REPORT NO. 16

DAILY STREAM FLOW DEPLETIONS

in

UPPER AND CENTRAL DIVISIONS

of

BEAR RIVER BASIN

Study of depletion method of division

Preliminary Report, not for release to the public, and subject to revision. This report is for restricted use by the Bear River Compact Commission and its Committees and is not to be published, reproduced or circulated, except by approval of the Director of the U. S. Geological Survey.

Prepared by

W. V. Iorns, Project Engineer
U. S. Geological Survey

May 22, 1951

BEAR RIVER BASIN

Daily Depletions of Stream Flow

One of the several methods for division of the natural flow waters of Bear River between the several states concerned is the daily depletion method. "Daily depletion" is defined as the amount of water that flows into a valley area minus the amount of water that flows out of the valley area during a twenty-four hour period, with due allowance for time interval of transit of water down the natural channel. This definition is practically the same as that for "valley stream flow depletion" in a previous report titled "Stream Flow Depletions and Consumptive Use in Bear River Basin above Border, Wyoming, dated December 14, 1950" except in that report depletion was computed for the irrigation season May to September.

Studies of stream flow in the Upper Bear River Basin have shown in general, that the rate of return flows from water applied in irrigation follows approximately the pattern of daily irrigation diversions. Because of this relation, there is indicated a possibility of devising a method for division between the states by using daily depletion, providing the daily depletions show the desired relation to irrigation diversions and supplies.

The quantity of water diverted from a stream by an upstream water user may not in all cases be a measure of the effect that user has upon other downstream water users drawing from the same source of supply. Only if the upstream use consumes all of the water diverted, would the quantity diverted be a measure of effect. However, if a portion, especially a major portion, of the water diverted quickly returns to the stream, the net effect of the upstream use would be the quantity of water that the stream was depleted, as compared to the flow which would reach the lower users if there were no upstream diversion. In the daily depletion method each state section would be

allowed to deplete the natural flow of the stream by certain amounts. These amounts may be made proportional to the supply available and predicated on the relative priorities of a state section as compared to other upstream and downstream state sections.

In the practical application of the daily depletion method, an index inflow gaging station or a group of inflow stations would be used as a measure of the supply and a gaging station at the lower end of a given section used as a measure of the outflow. The difference between the supply and outflow, allowing for time interval for movement of water through the reach, would be the depletion caused by use of water in the reach. In order to allow for unavoidable deviations and obtain consistent results, averages for several consecutive days of inflow and outflow may need be used.

Yearly, seasonal, or long period averages could not be used because total seasonal flows cannot be divided in conformity with any schedule of priority of rights.

As a means of investigating whether or not a daily depletion method is feasible, the supplies, outflows, daily diversions and daily depletions in the several river sections must be studied. In doing this the Upper Division is divided into the Upper Wyoming and Middle Utah State sections. The Central Division is divided into the Lower Wyoming and Upper Idaho State sections. The Lower Division down through Alexander was investigated to determine what effect restrictions of depletions in the Lower Wyoming State section will have on natural flows available for the Last Chance Canal system.

UPPER DIVISION

Upper Wyoming State Section

Inflow = Bear River near Utah Wyoming State line + Hilliard East Fork Canal + Mill Creek at State line + Sulphur Creek near Evanston + Yellow Creek near Evanston.

Outflow = Bear River near Woodruff (2 days later).

Depletion = Inflow - Outflow (average of 3 days plotted on mid-day).

On Plates 1, 2, and 3, the various data are plotted for 1944, 1945, and 1946.

Plate 1 - 1944 - Local runoff resulted in a net gain in the section prior to May 26. During this period plant growth probably advanced considerably as the depletion showed a rapid gain to about 350 second-feet daily in the last week of May. This rate continued throughout June, except for two periods when increased outflow due to local rains caused apparent decreases in depletion. The same rate of daily depletion continued in July until irrigation was curtailed due to decreasing supply.

Plate 2 - 1945 - Local runoff resulted in a net gain in the section prior to May 12. Considerable precipitation occurred during May and the first ten days of June, which supplied a good portion of moisture needed by the crops and resulted in decreased depletion in the section. The effect of precipitation apparently continued until late in June, when the depletion approached 350 second-feet daily and remained near that amount through the early part of July, after which, it decreased due to decrease in irrigation supplies or less moisture demand by the crops, or a combination of the two. The effect of heavy rain storms in August are very noticeable.

Plate 3 - 1946 - Snow on the valley floor melted early in April and local runoff was practically dissipated by the beginning of May. Three heavy rain storms occurred during May, the effects of which are evident on May 8, 9, and 21, 22, and 24, 25, however, the full effect in each case continued for several days following. In early June the depletion rate increased to 350 to 400 second-feet daily and then began to decrease as irrigation supplies diminished.

Summary and Conclusions of Depletion in Upper Wyoming Section

To obtain a better picture of depletion in the three years illustrated, the effects of precipitation should be ironed out. This can be accomplished by sketching in the probable position of the depletion curves if no precipitation had occurred by long dash lines. The general trends and relation of depletion to water applied can then be better understood. Apparently about seventy-five percent of the water applied to the lands in the first part of the irrigation season is used in building up the water table and soil moisture or is consumed by the crops. After the water table and soil moisture is built up, conditions apparently become stabilized and the depletion continues at a flat rate of about 350 second-feet daily, although water application greatly increases. As water application decreases due to diminishing supplies, the depletion decreases at a lesser rate until it coincides or equals the water applied in irrigation. It is apparent that no consistent relationship exists, which could be expressed as an allowable rate of depletion, either on the basis of irrigation diversions or supplies for this section.

Inflow = Bear River near Woodruff + Woodruff Creek above diversions + Big Creek above diversions + Randolph Creek above reservoir + Otter Creek above diversions.

Outflow = Bear River near Randolph (3 days later).

Depletion = Inflow - Outflow (average of 3 days plotted on mid-day).

On Plates 4 and 5 are plotted the various data for 1944 and 1945.

Plate 4 - 1944 - During the early part of the irrigation season practically all of the water applied for irrigation is used in building up the ground water table and soil moisture. Apparently after the water table is built up to a certain point, the return flows equal the amount of water fed to the ground water table. The depletion after this time becomes the quantity of water required to offset evaporation and transpiration. It is to be noted on Plate 4, that the depletion decreases in late May, whereas the water applied in irrigation is greatly increased. The depletion rate remains quite constant at 400 to 500 second-feet daily throughout June and then begins to decrease rapidly early in July, when supplies begin to diminish and irrigation is curtailed. The low sag in depletion rate in the first part of June is probably due to the effect of local precipitation, which supplied a good portion of moisture needed by the crops.

Plate 5 - 1945 - The same characteristics noted in 1944 are again repeated in 1945. There was, however, a better sustained flow for irrigation supplies in July, which gives some indication of what would occur if a more prolonged water supply were available through supplemental storage.

Summary and Conclusions of Depletion in Middle Utah Section

As was done on the graphs for the Upper Wyoming section, the apparent effects of precipitation were smoothed out by indicating a probable precipitation free depletion curve. The two years show that practically all of the water applied in the early part of the irrigation season is retained in building up the water table and soil moisture. An apparent stabilized condition is reached, after which, the depletion decreases to about 400 second-feet daily and remains approximately at this amount until supplies diminish and water application is curtailed. It is to be noted that the depletion decreases to zero near the end of the irrigation season, after which time there is more or less gain in the section as the water table is depleted. It does not appear that any conclusive relationships can be drawn from the two years illustrated, sofar as correlating depletion with supplies. It does appear, however, that the depletion curves developed for both this section and the Upper Wyoming section can serve as a means of estimating the probable depletion which would occur if additional supplemental water were made available.

Recommendations for the Upper Division

As pointed out in the summaries and conclusions of the two sections previously discussed, there does not appear to be sufficient proportional consistency in the relation of depletion to supply to make an allowable daily depletion method workable for this division of the basin. Contributing factors not included in the discussion are the large acreages, considerable distances and time intervals involved between the inflow and outflow stations. These probably have considerable import on the results obtained. They at least add to the reasons for ruling out the depletion method. Consequently, the depletion method

is not recommended for the Upper Division. Considering the relative rights of the two major sections in this Division, a method of distribution of the waters on the basis of priority of rights or some similar schedule would probably be far more workable. It is also believed that the two states involved, Utah and Wyoming, can reach an agreement on a schedule of rights without too much difficulty.

CENTRAL DIVISION

Preliminary studies of daily depletions in the Lower Wyoming Section of the Central Division indicated a daily depletion method could be used and which could be regulated in reasonable accordance with relative priority of rights of this section as related to downstream water users. The rights of Wyoming and Idaho to the waters of Bear River have long been in dispute and there appears to be small chance of the two states reaching any agreement by which the waters in this reach of the river could be distributed on any priority of right schedule based on presently recorded water rights. The depletion method therefore offers a solution to the problem.

The best method to study this division is to begin first with a preview of the relative rights of the two sections and on the basis of this study arrive at a recommended percentage depletion to be applied to the upper section when supplies for the Upper Idaho section drop to a critical point.

Relative Rights - Central Division

In the reports titled "Water Rights in Bear River Basin" and "Analysis of Bear River Water Rights", some of the peculiarities existing in the present day recordings were discussed. On Page 11 of the latter named report a revised tabulation for Idaho was given. By combining this tabulation with recorded

Wyoming rights, the following tabulation has been prepared which is depicted graphically on Plate 6. To illustrate the extent of deviation from the presently recorded rights the graphs of the relative recorded rights are also shown as dotted lines.

Lower Wyoming rights include those from Bear River below mouth of Smiths Fork, Smiths Fork, Grade Creek, Pine Creek, Sublette Creek, Pine Creek Springs, and Spring Creek, involving a total of 17,830 acres of irrigated lands.

Upper Idaho rights include those from Bear River between Border and Stewart Dam, involving a total of 22,~~150~~ acres of irrigated lands as tabulated in "Analysis of Bear River Water Rights, Page 11."

A duty of water of 1 second foot for each 50 acres of irrigated lands has been used throughout in the tabulation.

Table of Relative Ri[illegible]ts - Central Division

Year	Lower Wyoming		Revised Upper Idaho		Accumulative Rights in Central Division
	Right	Accum. Rights	Right	Accum. Rights	
1870		0	40.00	40	40
1871		0		40	40
1872		0		40	40
1873		0	4.64	45	45
1874		0	40.00	85	85
1875		0		85	85
1876		0		85	85
1877	2.10	2	100.68	185	187
1878	6.08	8	7.92	193	201
1879	.10	8	76.80	270	278
1880		8	6.00	276	284
1881	10.54	19		276	295
1882	13.52	32	18.60	295	327
1883	58.87	91	16.68	311	402
1884	13.38	105	30.74	342	447
1885	24.80	129		342	471
1886	12.34	142		342	484
1887	20.74	162	56.00	398	560
1888	9.38	172		398	570
1889	5.26	177		398	575
1890	1.30	178	[illegible].20	401	579

Year	Lower Wyoming		Revised Upper Idaho		Accumulative Rights in Central Division
	Right	Accum. Rights	Right	Accum. Rights	
1891		178	52.00	453	631
1892	4.12	183		453	636
1893	5.50	188		453	641
1894	6.40	194		453	647
1895		194		453	647
1896		194		453	647
1897	12.68	207		453	660
1898	2.38	209		453	662
1899		209		453	662
1900	2.70	212		453	665
1901	2.80	215		453	668
1902	.68	216		453	669
1903	15.54	231		453	684
1904	8.26	239		453	692
1905	16.00	255		453	708
1906	9.08	265		453	718
1907	9.68	274		453	727
1908	4.06	278		453	731
1909	43.22	322		453	775
1910	5.70	327		453	780
1911	11.17	338		453	791
1912	1.96	340		453	793
1913	2.33	343		453	796
1914		343		453	796
1915	8.04	351		453	804
1916	.68	351		453	804
1917		351		453	804
1918		351		453	804
1919	2.30	354		453	807
1920		354		453	807
1921		354		453	807
1922		354		453	807
1923		354		453	807
1924		354		453	807
1925		354		453	807
1926		354		453	807
1927	1.99	356		453	809
1928		356		453	809
1929		356		453	809
1930		356		453	809
1931		356		453	809
1932		356		453	809
1933		356		453	809
1934		356		453	809
1935		356		453	809
1936		356		453	809
1937	1.64	357		453	810
1938		357		453	810
1939		357		453	810

It is to be noted from this tabulation and Plate 6, that 631 second-feet is required to fill rights of 1891 dated priority in Idaho and Wyoming. Of this total, Idaho's share is 453 second-feet and Wyoming's 178 second-feet. The lands involved in Wyoming of 1891 dated priority and older, are principally those on the Smiths Fork alluvial fan and the Bear River bottom lands and do not include later day extensions of the Covey Canal system and new lands on Smiths Fork above the narrows.

The 453 second-feet supply for Idaho represents a critical point in the relation of supplies and rights of the Idaho water users. Above this point Wyoming may increase her diversions until all Wyoming rights are filled. Below this point is becomes necessary for Idaho users to start cutting rights and likewise Wyoming users should do the same.

It is to be noted from the graphs on Plate 6 that the Idaho and Wyoming relative rights between 480 and 631 second-feet total accumulative, closely approximate 70 percent for Idaho and 30 percent for Wyoming. On a strictly relative basis, Idaho's share would increase to almost 100 percent as the supply dropped from 480 second-feet to 280 second-feet, while Wyoming's share decreases to practically nothing. Drawn on Plate 6 are two sets of percentage divisions showing flat percentage relations for Wyoming and Idaho on a 30-70 percent basis and a 20-80 percent basis. If any conclusion can be drawn from these graphs it would be when the supply is less than 631 second-feet that Idaho water users should receive 70 to 80 percent of the supply and Wyoming 30 to 20 percent.

