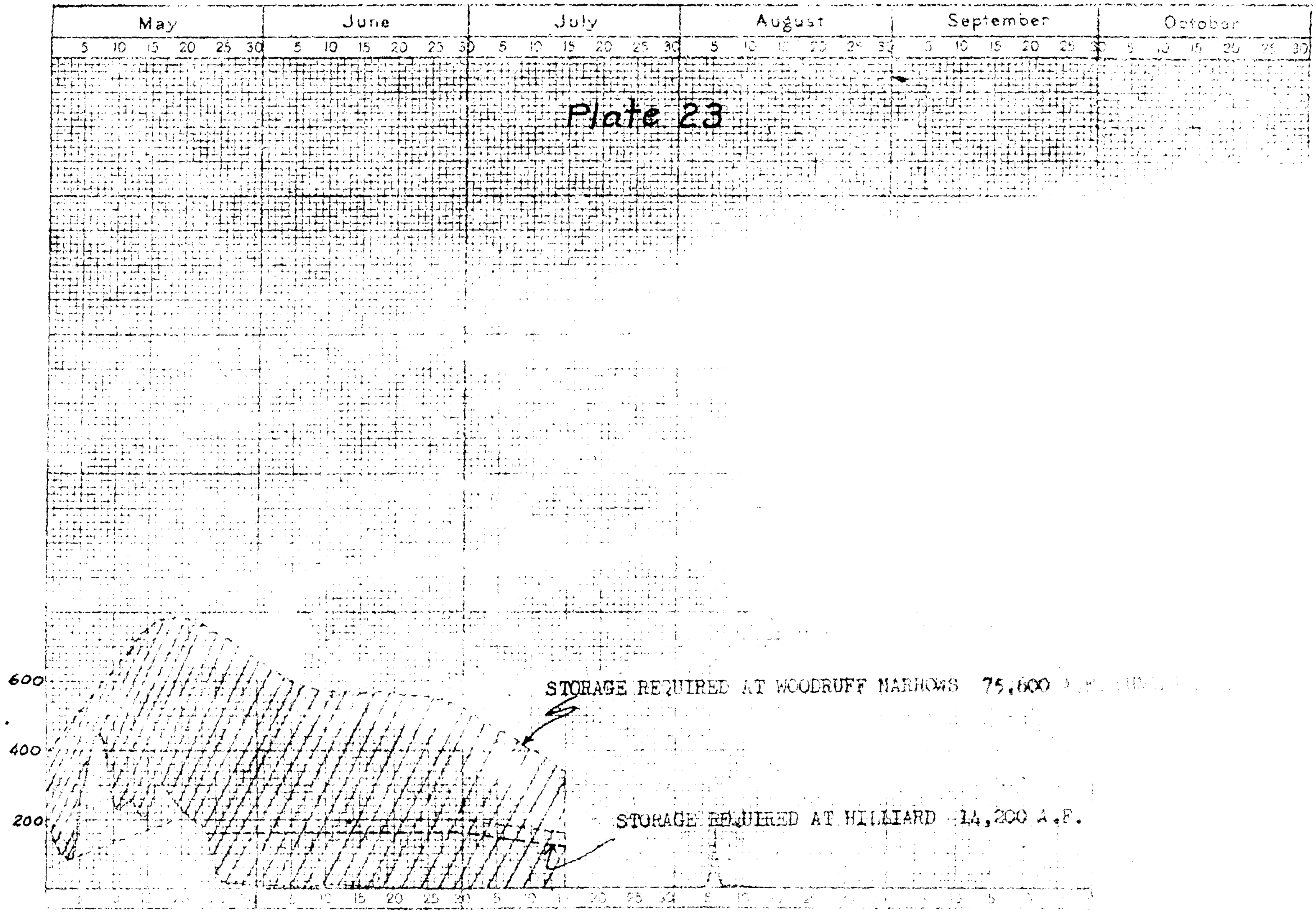
BEAR RIVER NEAR EVANSTON, WYO. 1933

Plate 22

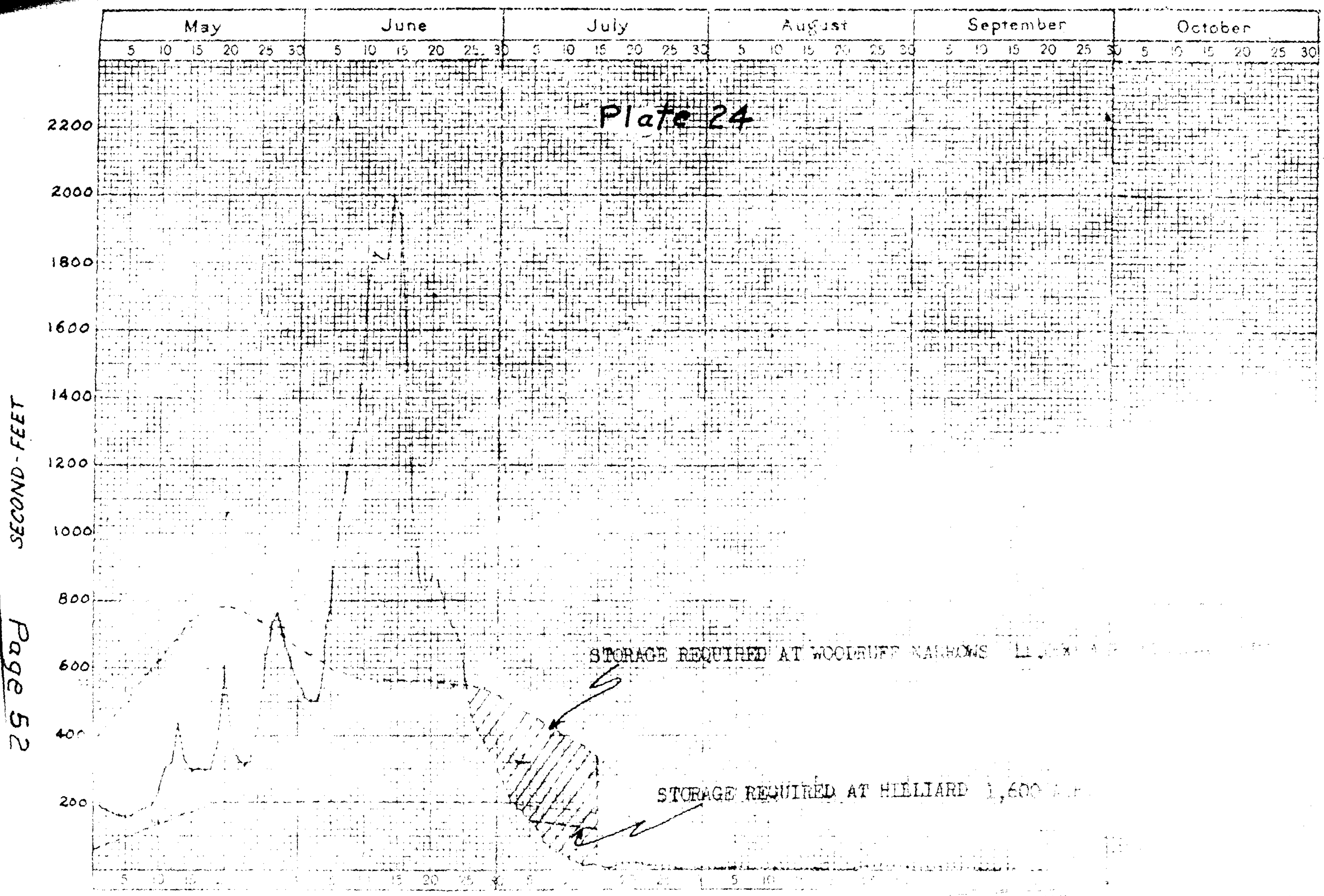


BEAR RIVER NEAR EVANSTON, WYO. 1934

Plate 23