Lower Wyoming Section

Except for a few minor supplies which are dissipated early in the irrigation season, the total natural flow into the Wyoming section of the Central Division is that recorded at the following gaging stations:

1. Bear River above Sublette Creek
2. Smiths Fork near Border
3. Pine Creek above Diversions
4. Howland Creek at Mouth
5. Grade Creek above Diversions
6. Sublette Creek above Diversions
7. Pine Creek Springs
8. Spring Creek

Studies of the relation of daily flows at these stations were made to determine if the number of inflow stations could be decreased. These studies showed that daily flows of Howland Creek above diversions, Grade Creek above diversions, and Sublette Creek above diversions, were proportional to the flow of Smiths Fork near Border and the flows of Pine Creek Springs and Spring Creek were proportional to Pine Creek above diversions. Practically the same inflow figures can be obtained by using the records of three gaging stations in the following equation:

Inflow = 1.07 x Smiths Fork near Border + 1.55 x Pine Creek above diversions + Bear River above Sublette Creek.

The outflow from the Wyoming section is the flow of Bear River at Border.

An allowance of one day time interval between the inflow stations and outflow station is reasonably applicable throughout the irrigation season although actually, the time is somewhat less during high flows and longer during low flows.

On Plates 7, 10, 13 and 16, have been plotted the daily depletions for 1944, 1946, 1947 and 1948 for the Lower Wyoming section. Plotted on these plates are also the amounts actually diverted for irrigation and 20 percent and 30 percent of the inflow.

Upper Idaho Section

The Bear River at Border gaging station records the surface flow delivered to Idaho from the Wyoming section. In addition to the recorded flows passing this station, the Idaho total supply is ~~argumented~~ augmented by surface and groundwater flows from Thomas Fork, return flows from the Cook Canal lands and possibly some underflow from the Lower Wyoming section. These additional supplies are as much as 20 to 25 percent of the recorded flow of the Bear River at Border gaging station.

On Plates 8, 11, 14 and 17, are plotted actual flows of Bear River at Border gaging station, 70 percent and 80 percent of the inflows to the Wyoming section, and amounts diverted for irrigation between Border and Stewart Dam for the years 1944, 1946, 1947, and 1948.

LOWER DIVISION

Stewart Dam to Alexander

The natural flow supplies available and the rights of the Last Chance Canal system must also be considered along with any division between Idaho and Wyoming in the Central Division. Natural flow waters available for filling rights of the Last Chance Canal system are derived from natural flows at Stewart Dam and natural inflow between Stewart Dam and Alexander. Storage in Bear Lake, release of storage from Bear Lake, water in transit between Bear Lake and Alexander, and Soda Reservoir storage and release in connection with power generation, considerably complicate the determination of natural flow at Alexander. However, by averaging 5 day periods of flow, allowing one day time interval between Bear Lake and Alexander, taking into account storage releases from Bear Lake and Soda Reservoir and charging Bear Lake storage with a $1\frac{1}{2}$ percent loss, the natural flow at Alexander can be computed, although at

times the results are quite erratic. On Plates 9, 12, 15, and 18, are plotted the natural flow at Stewart Dam, natural inflow between Stewart and Alexander, natural flow at Alexander and total diversions of the Last Chance, Bench "B" and Tanner "B" canals for years 1944, 1946, 1947 and 1948.

Conclusions and Recommendations

From a study of Plates 7 to 18, the following are apparent:

1. Maximum rate of depletion in the Lower Wyoming section varies from 200 to 300 second-feet daily, and occurs in the early part of the irrigation season while supplies are plentiful.
2. The rate of depletion decreases in proportion to the natural flow supply following the high water period.
3. If the depletion rate for the Lower Wyoming Section were limited to about 20 to 30 percent of the natural flow supply following the high water period, the allowable depletion would be in reasonable conformity with the relative rights of the Lower Wyoming and Upper Idaho Sections.
4. If a critical flow of 400 second-feet at Border were used at the time to begin limiting depletion in Wyoming to about 25 percent, there would be no interference with the rights of the Last Chance Canal system.
5. In years in which the runoff is about normal, a 20 to 30 percent allowable depletion for Lower Wyoming would cause some restriction in irrigation diversions in the Lower Wyoming Section.
6. In years when runoff is considerably below normal, irrigation as practiced in the past in the Lower Wyoming Section would be materially restricted, although the water Lower Wyoming would be allowed

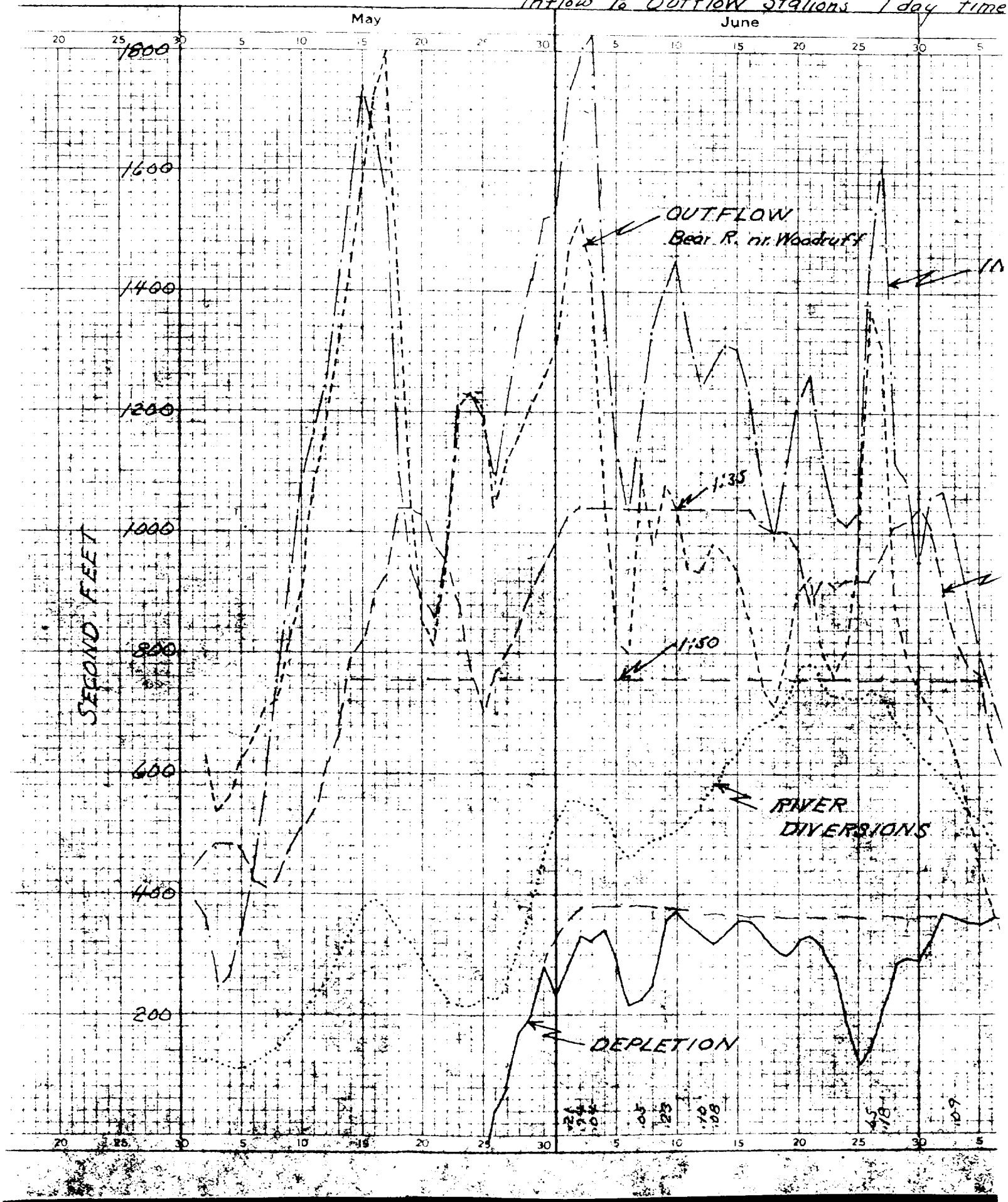
would be greater than 25 percent of the total available for use in the Central Division as Lower Wyoming would be receiving credit for her return flows.

7. Idaho would be assured of a more equitable share of the supplies available in years of drought and would not suffer losses as in the past.

The application of the depletion method in the Lower Wyoming Section of the Central Division appears to have sufficient foundation and merit to warrant its use and it is recommended as a workable method for the division of the waters in this river division. The recommended provision is to limit the depletion in Lower Wyoming to about 25 percent of the natural inflow whenever the flow at the Border gaging station is below 400 second-feet.

UPPER WYOMING SECTION - 1944

Inflow to Outflow stations 1 day time



State Line Dates

File No. | Washington

Field

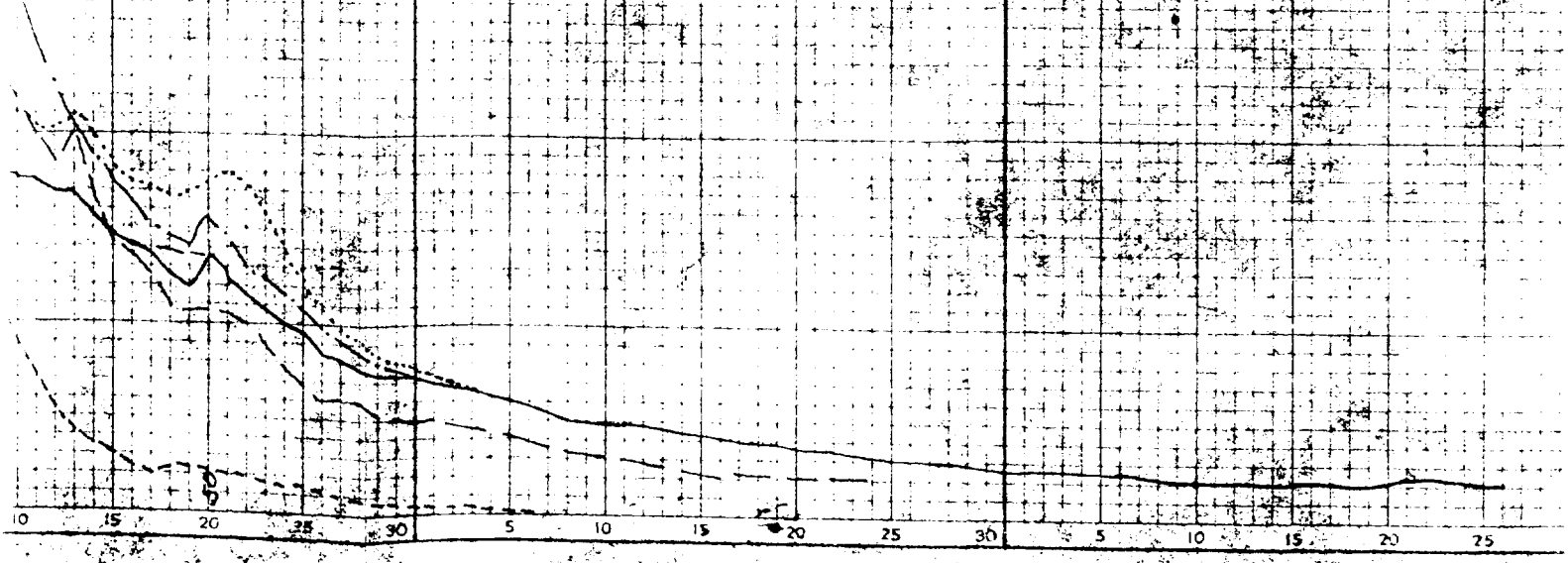
terval May1 to July 14; 2 day time interval thereafter

July | August | September

PLATE 1

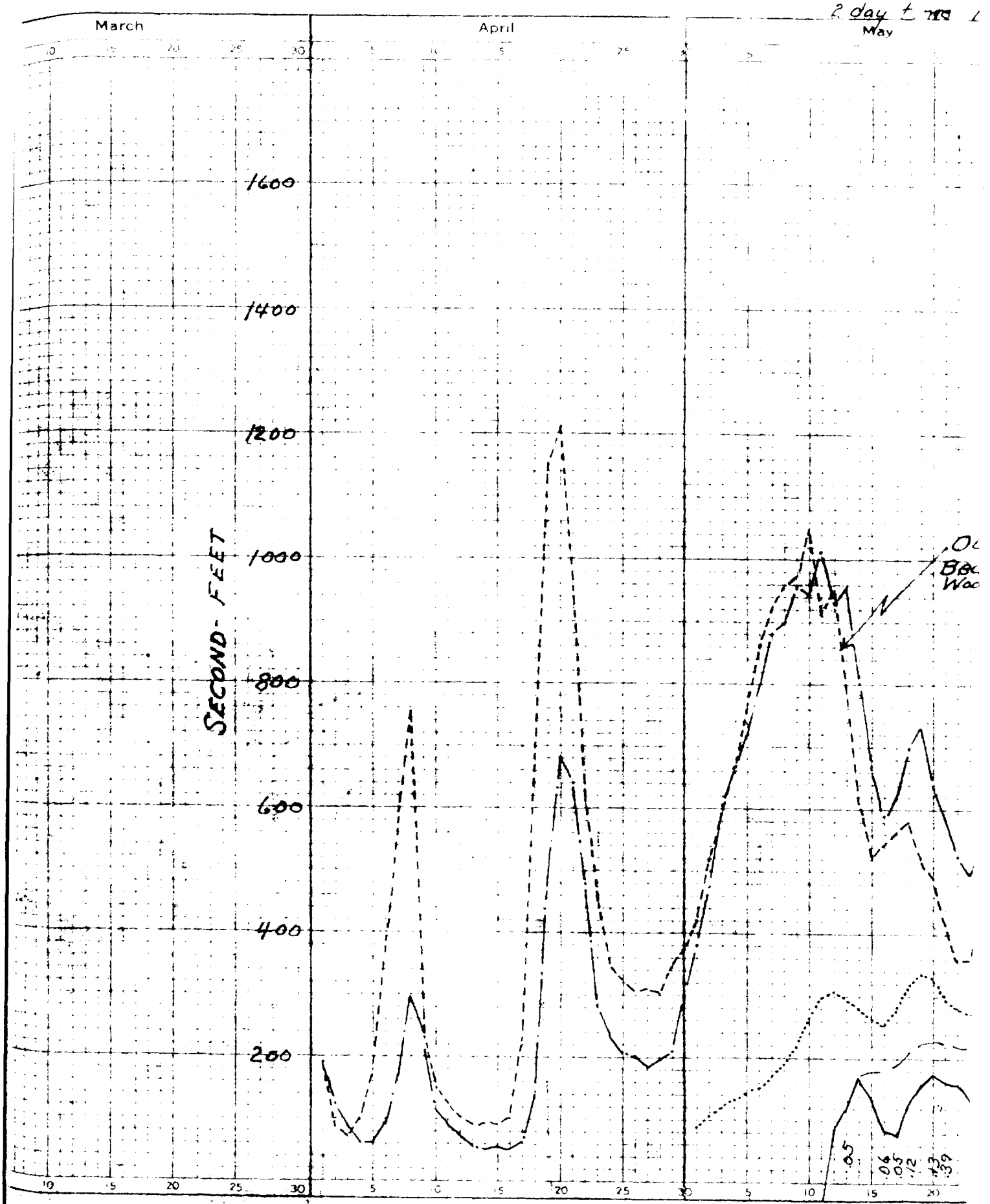
ow

TENTATIVE DRAFT ALLOCATION



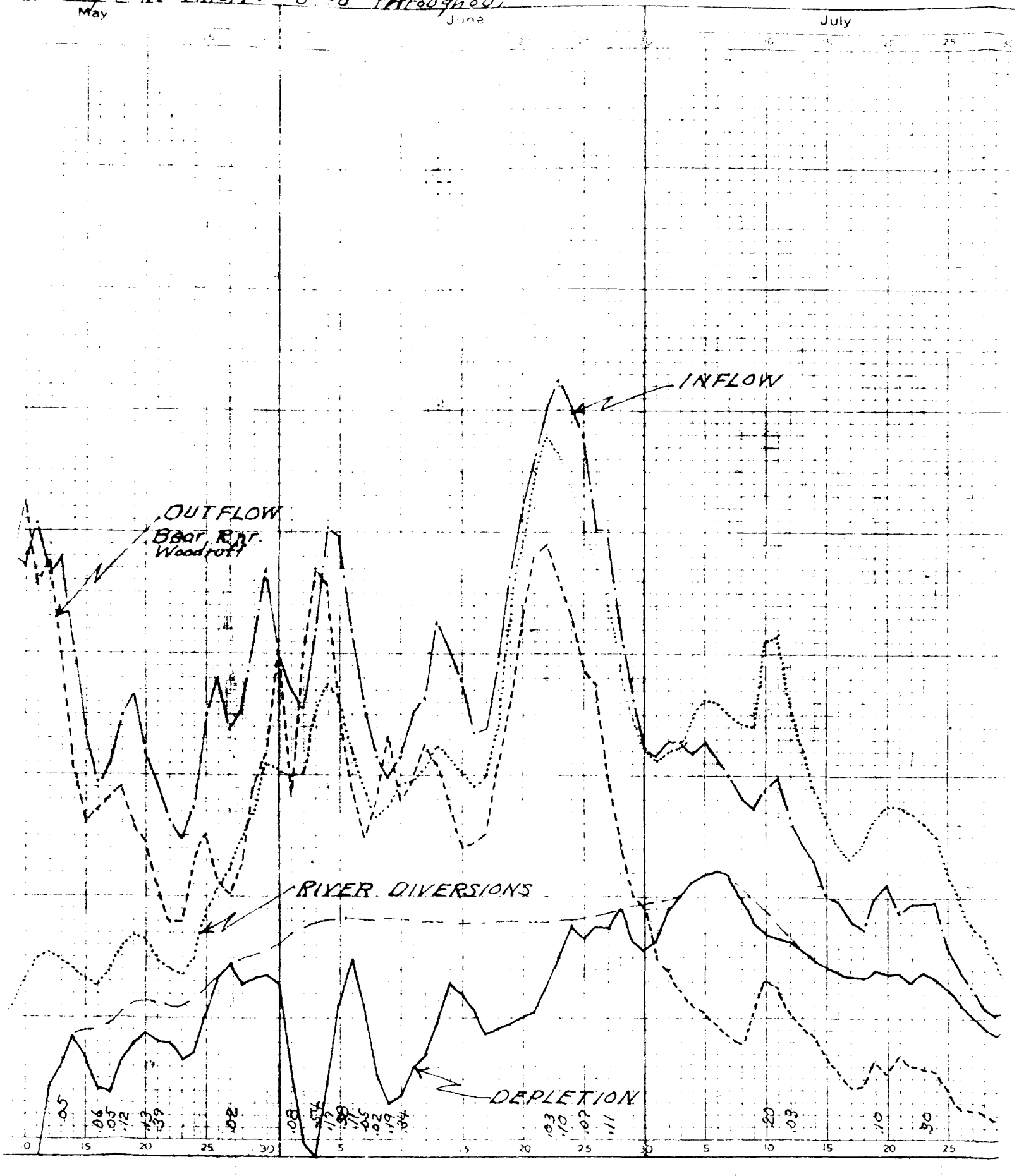
UPPER WYOMI

2 day t



PLK WYOMING SECTION 1945 State Line Dates

2 day time interval used throughout

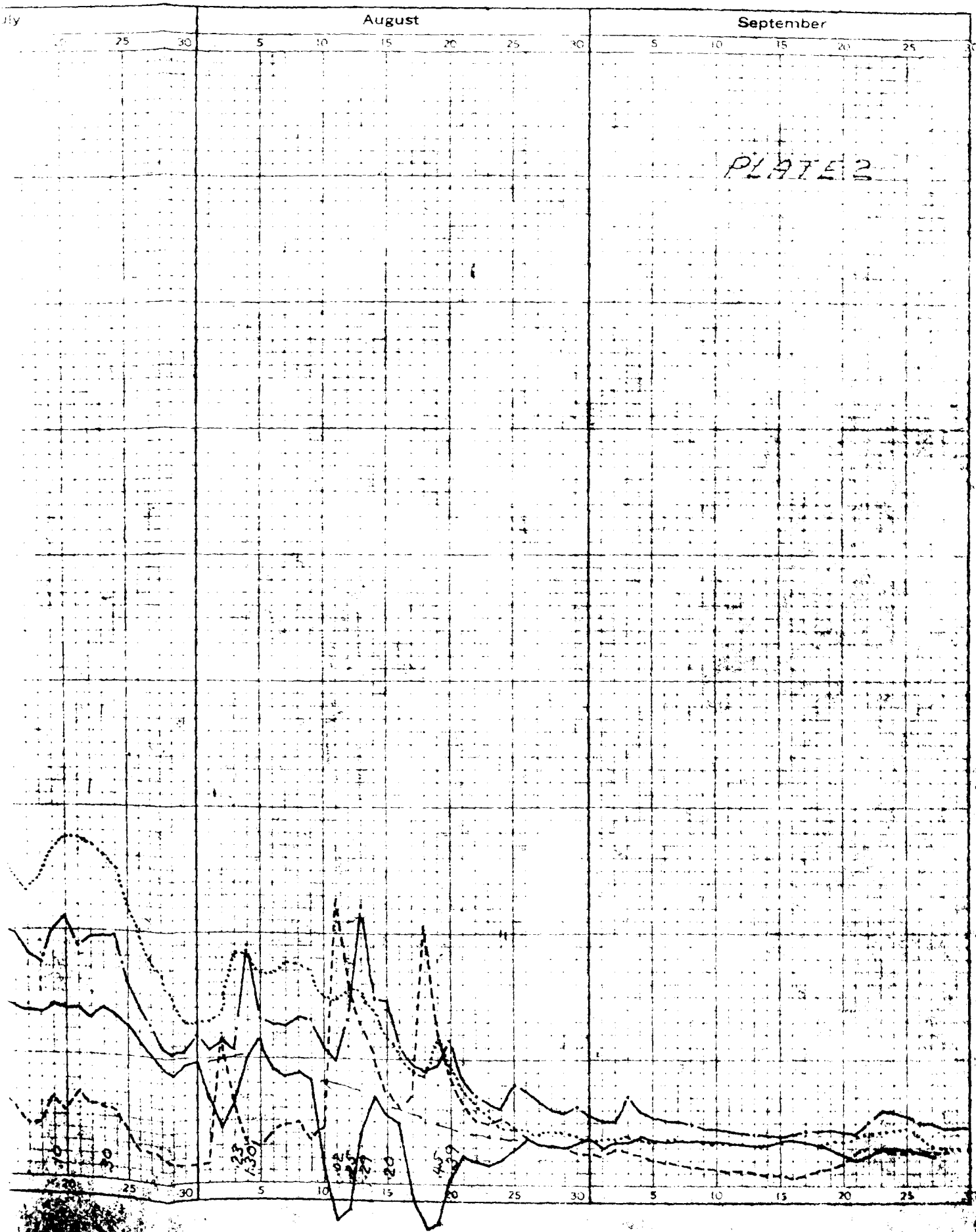


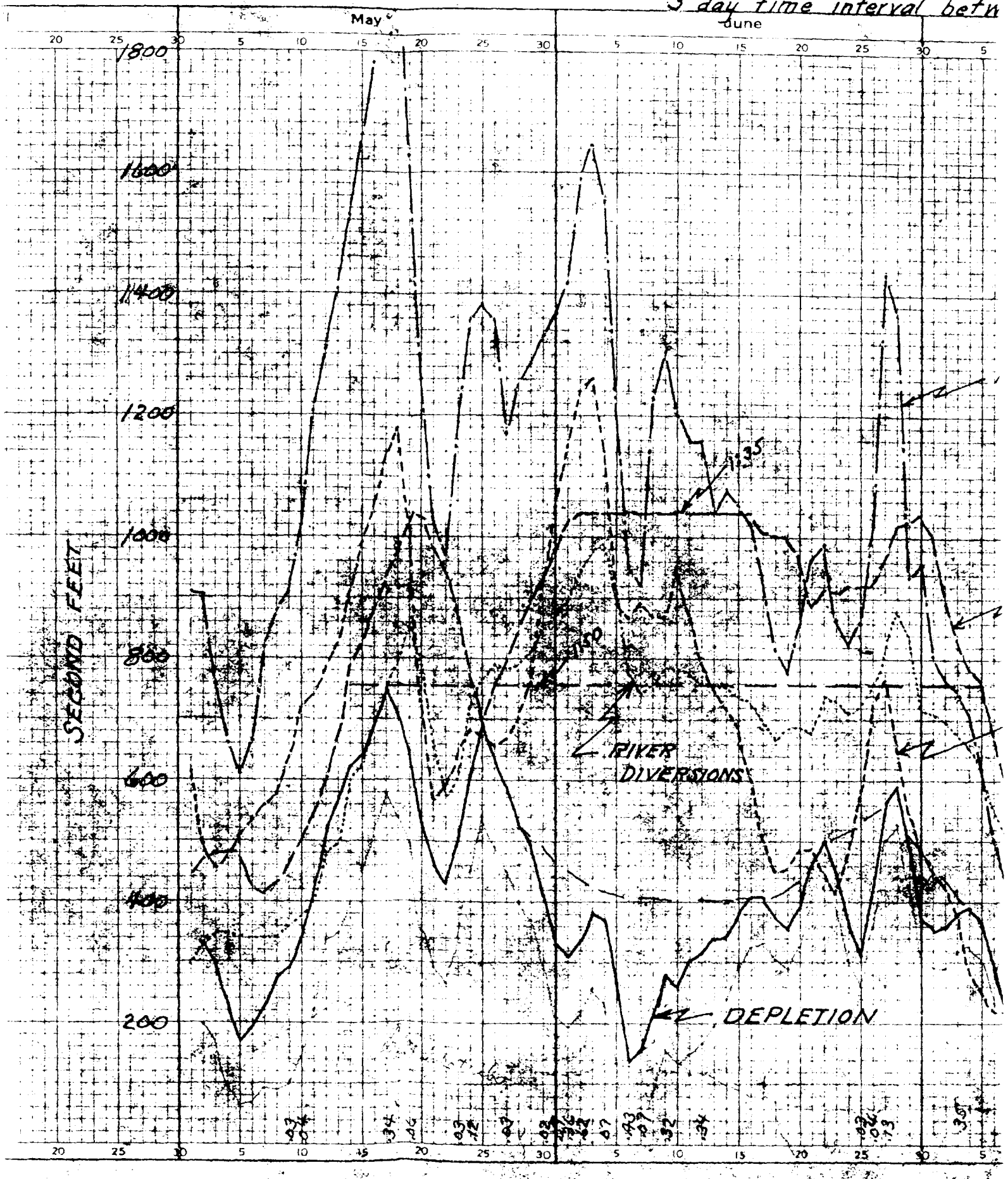
Notes

File No.