BEAR RIVER NEAR EVANSTON, WYO. 1935



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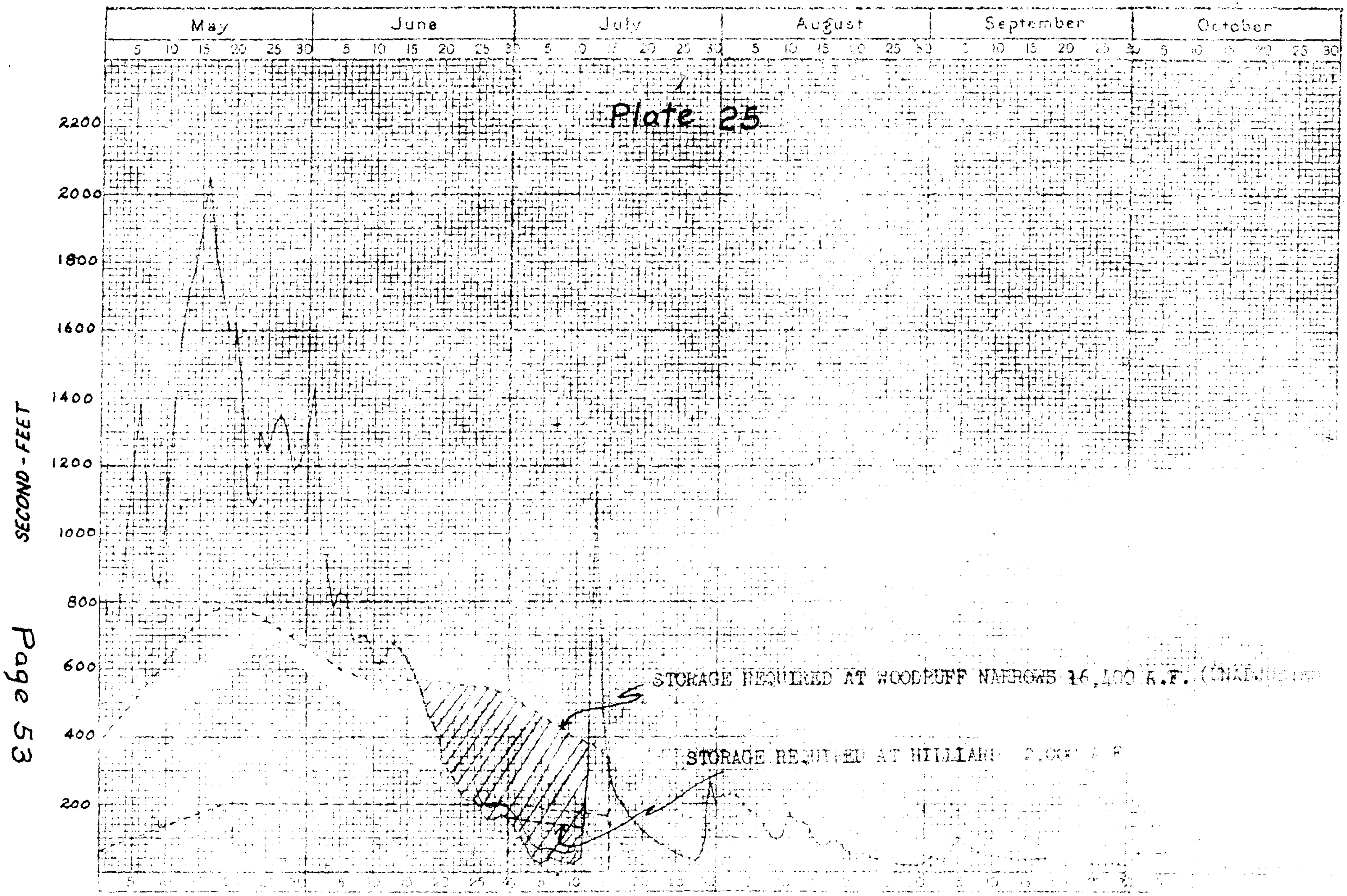
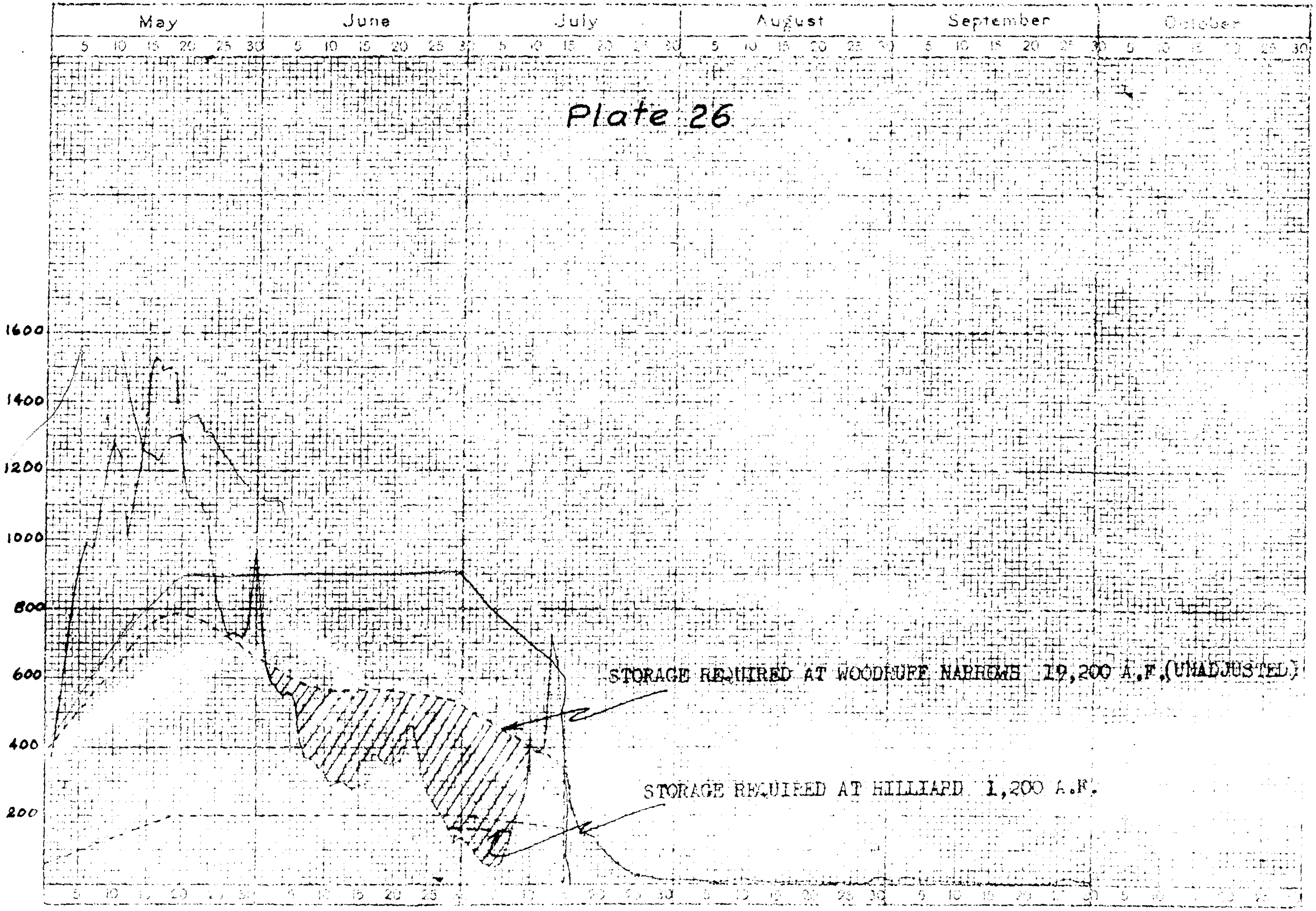
BEAR RIVER NEAR EVANSTON, WYO. 1936