Washington

Field




MIDDLE UTAH SECTION -
3 day time interval betw
May
June
SECOND FEET
1800
1600
1400
1200
1000
800
600
400
200
RIVER DIVERSIONS
DEPLETION

944 Woodruff dates

7 inflow and Outflow stations

File No. Washington

Field

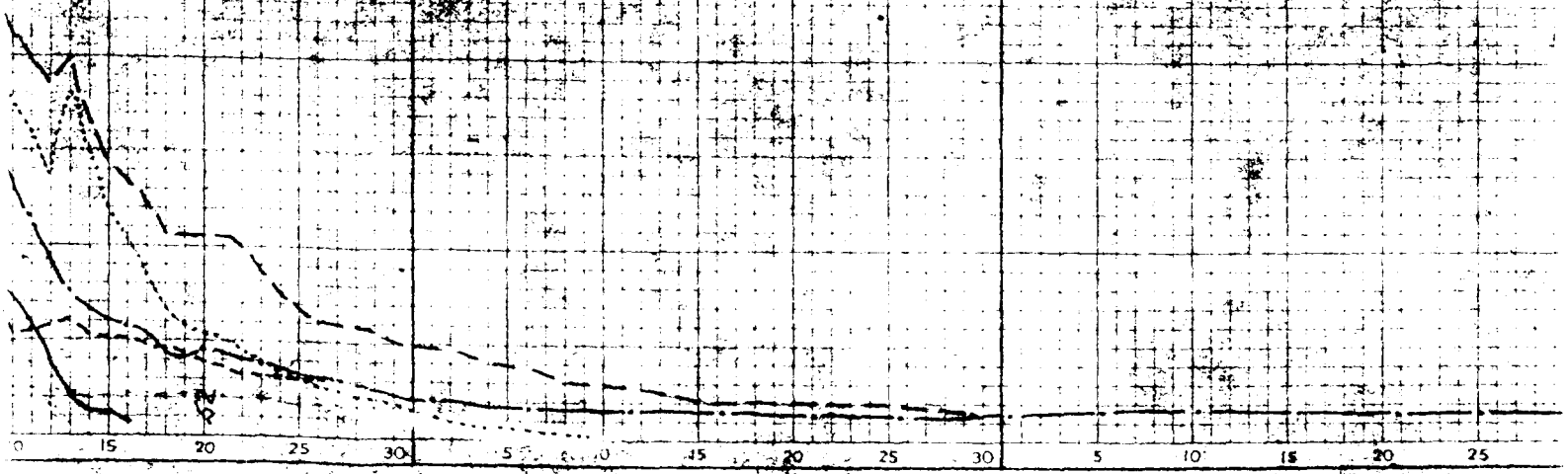
July | August | September

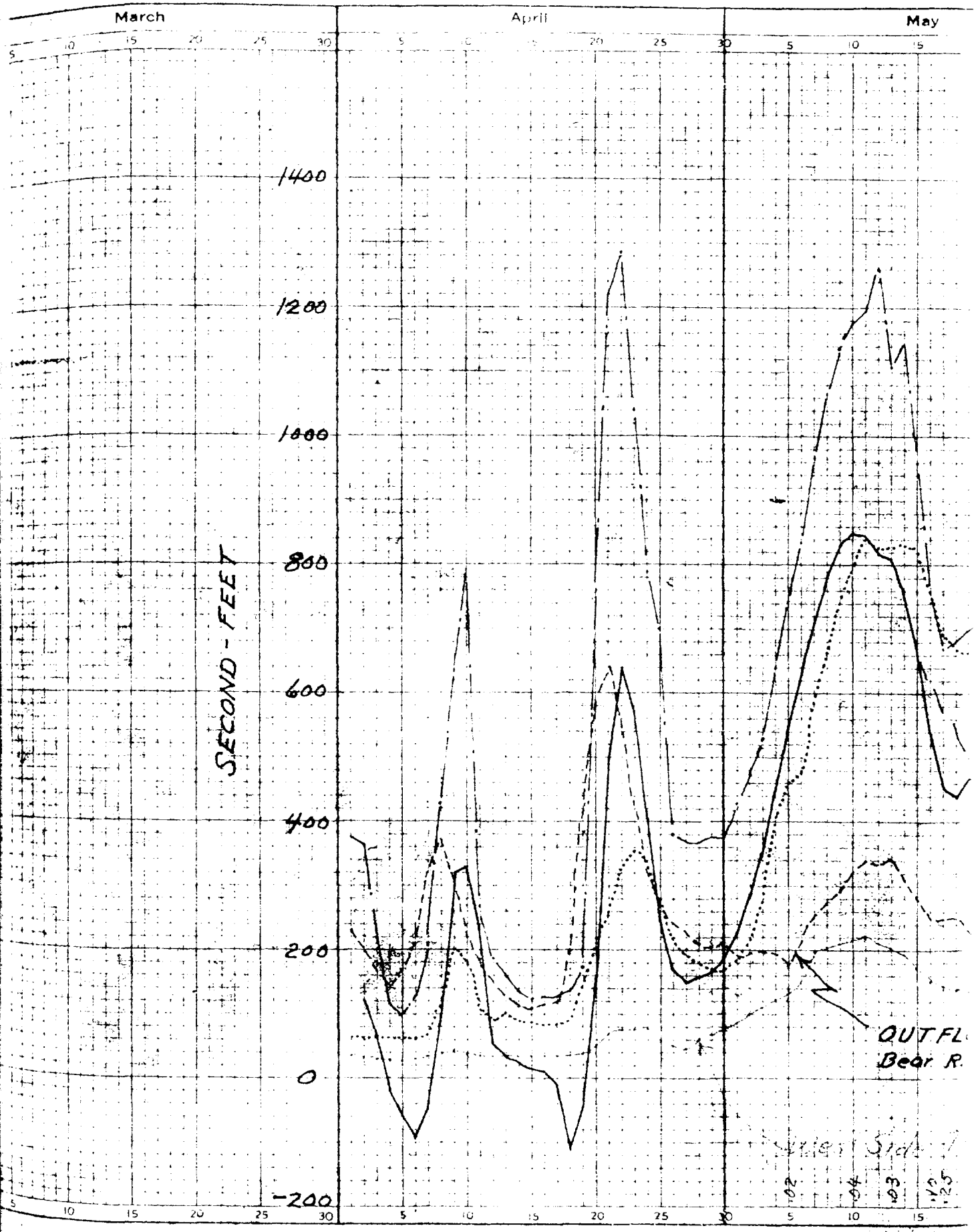
PLATE 4

LOW

TENTATIVE DRAFT ALLOCATION

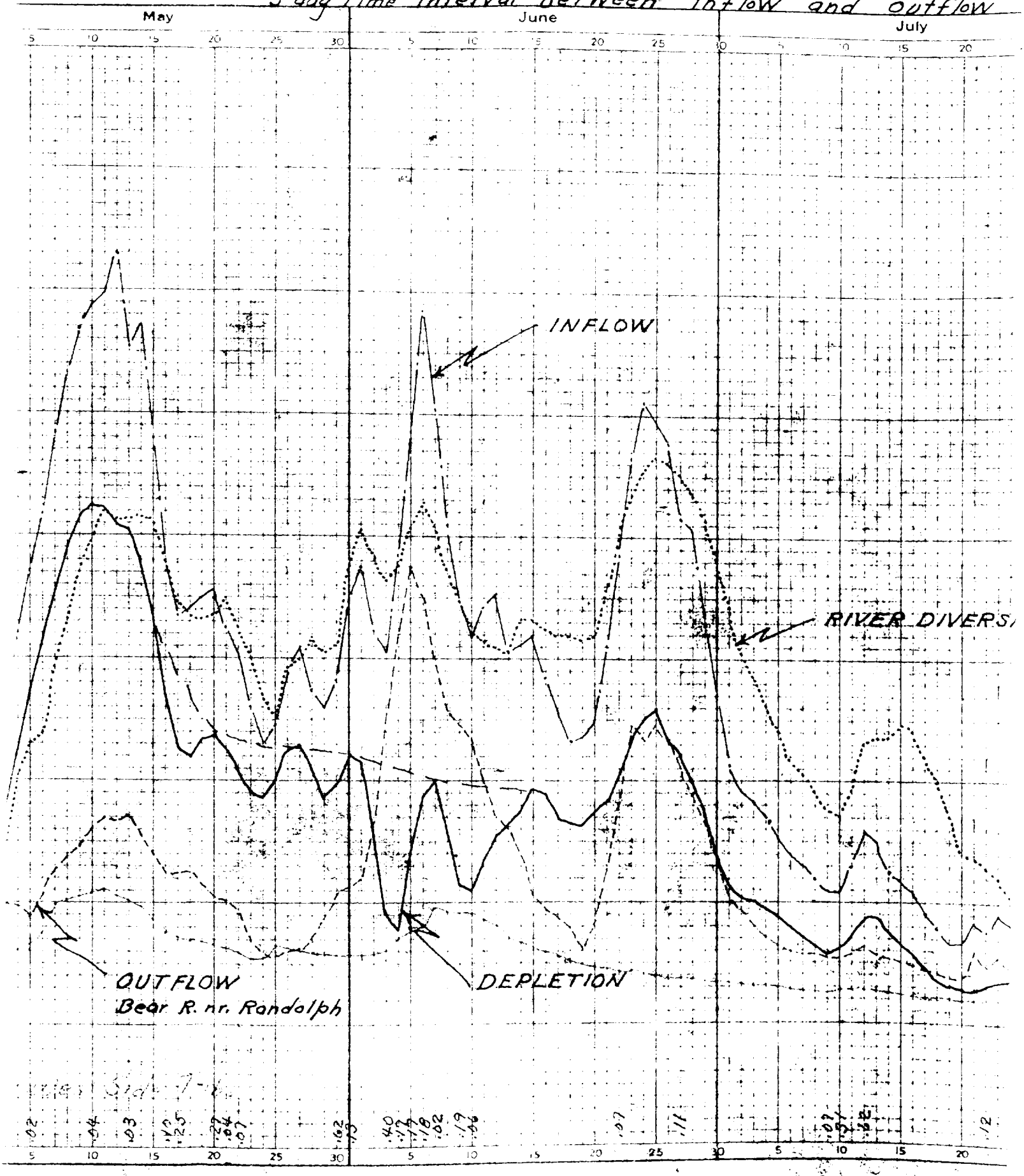
OUTFLOW
Bear R. nr. Randolph




March
April
May
1400
1200
1000
800
600
400
200
0
-200
SECOND-FEET
QUTFL
Bear R.

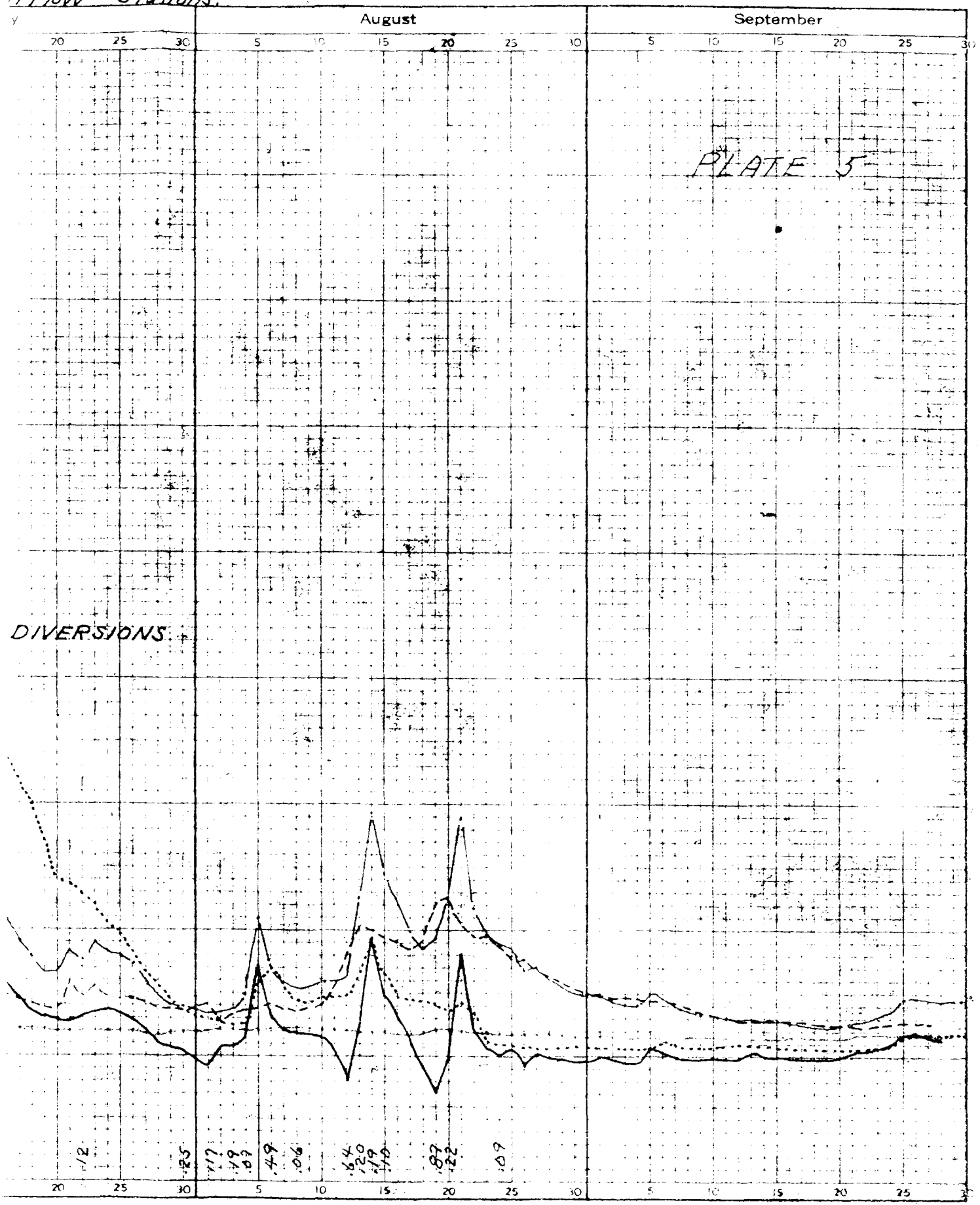
MIDDLE UTAH SECTION - 1945 Woodruff

3 day time interval between inflow and outflow



druff dates
tflow stations.