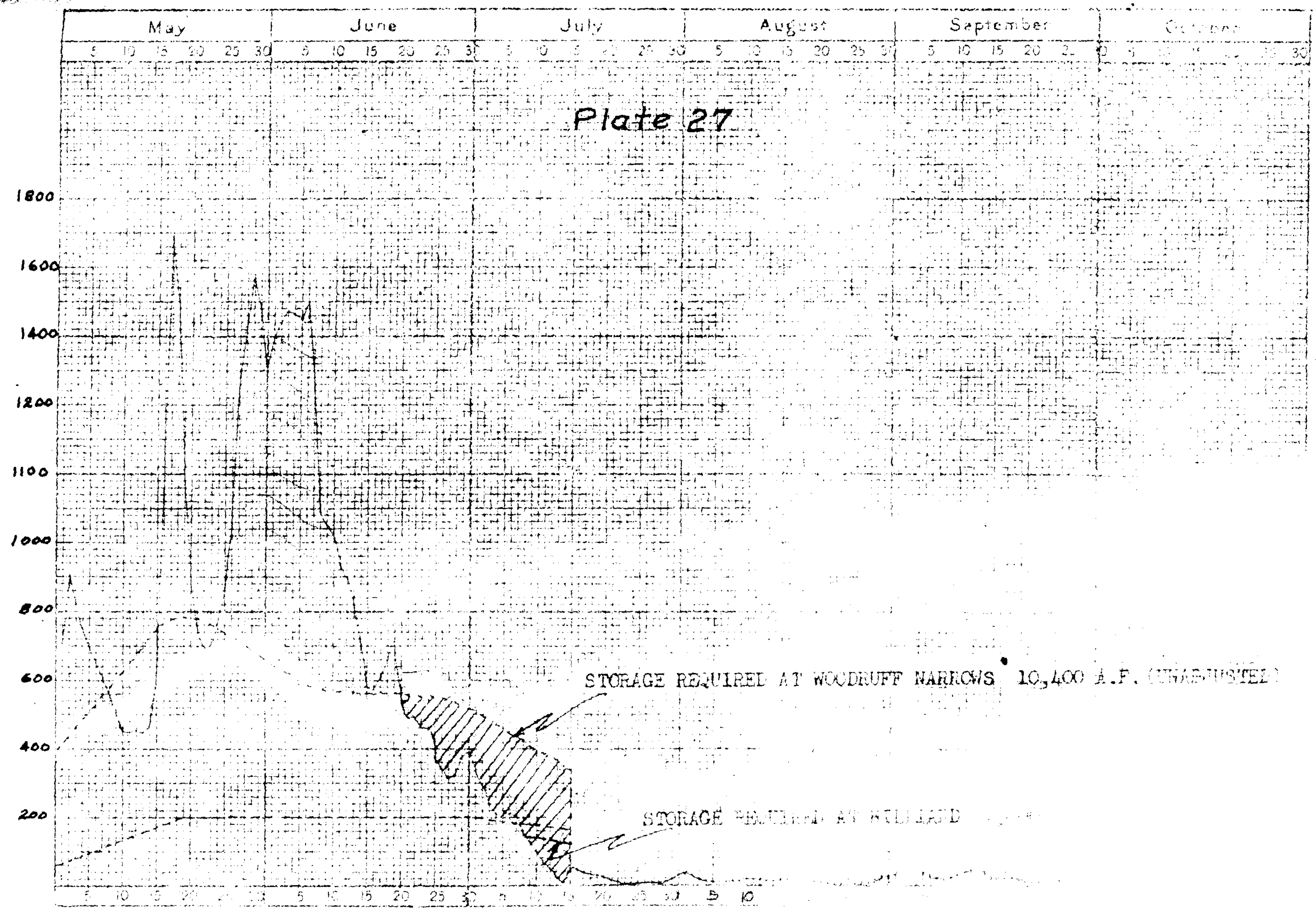
BEAR RIVER NEAR EVANSTON, WYO. 1937

Plate 26

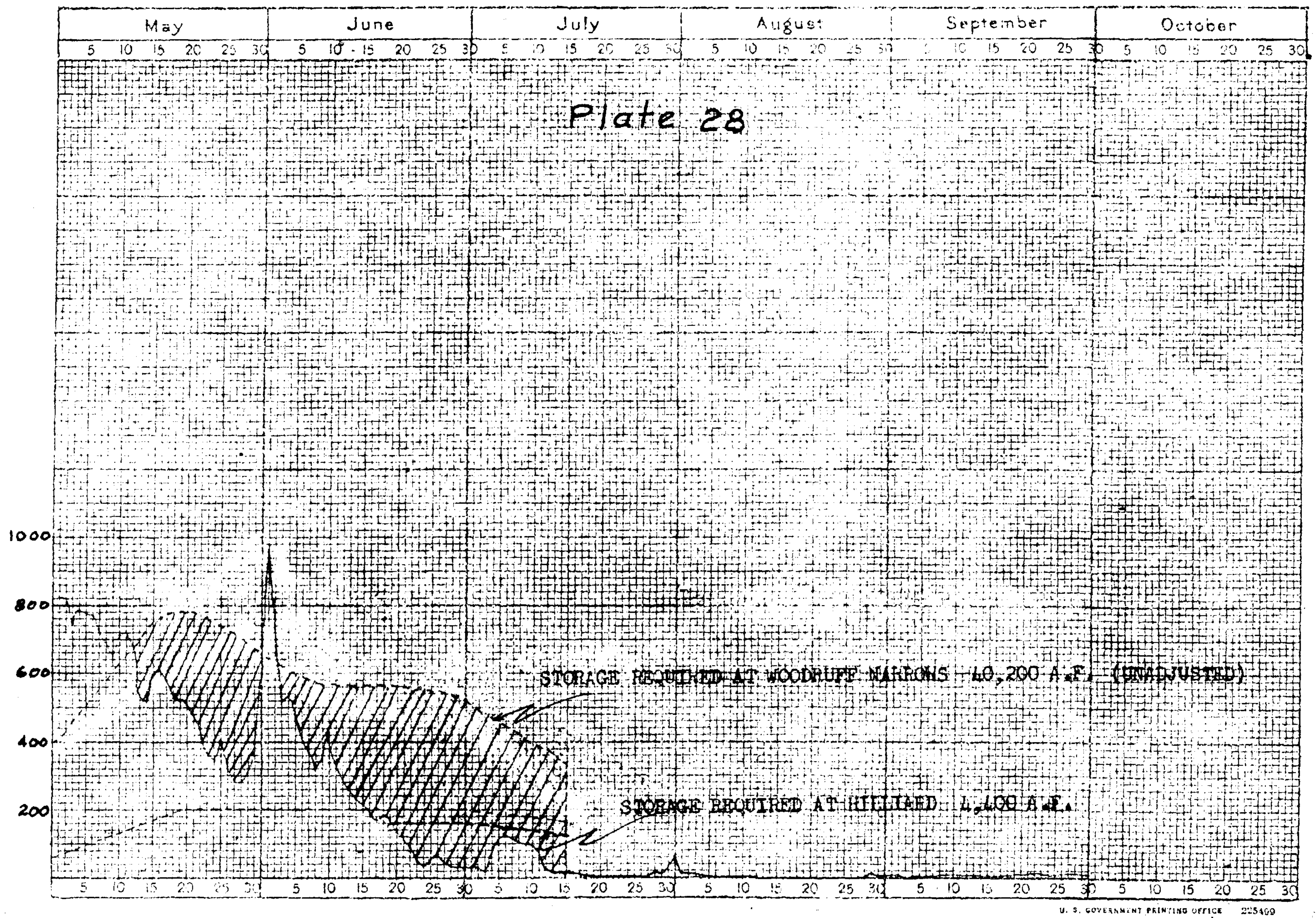


BEAR RIVER NEAR EVANSTON, WYO. 1938

Plate 27

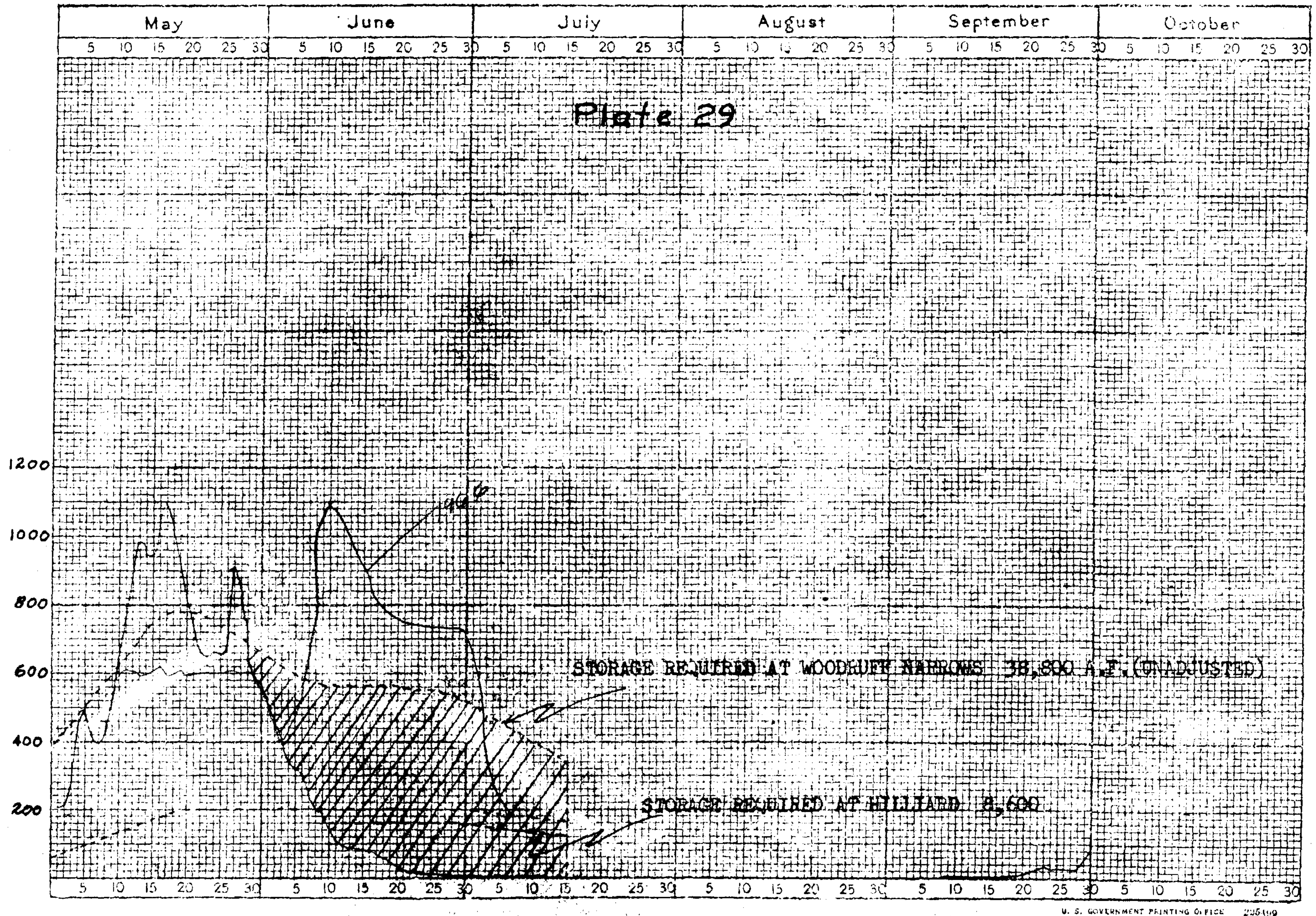


BEAR RIVER NEAR EVANSTON, WYO. 1939