File No. [illegible] Washington
Field



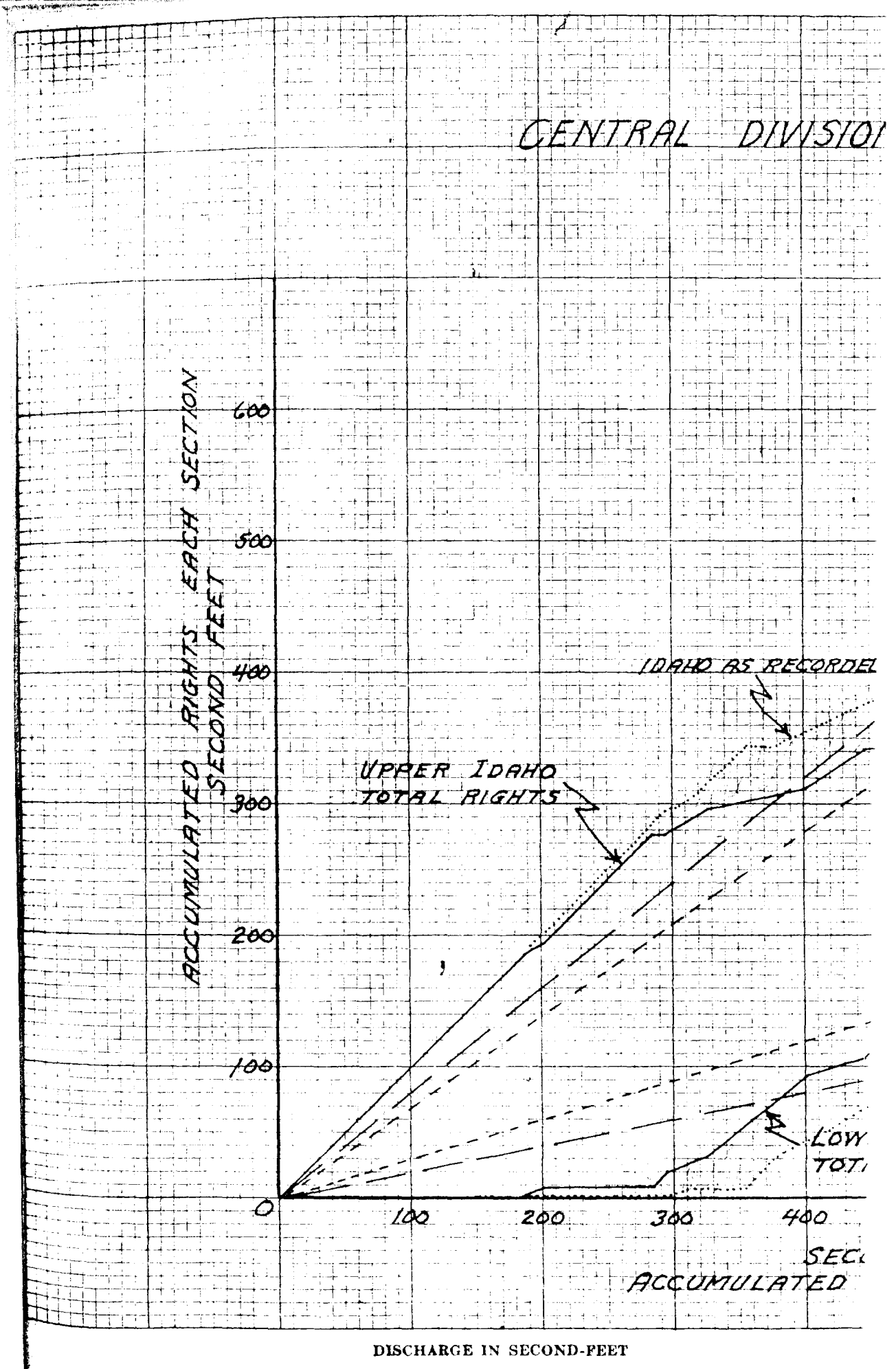
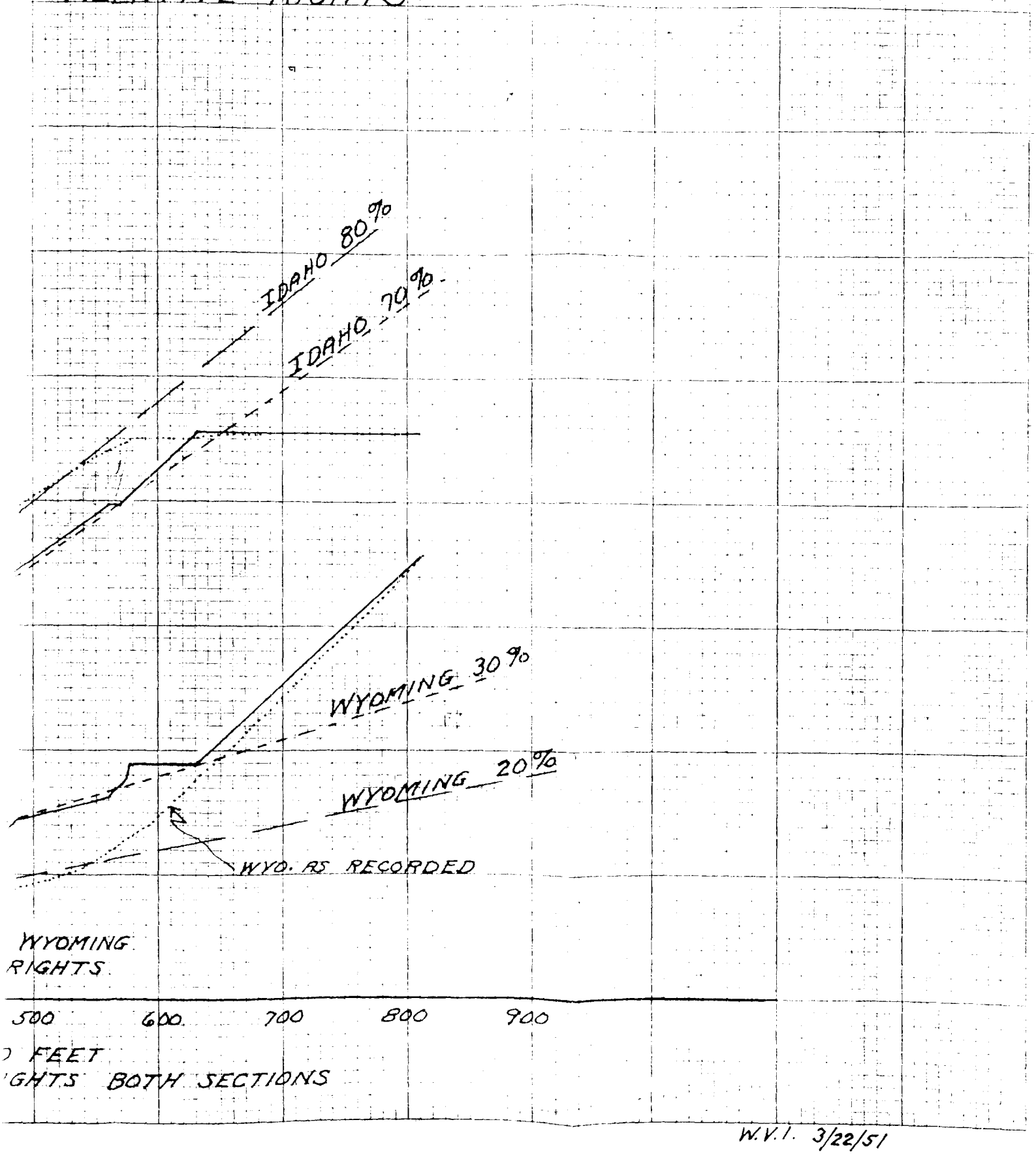
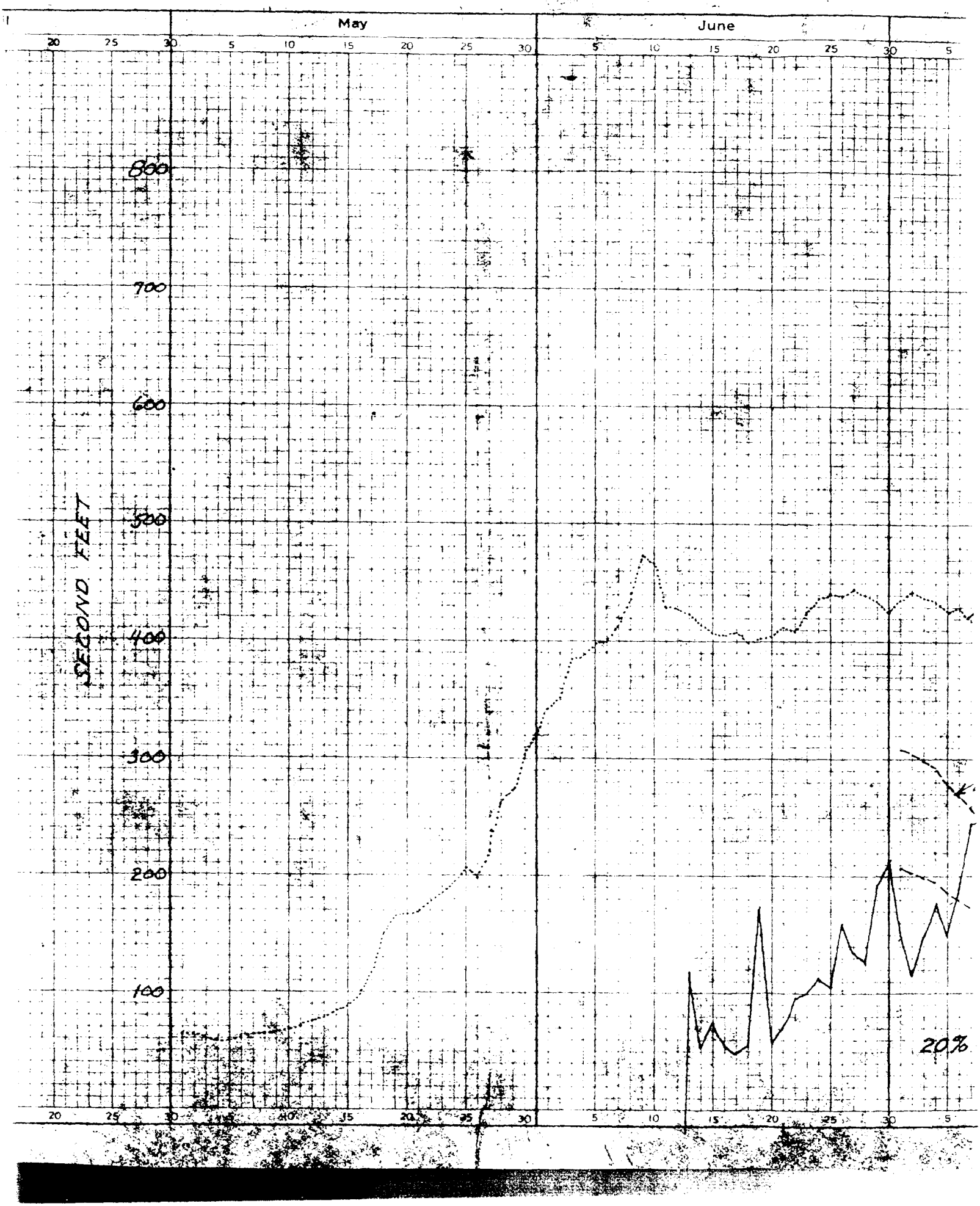

CENTRAL DIVISIO
ACCUMULATED RIGHTS EACH SECTION
SECOND FEET
600
500
400
300
200
100
0
IDAHO AS RECORDED
UPPER IDAHO
TOTAL RIGHTS
LOW
TOT
100
200
300
400
SEC
ACCUMULATED
DISCHARGE IN SECOND-FEET