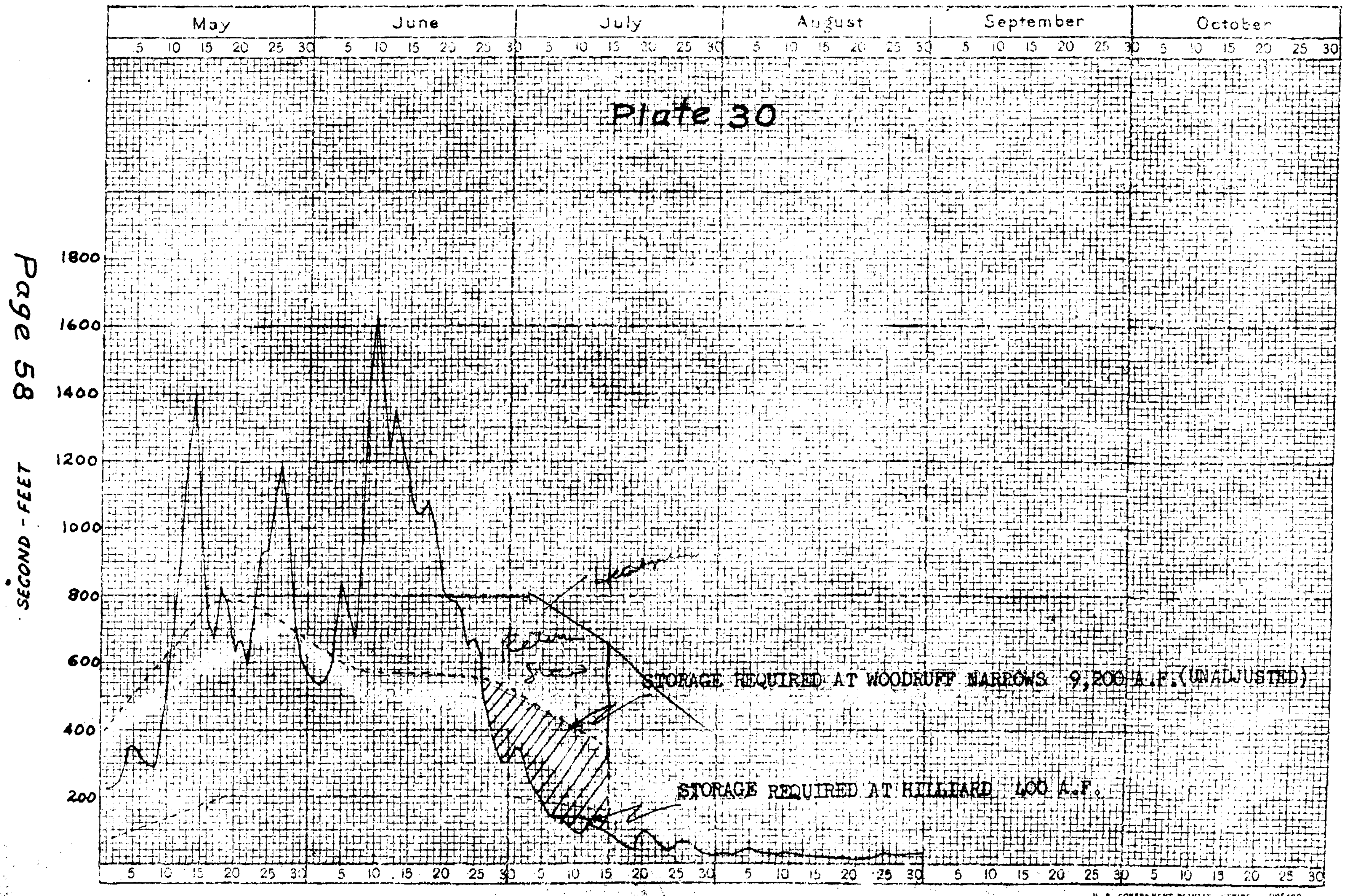


BEAR RIVER NEAR EVANSTON, WYO. 1940

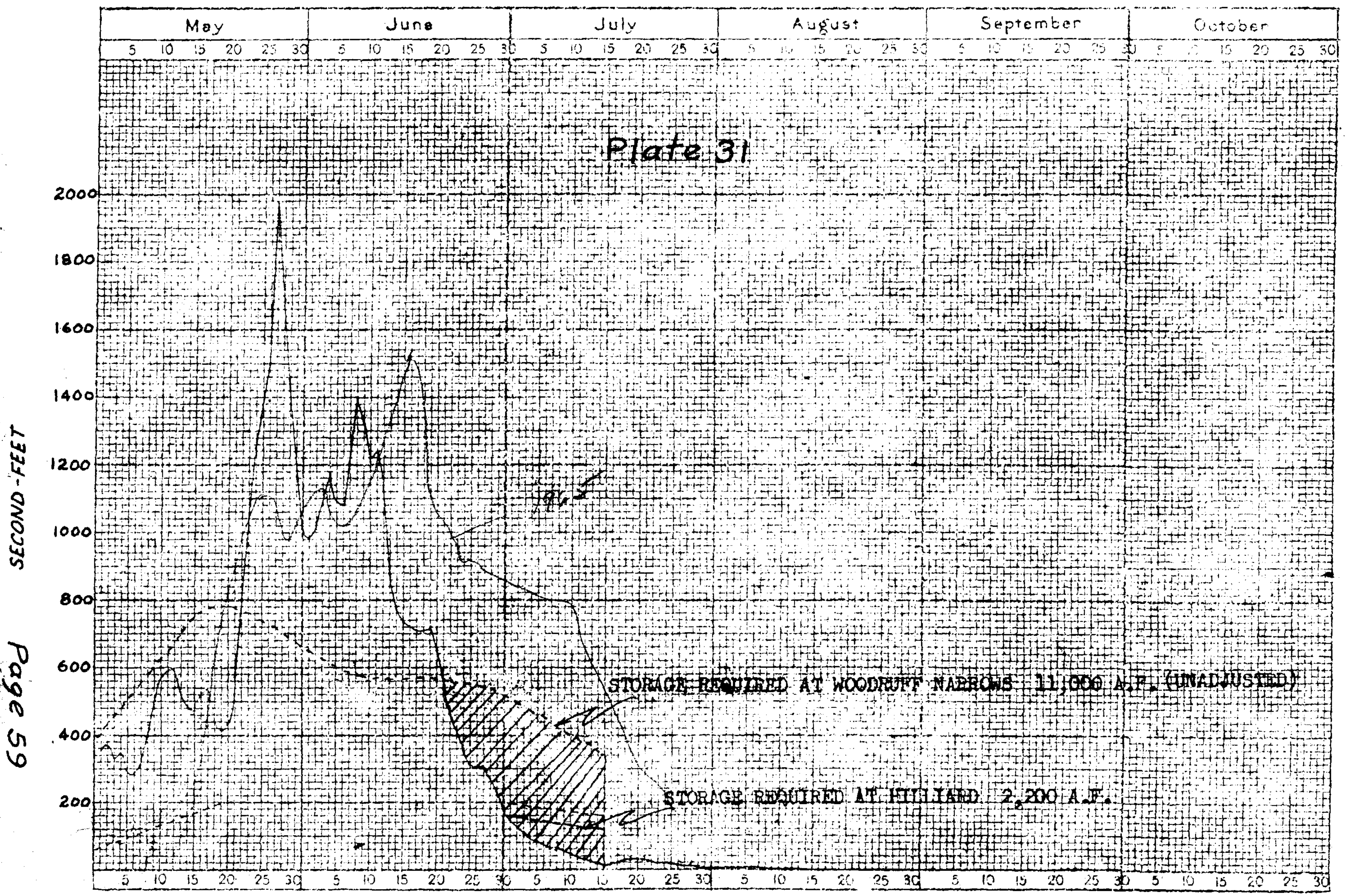
Plate 29



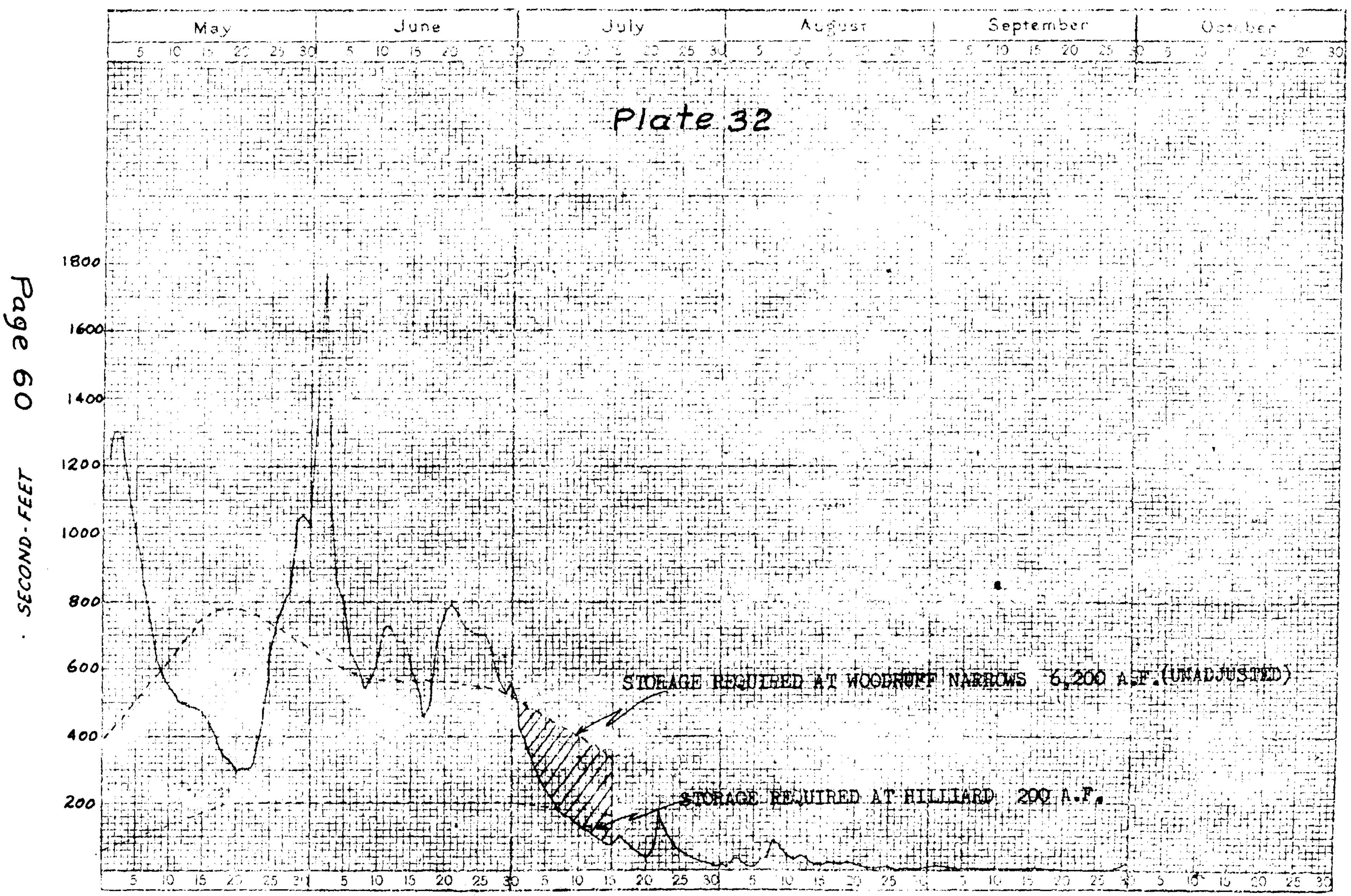
BEAR RIVER NEAR EVANSTON, WYO. 1941



BEAR RIVER NEAR EVANSTON, WYO. 1942

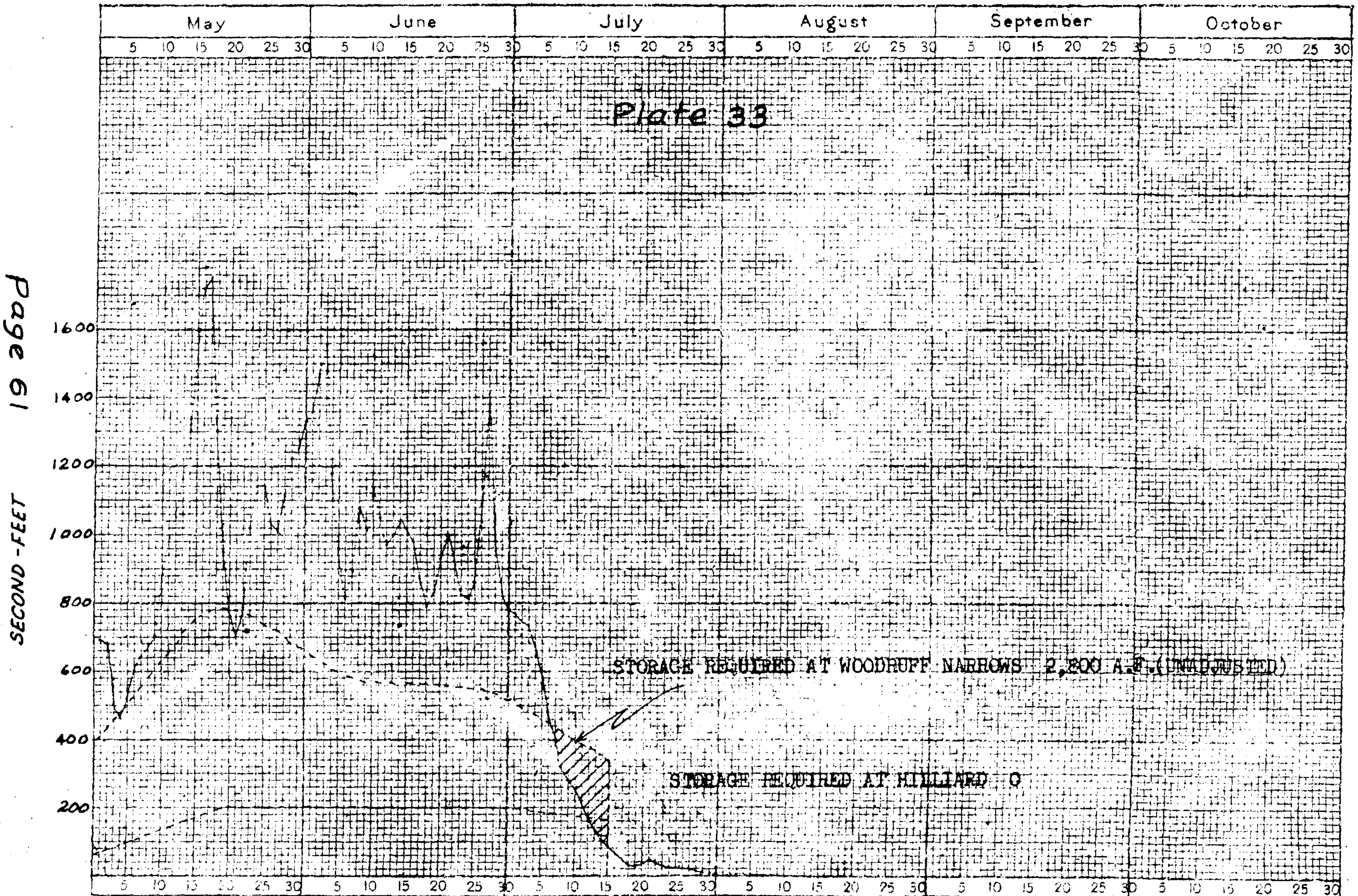


BEAR RIVER NEAR EVANSTON, WYO. 1943



BEAR RIVER NEAR EVANSTON, WYO. 1944

Plate 33



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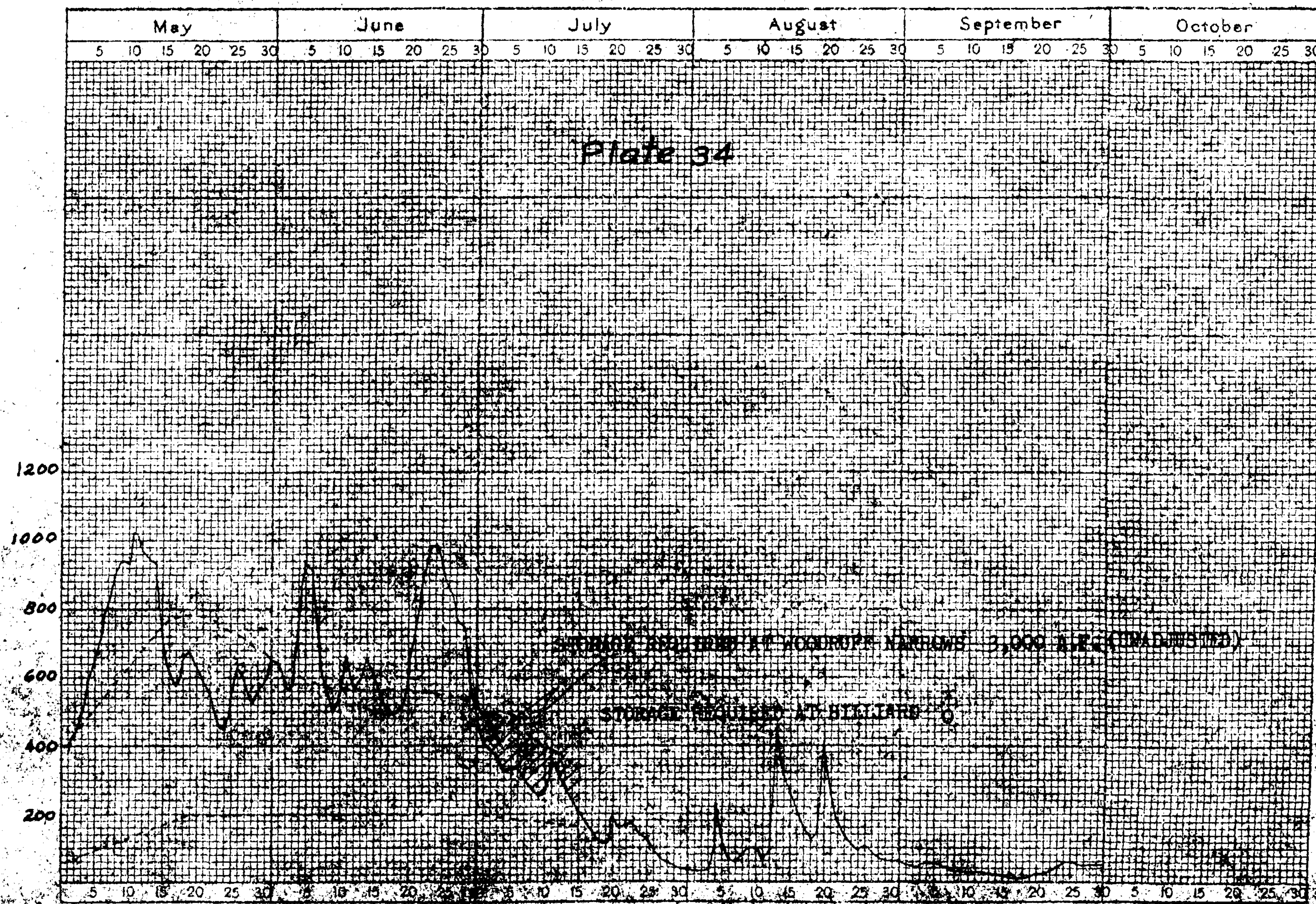
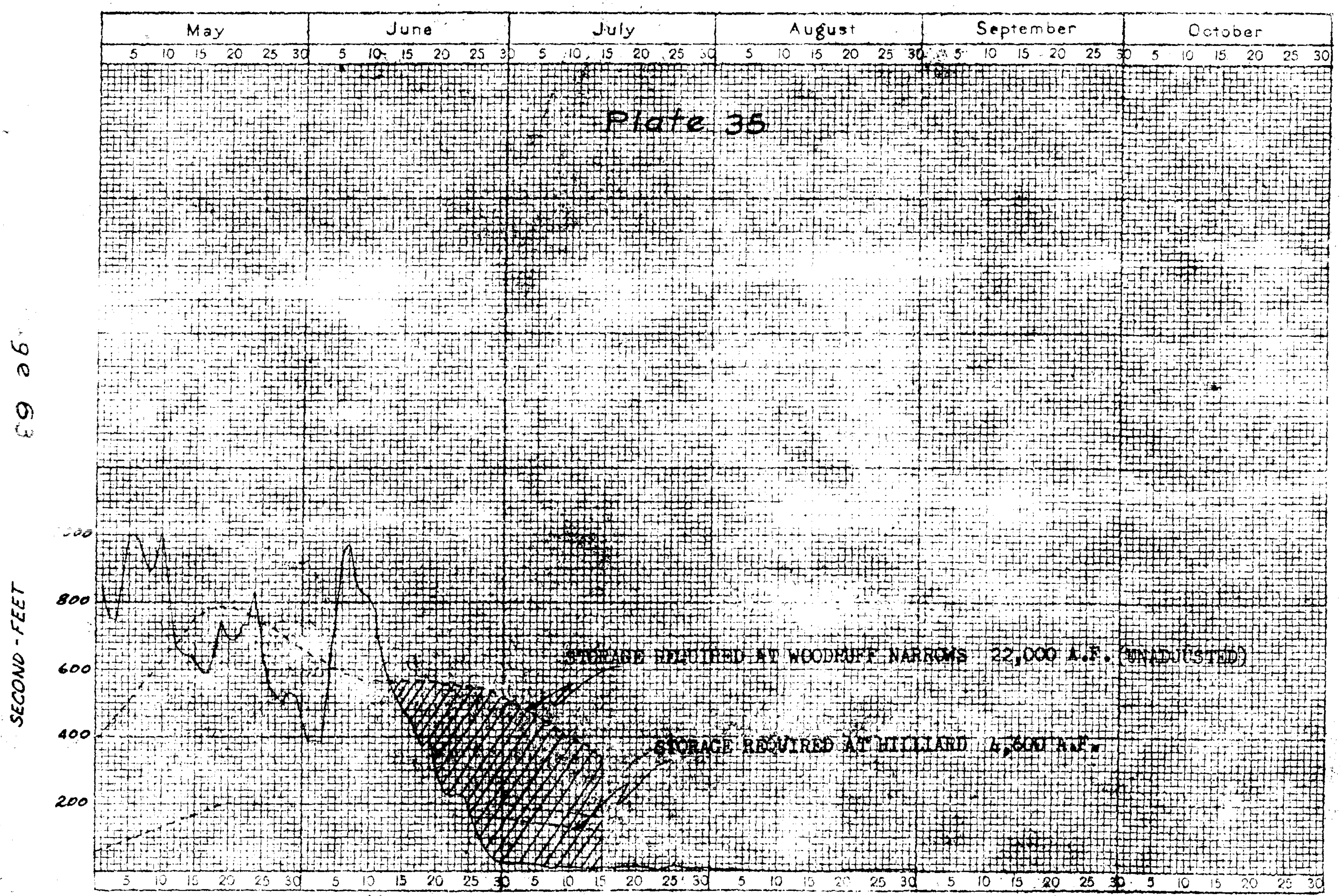
BEAR RIVER NEAR EVANSTON, WYO. 1945