PLATE 6

RELATIVE RIGHTS

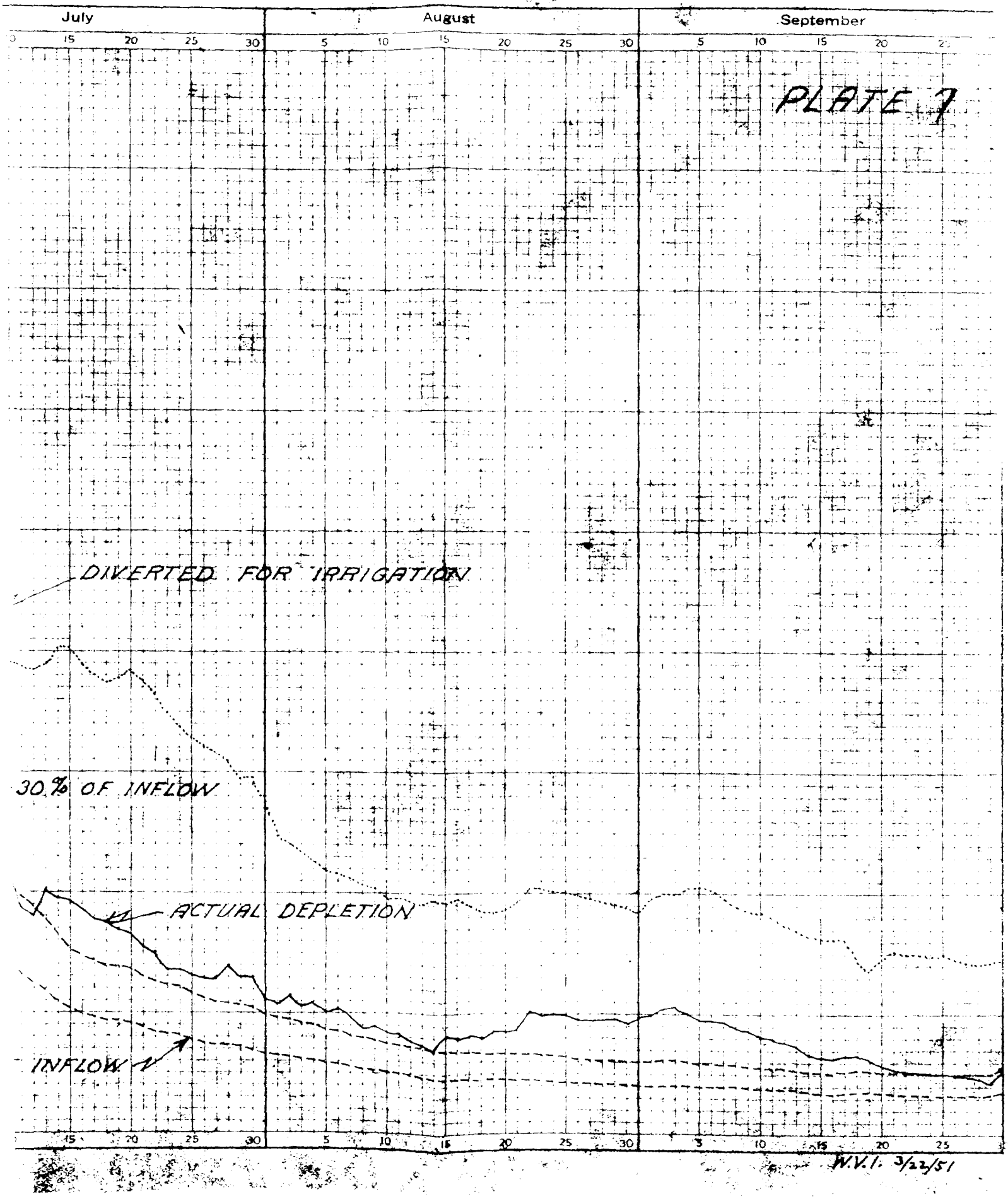


W.V.I. 3/22/51

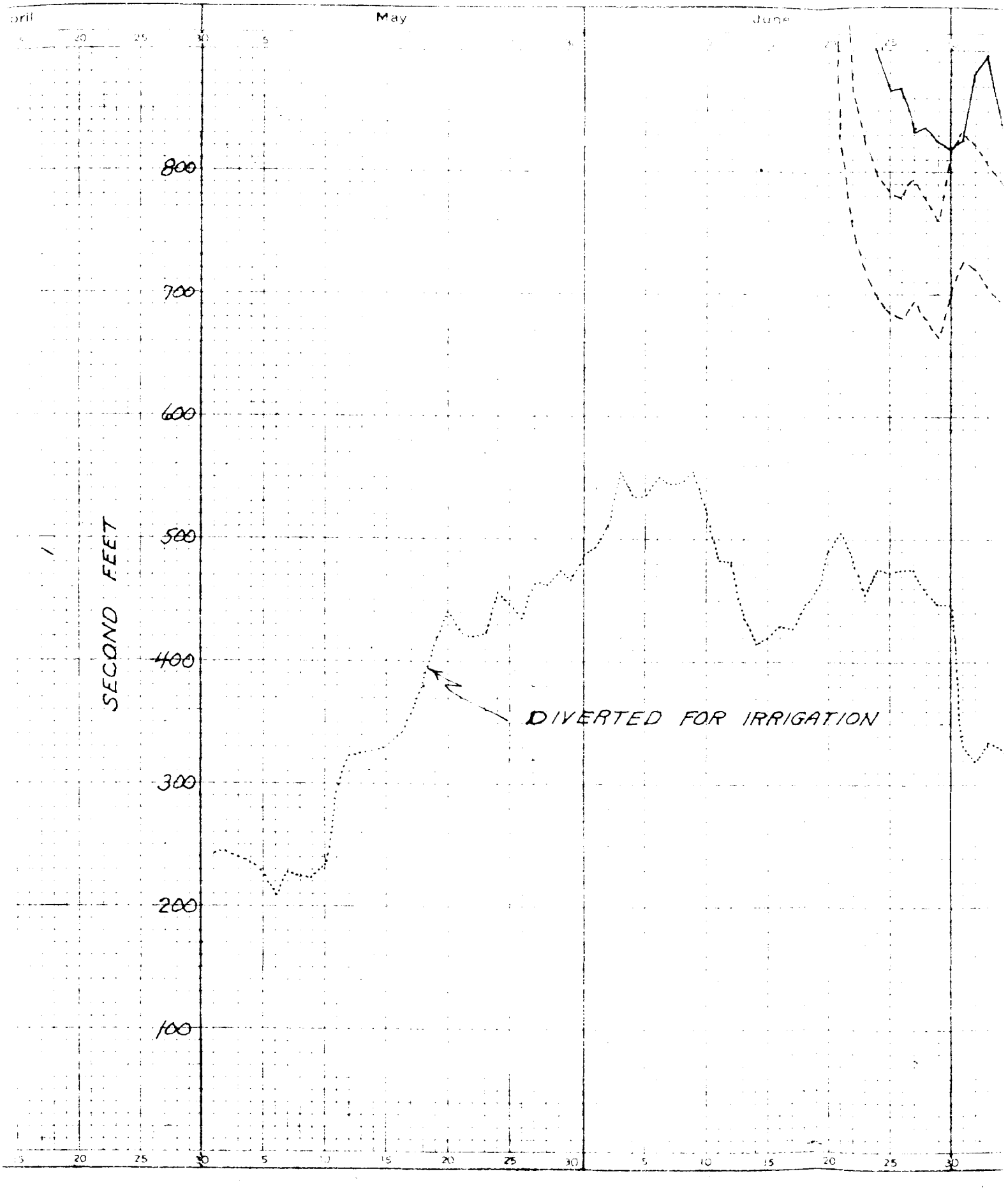

May
June
20
25
30
5
10
15
20
25
30
5
800
700
600
500
400
300
200
100
SECOND FEET
20%

CENTRAL DIVISION-WYOMING 1944

File No. Washington
Field



W.V.I. 3/22/51

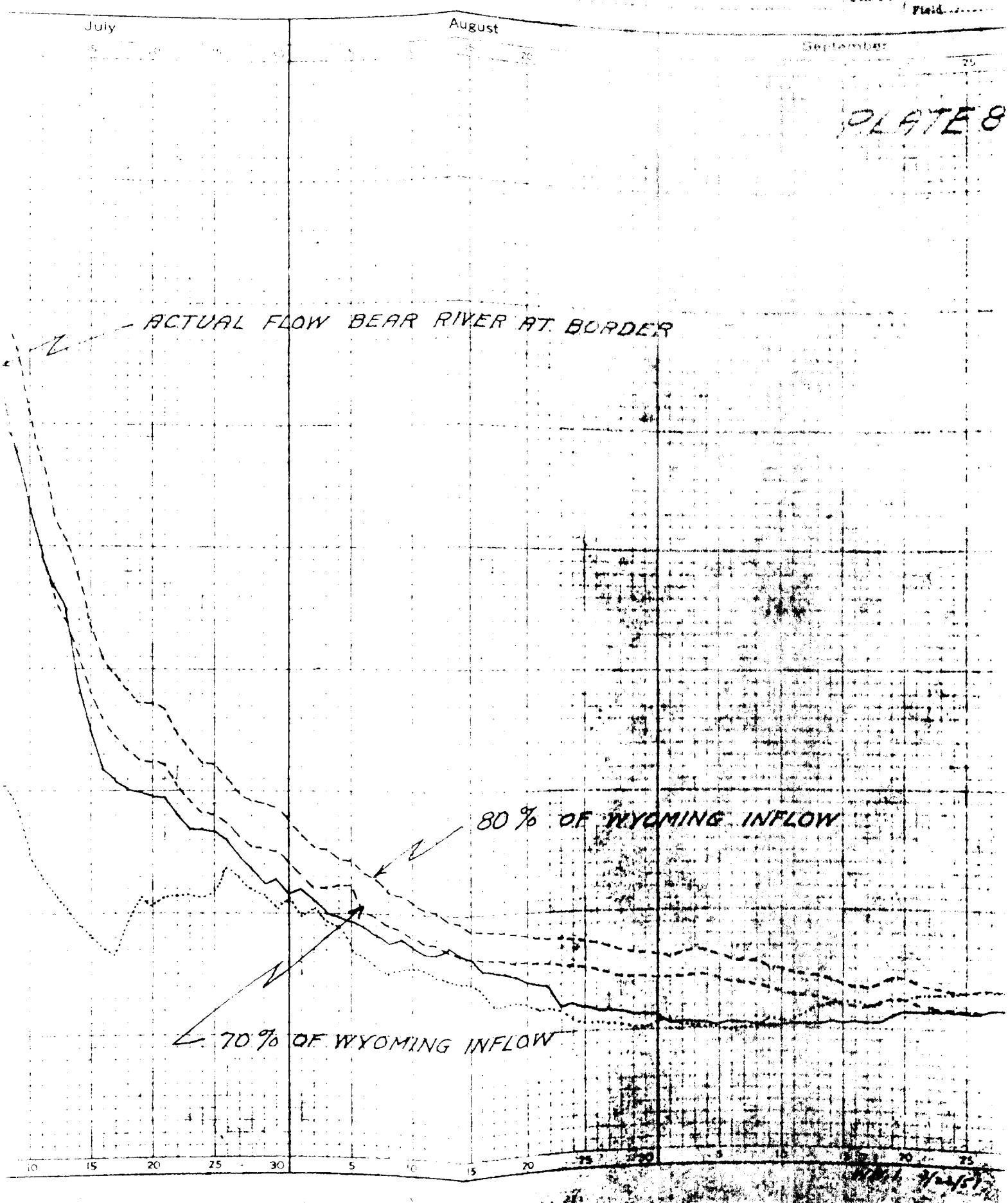

April
May
June
800
700
600
500
400
300
200
100
SECOND FEET
DIVERTED FOR IRRIGATION
5
10
15
20
25
30

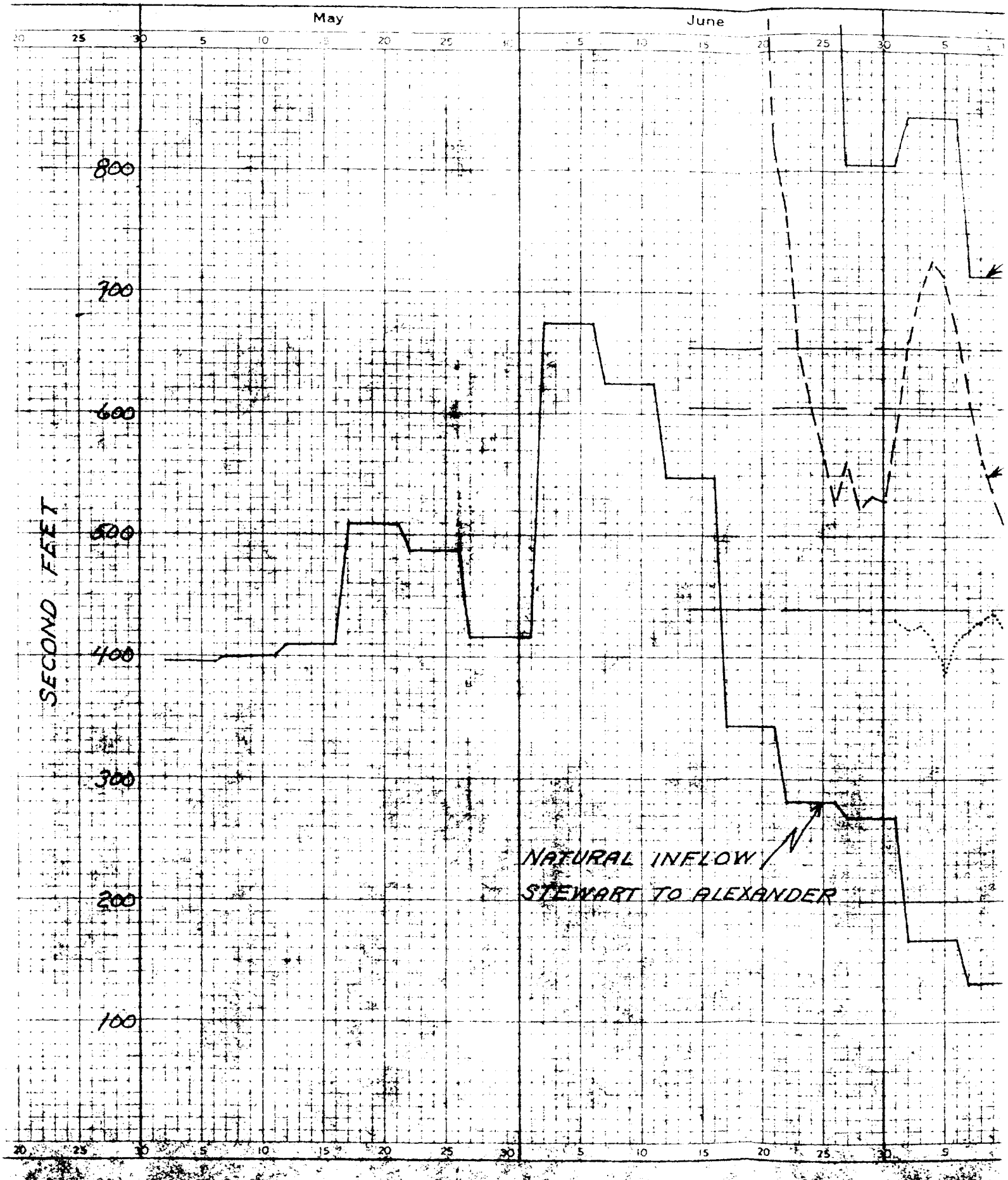
CENTRAL DIVISION - IDAHO 1944

File No. Washington

Field

PLATE 8



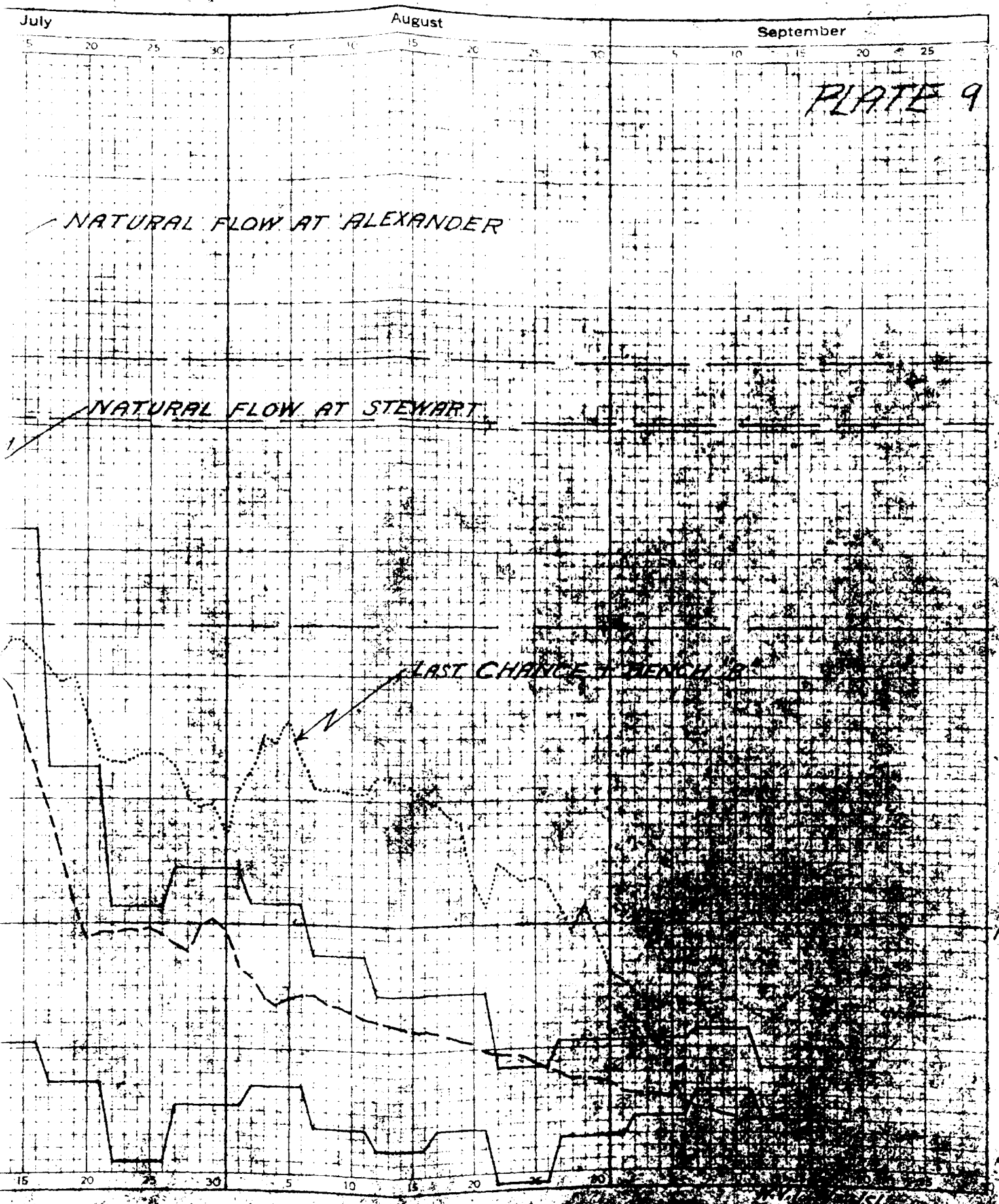

May
June
800
700
600
500
400
300
200
100
SECOND FEET
NATURAL INFLOW
STEWART TO ALEXANDER

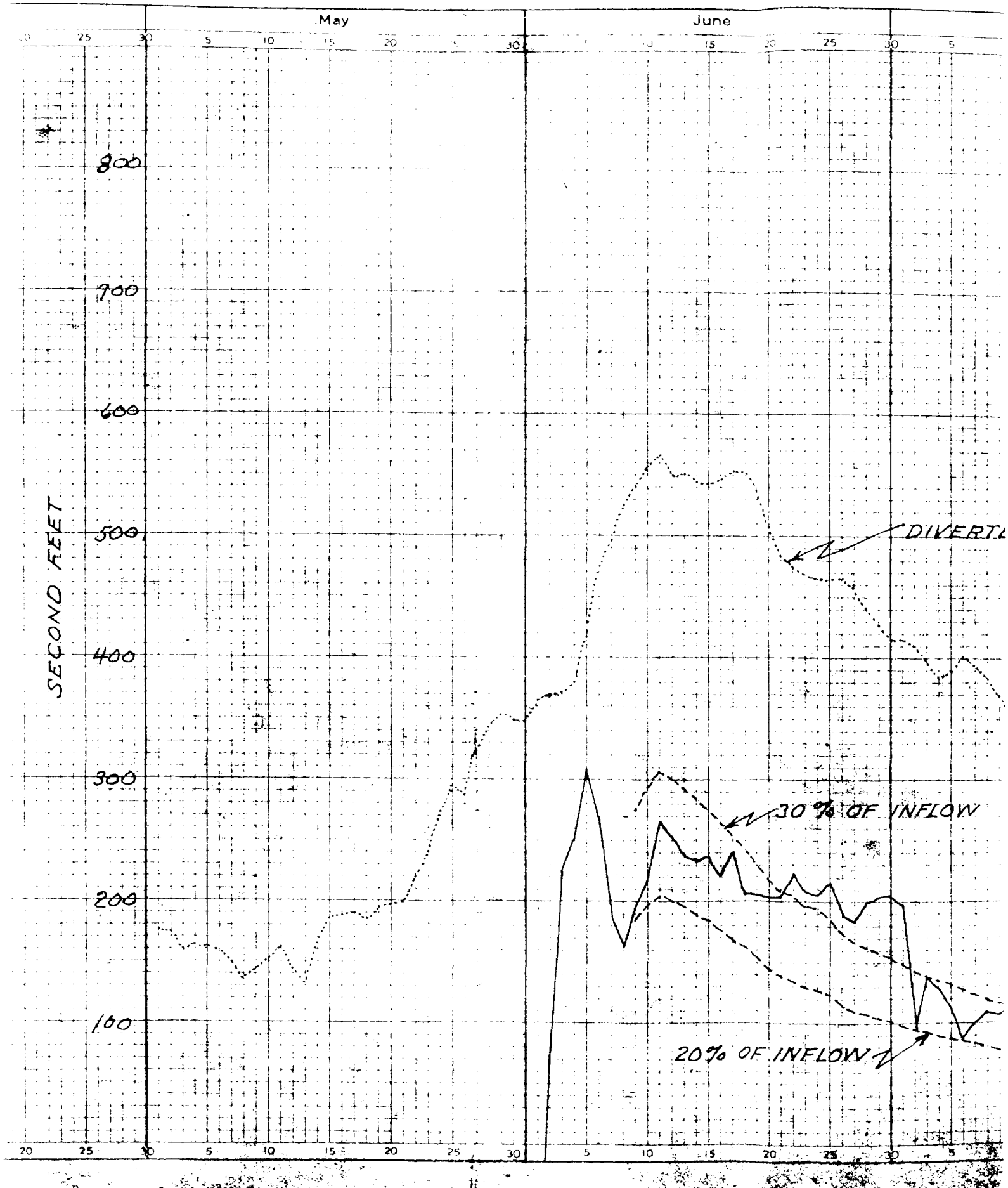
DIVISION - STEWART TO ALEXANDER 1944

File No. Washington

Field

PLATE 9

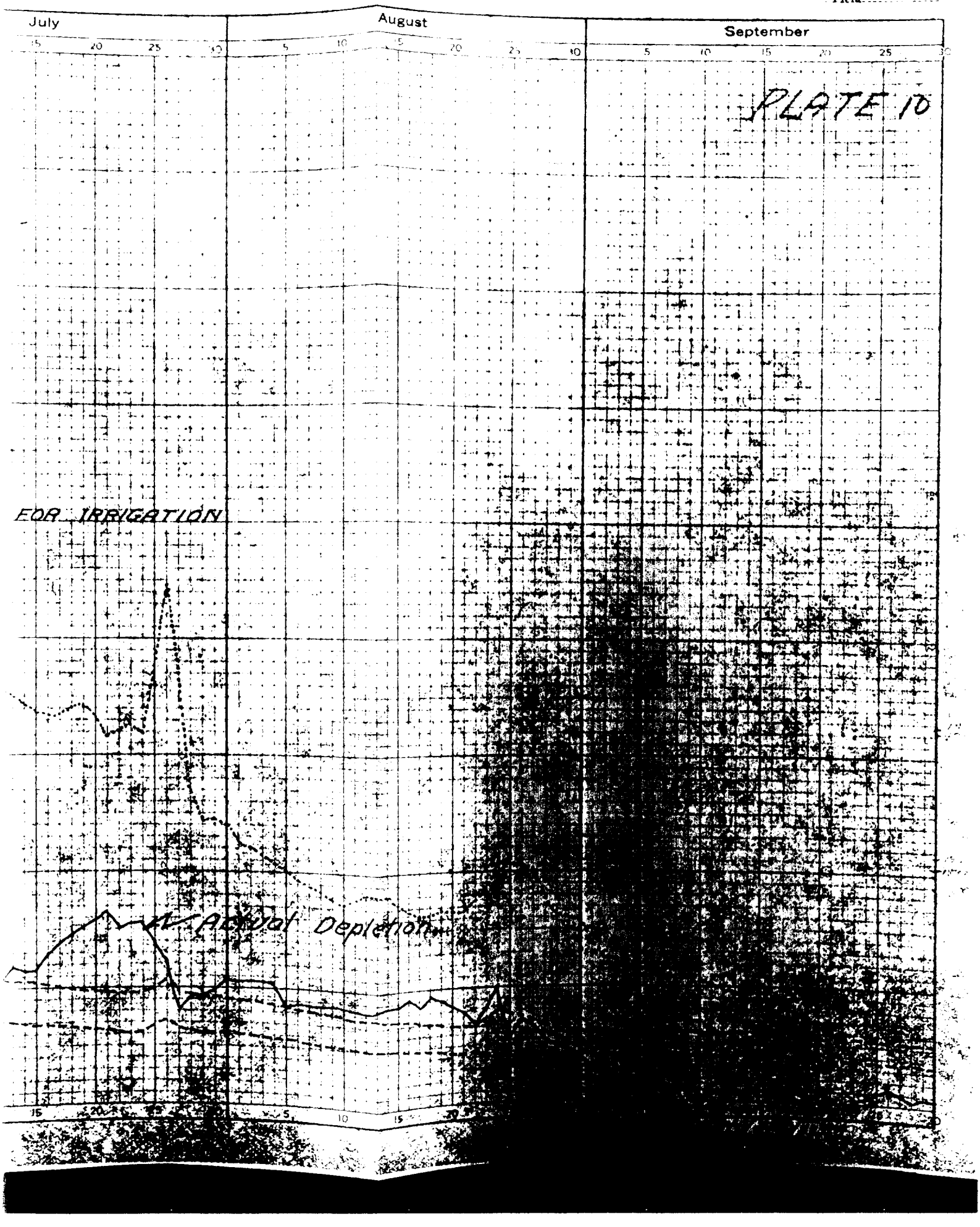


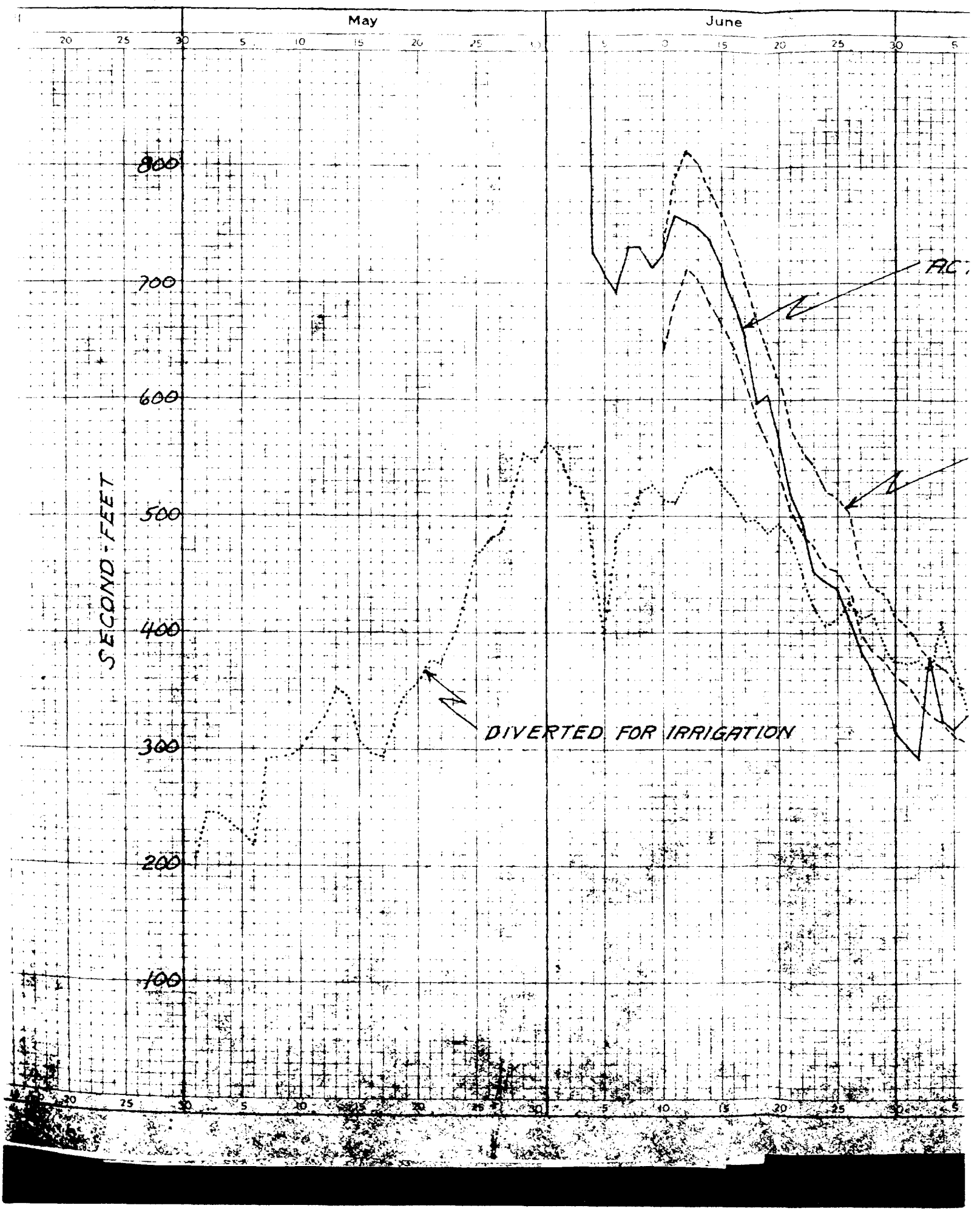

May
June
SECOND FEET
800
900
600
500
400
300
200
100
DIVERTI
30 % OF INFLOW
20% OF INFLOW

ENTRAL DIVISION - WYOMING 1946

File No. Washington

Field