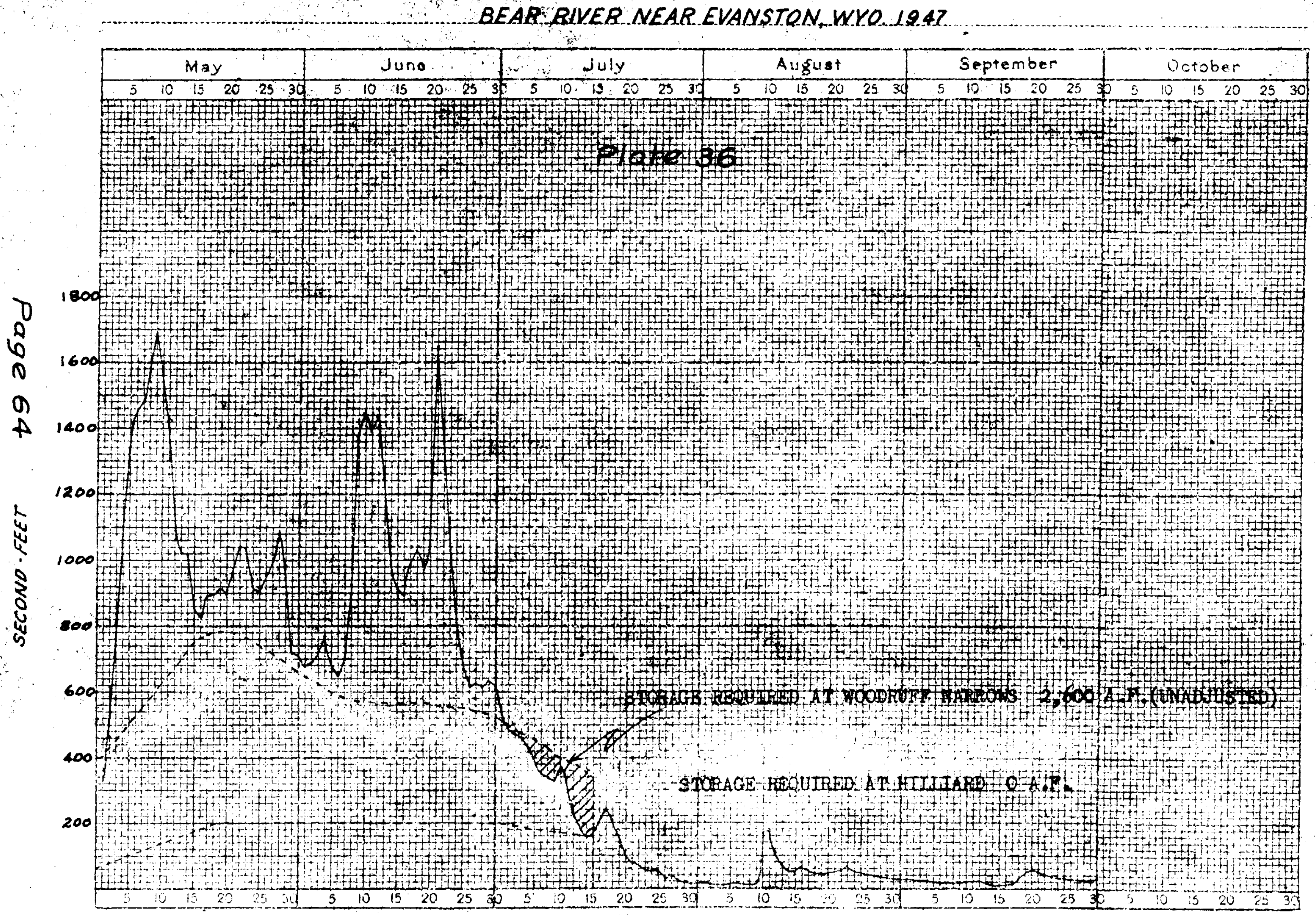


9-279-r
(Sept. 1922)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY

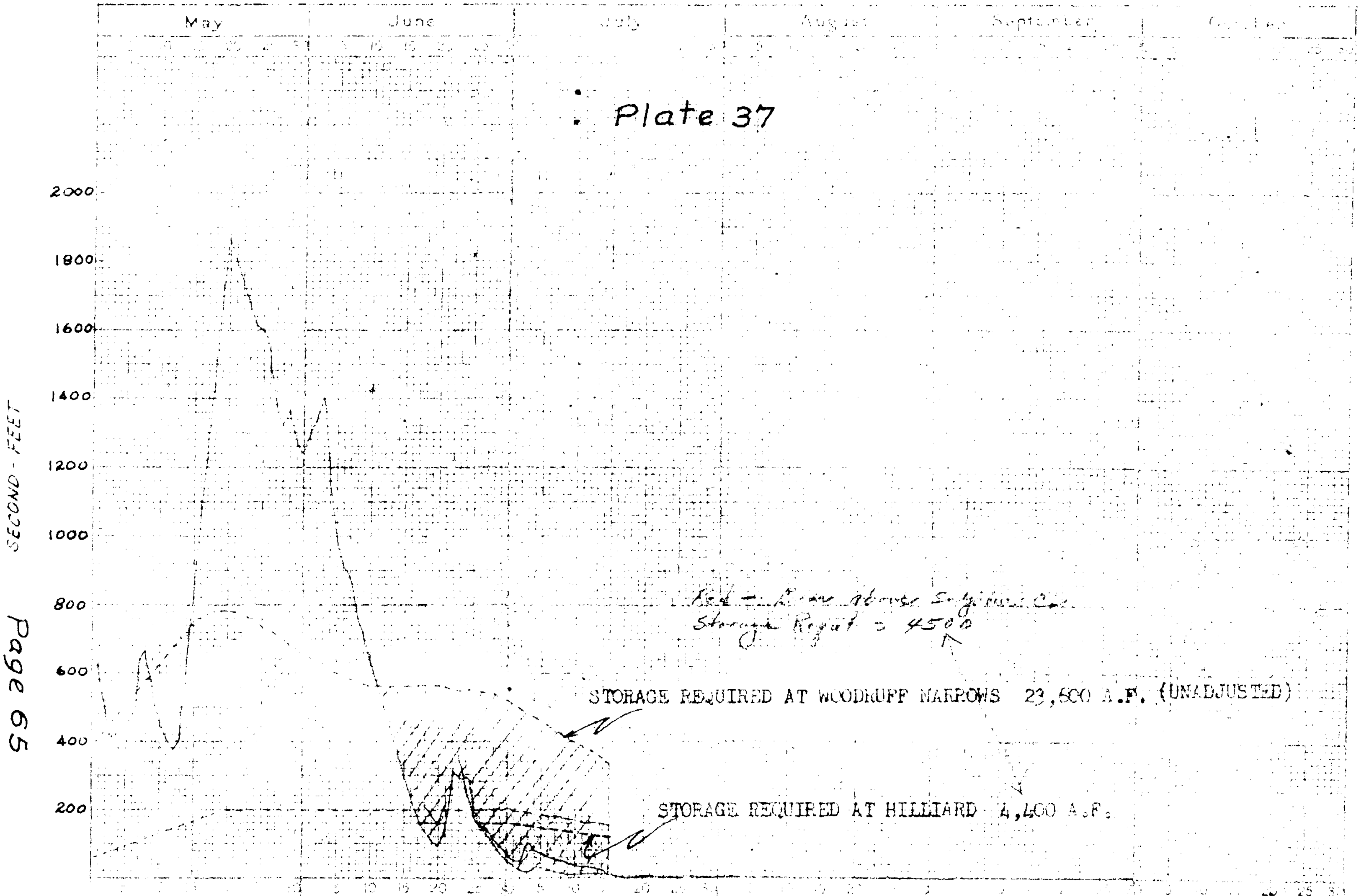
BEAR RIVER NEAR EVANSTON, WYO. 1946




BEAR RIVER NEAR EVANSTON, WYO. 1947
Plate 36
Page 64
May
June
July
August
September
October
SECOND-FEET
1800
1600
1400
1200
1000
800
600
400
200
STORAGE REQUIRED AT WOODRUFF NARROWS 2,600 A.F. (UNADJUSTED)
STORAGE REQUIRED AT HILLIARD 0 A.F.

BEAR RIVER NEAR EVANSTON, WYO. 1948

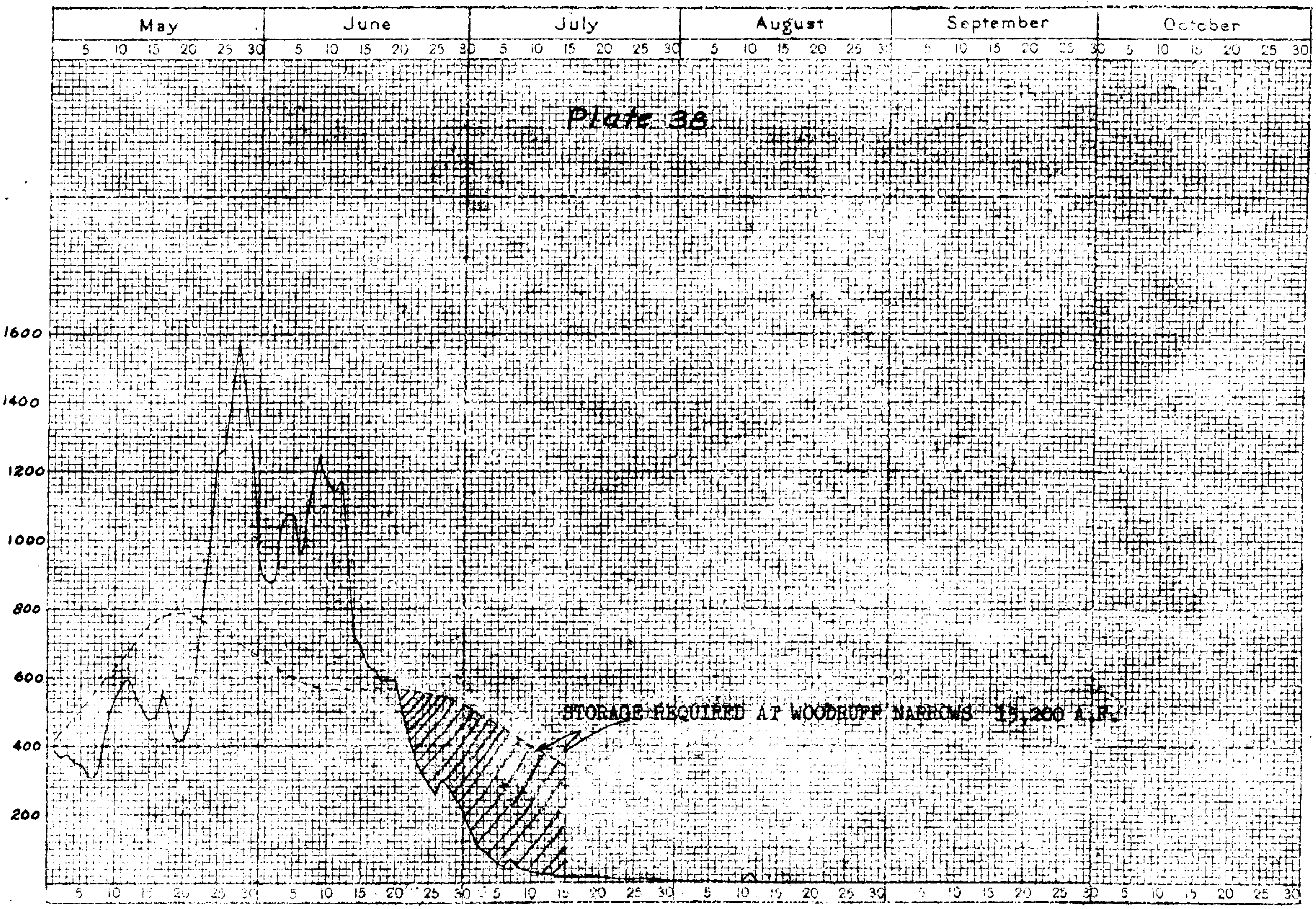
Plate 37



(Sept. 1922)

UNITED STATES DEPARTMENT ...

BEAR RIVER NEAR WOODRUFF, UTAH 1942



9-279-E
(Sept. 1922)

UNITED STATES DEPARTMENT OF THE INTERIOR

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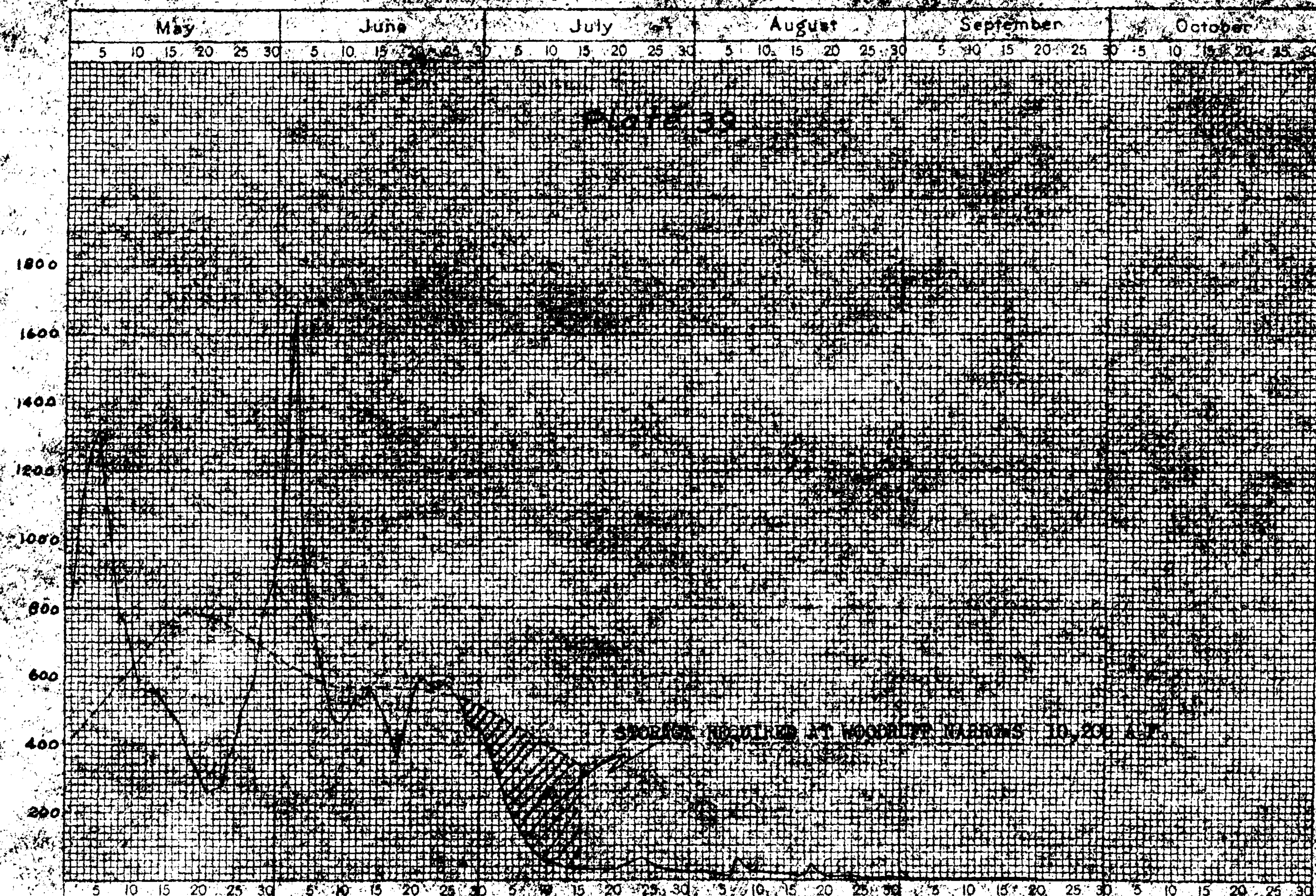
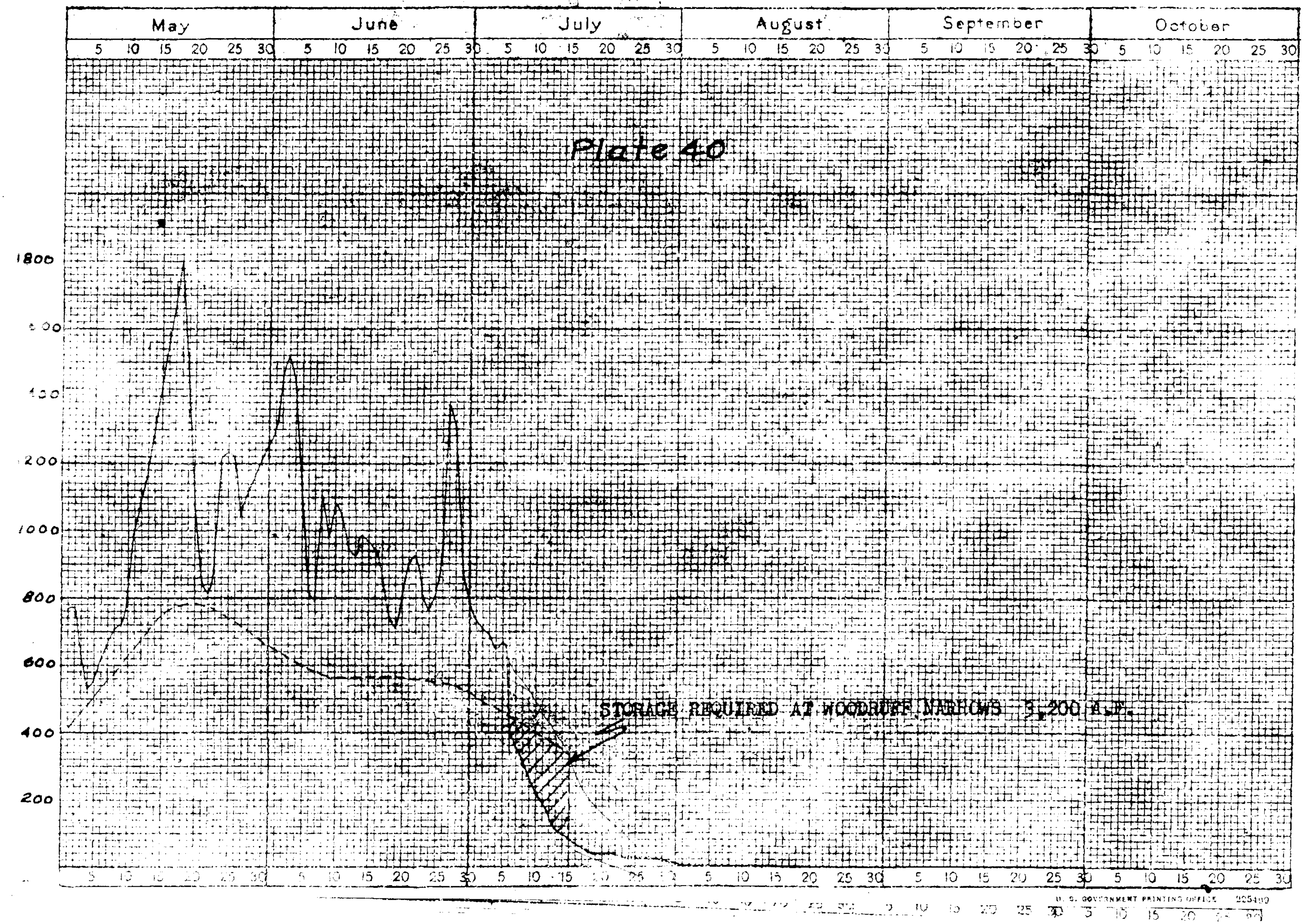
BEAR RIVER NEAR WOODRUFF, UTAH 19..



9-279-f
(Sept. 1922)

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCES

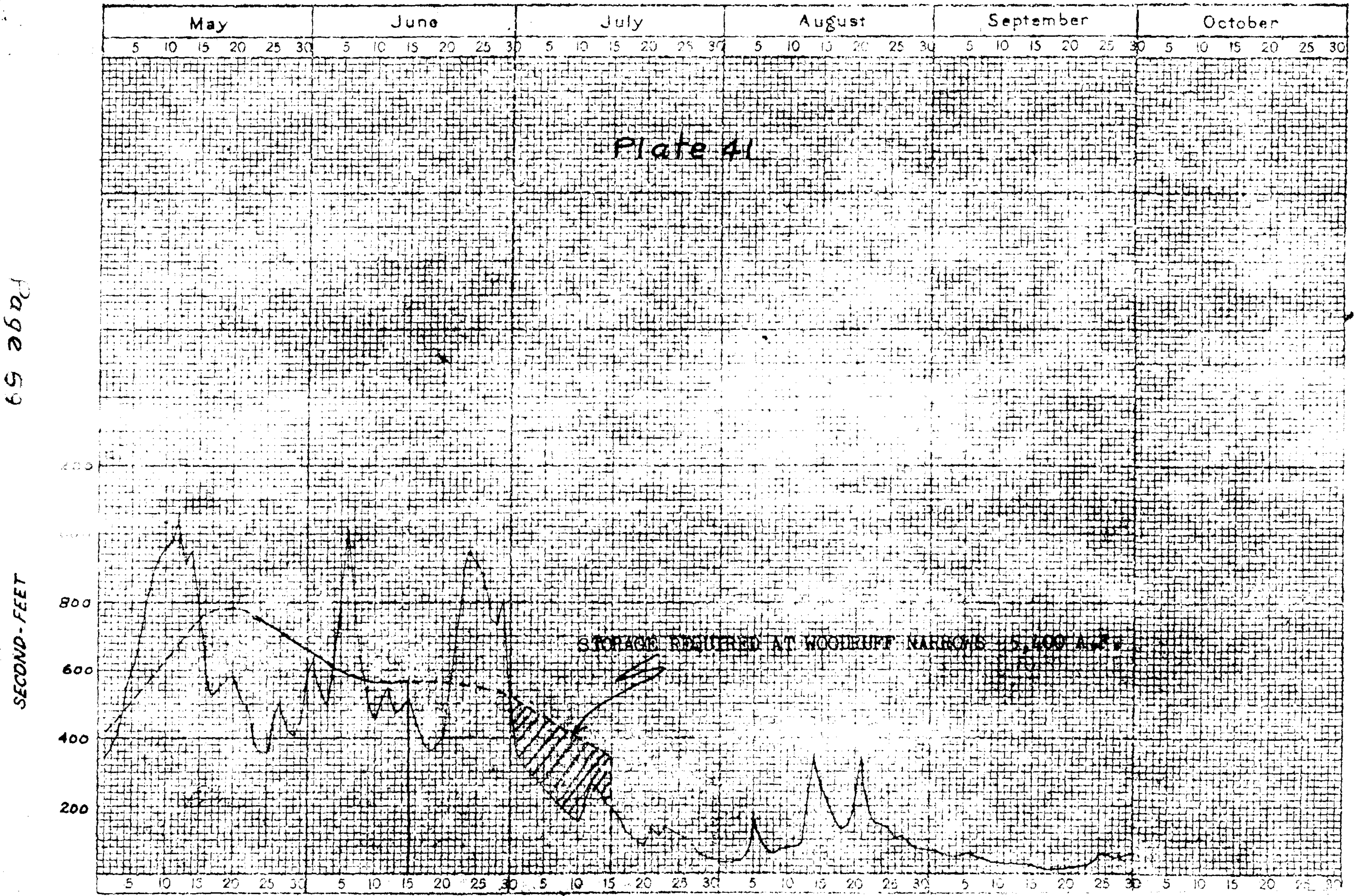
BEAR RIVER NEAR WOODRUFF, UTAH 1944



9-279-f
(Sept. 1922)

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

BEAR RIVER NEAR WOODRUFF, UTAH 1945



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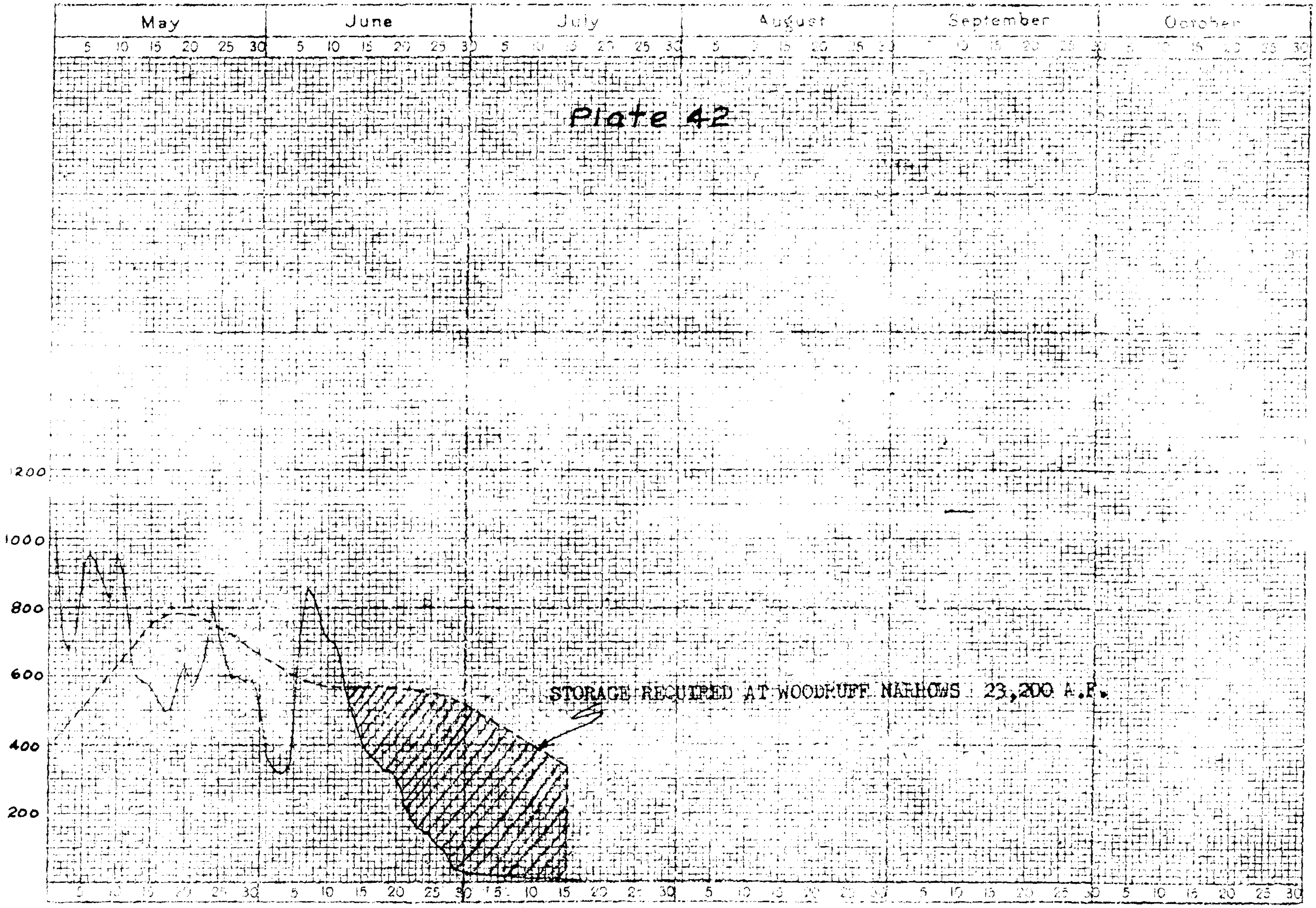
9-279-f
(Sept. 1922)

UNITED STATES DEPARTMENT OF THE INTERIOR

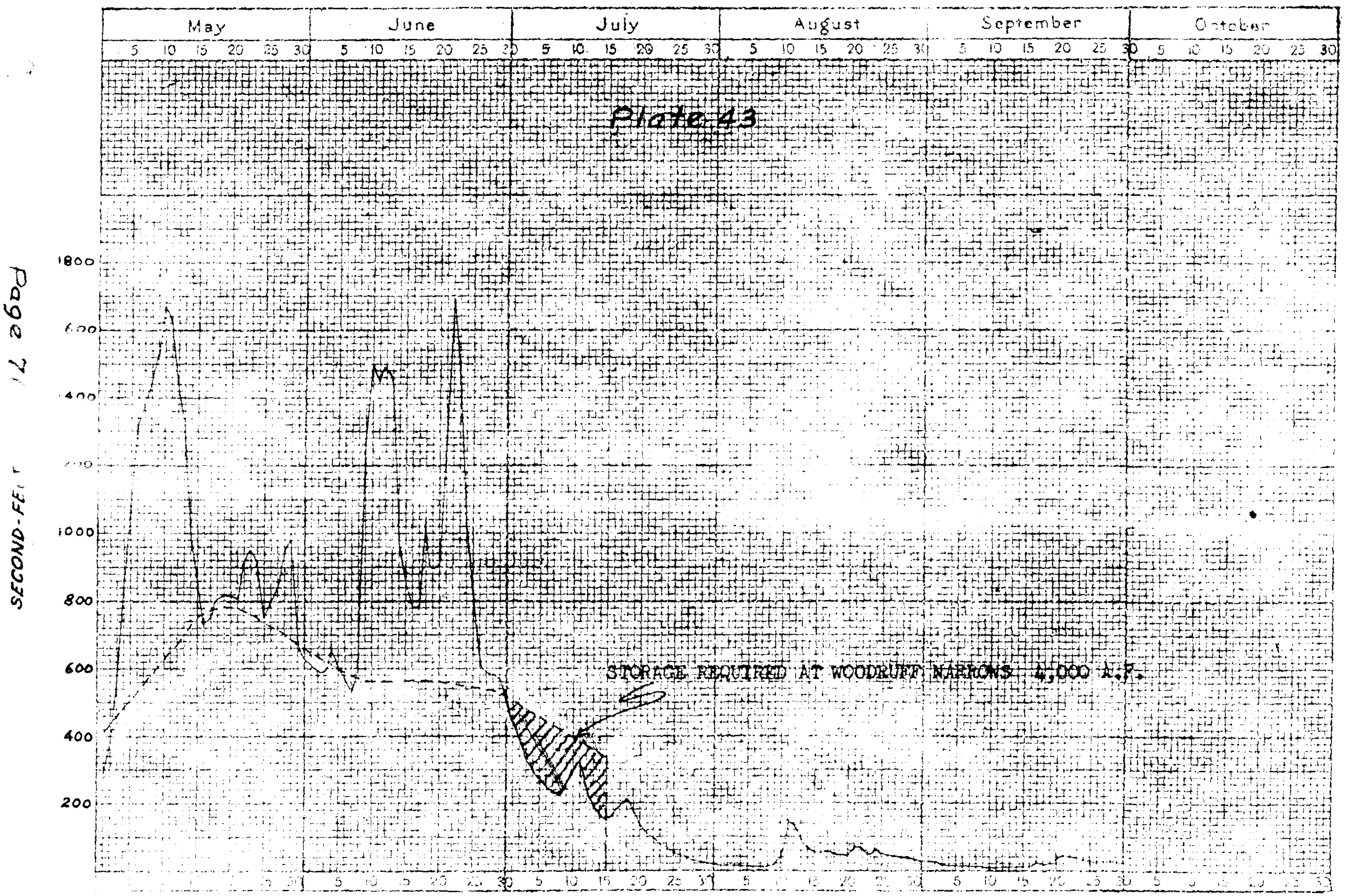
BEAR RIVER NEAR WOODRUFF, UTAH 1946



9-279-f
(Sept. 1922)

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

BEAR RIVER NEAR WOODRUFF, UTAH 1947



UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

BEAR RIVER NEAR WOODRUFF, UTAH 1948

Plate 44