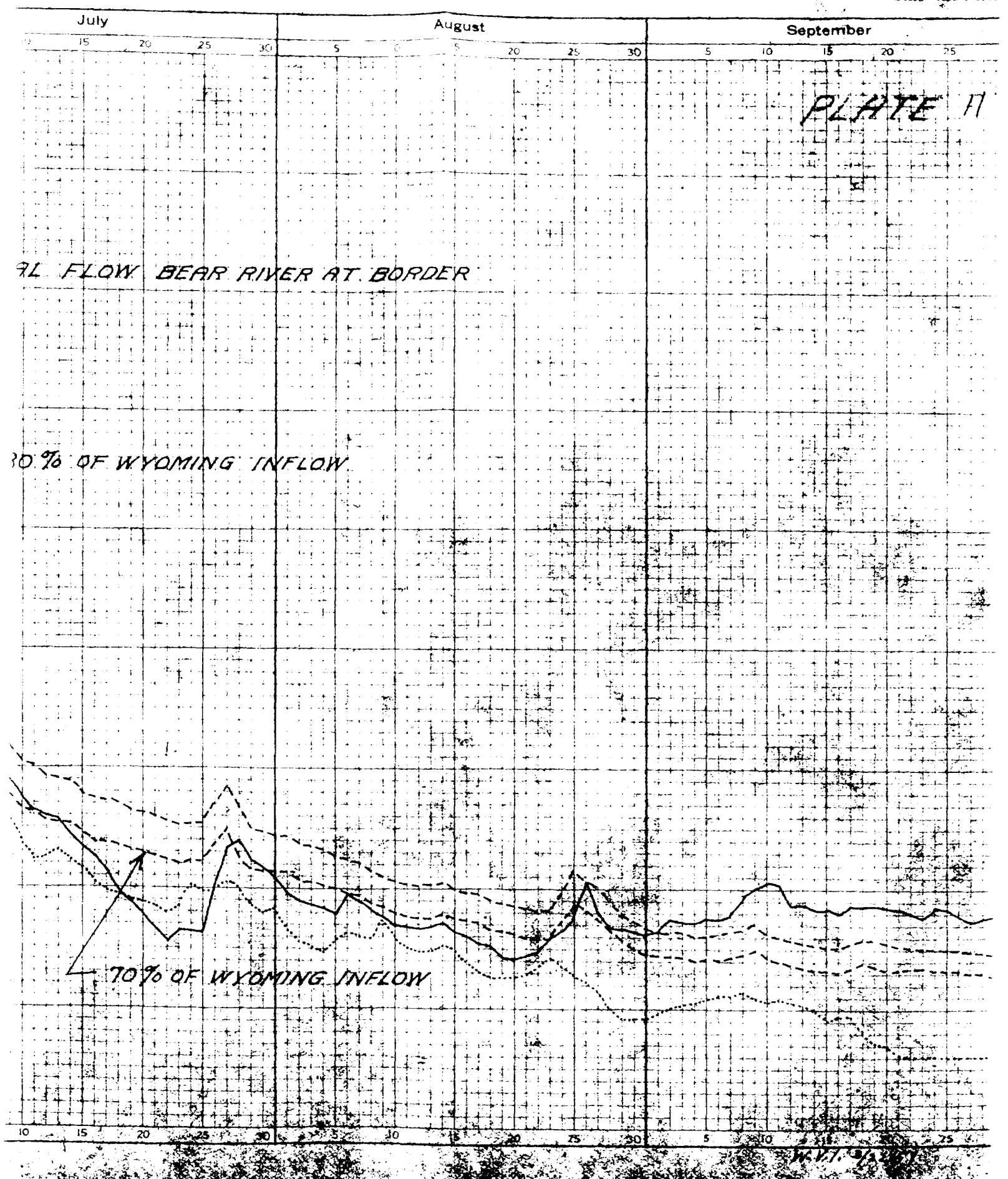

May
June
20
25
30
5
10
15
20
25
30
5
800
700
600
500
400
300
200
100
SECOND-FEET
AC
DIVERTED FOR IRRIGATION

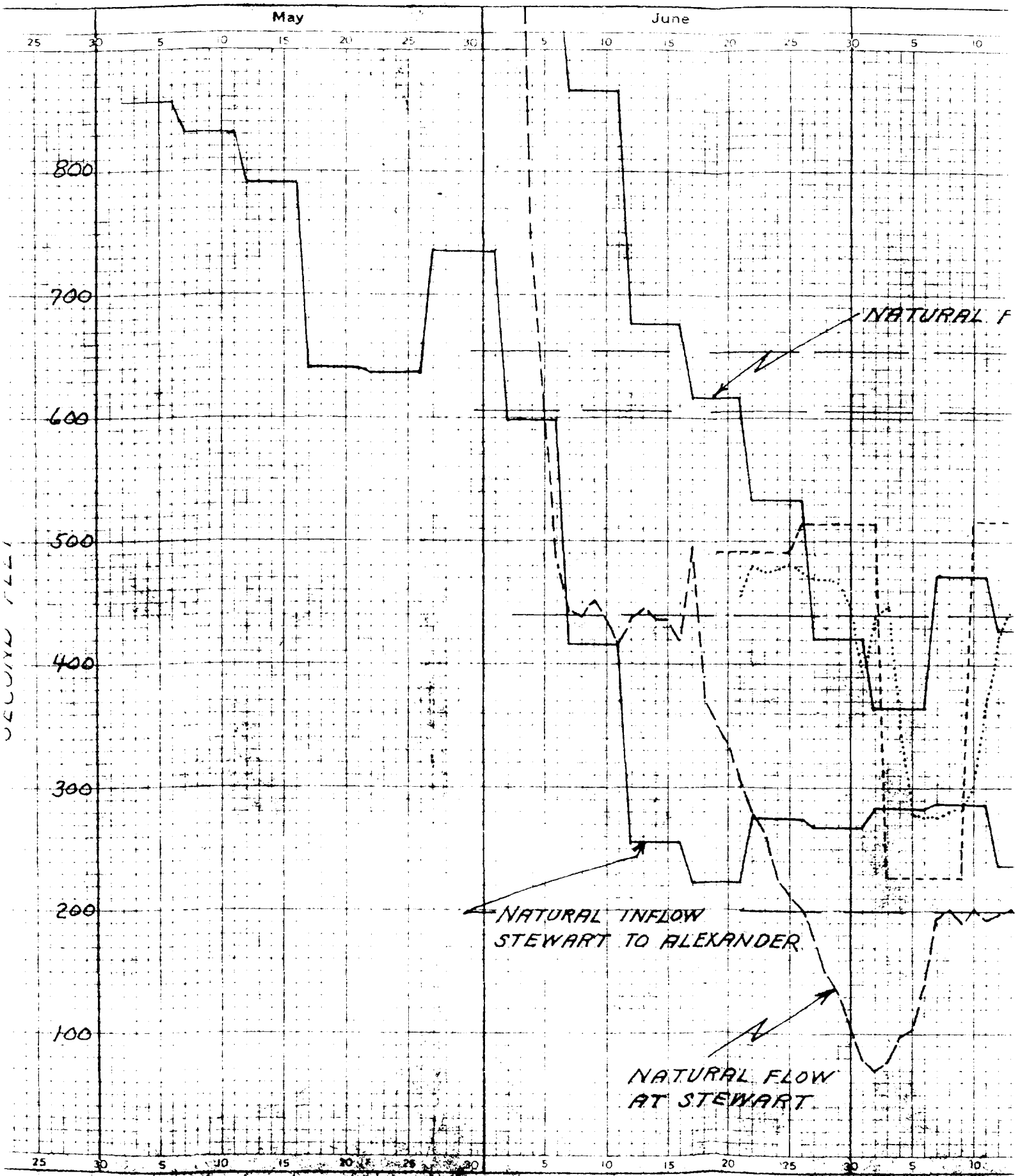
CENTRAL DIVISION - IDAHO 1946

File No. [illegible] Washington

Field

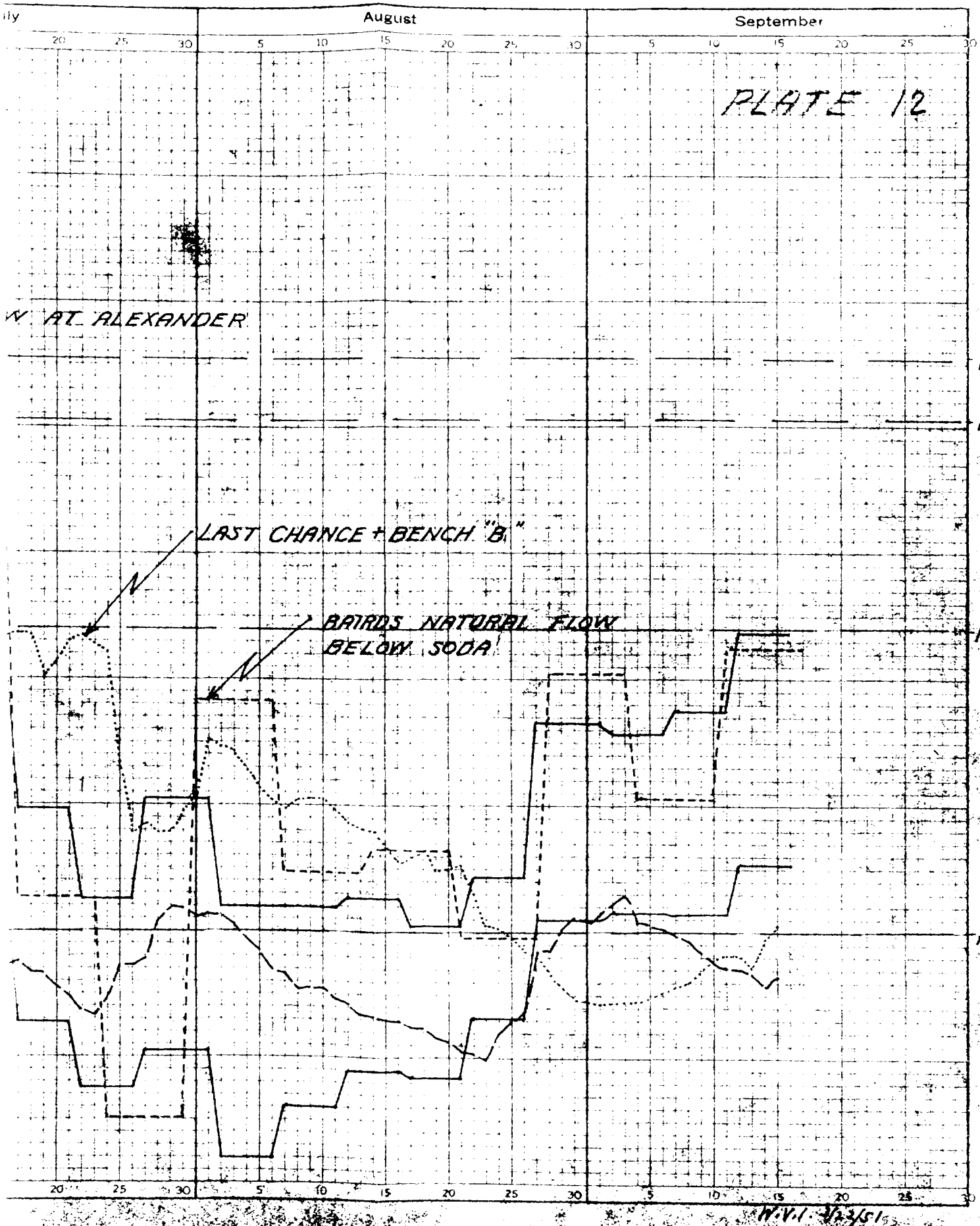
PLATE 11




May
June
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
800
700
600
500
400
300
200
100
NATURAL F
NATURAL INFLOW
STEWART TO ALEXANDER
NATURAL FLOW
AT STEWART

DIVISION - STEWART TO ALEXANDER 1946

File No. Washington
Field

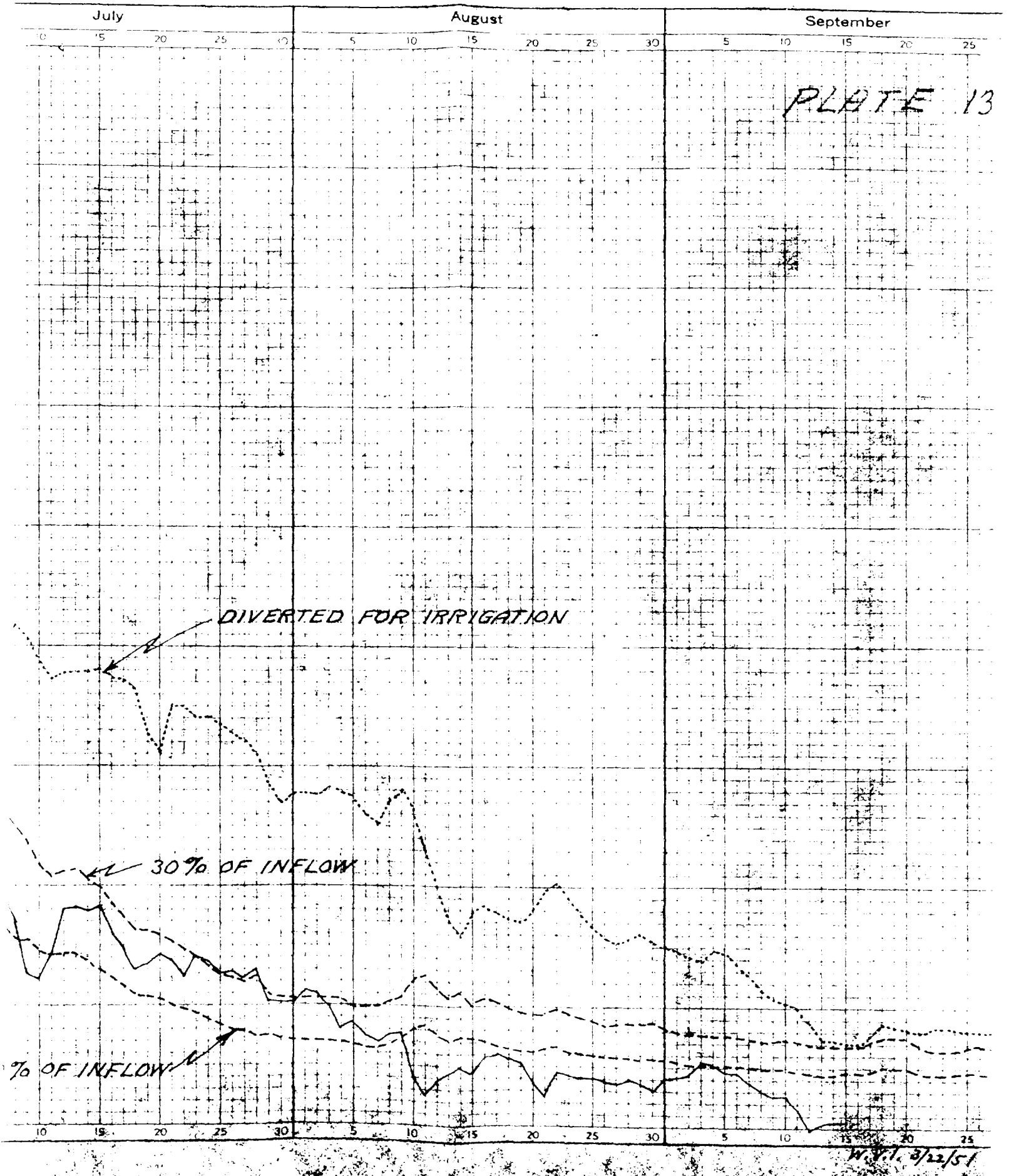


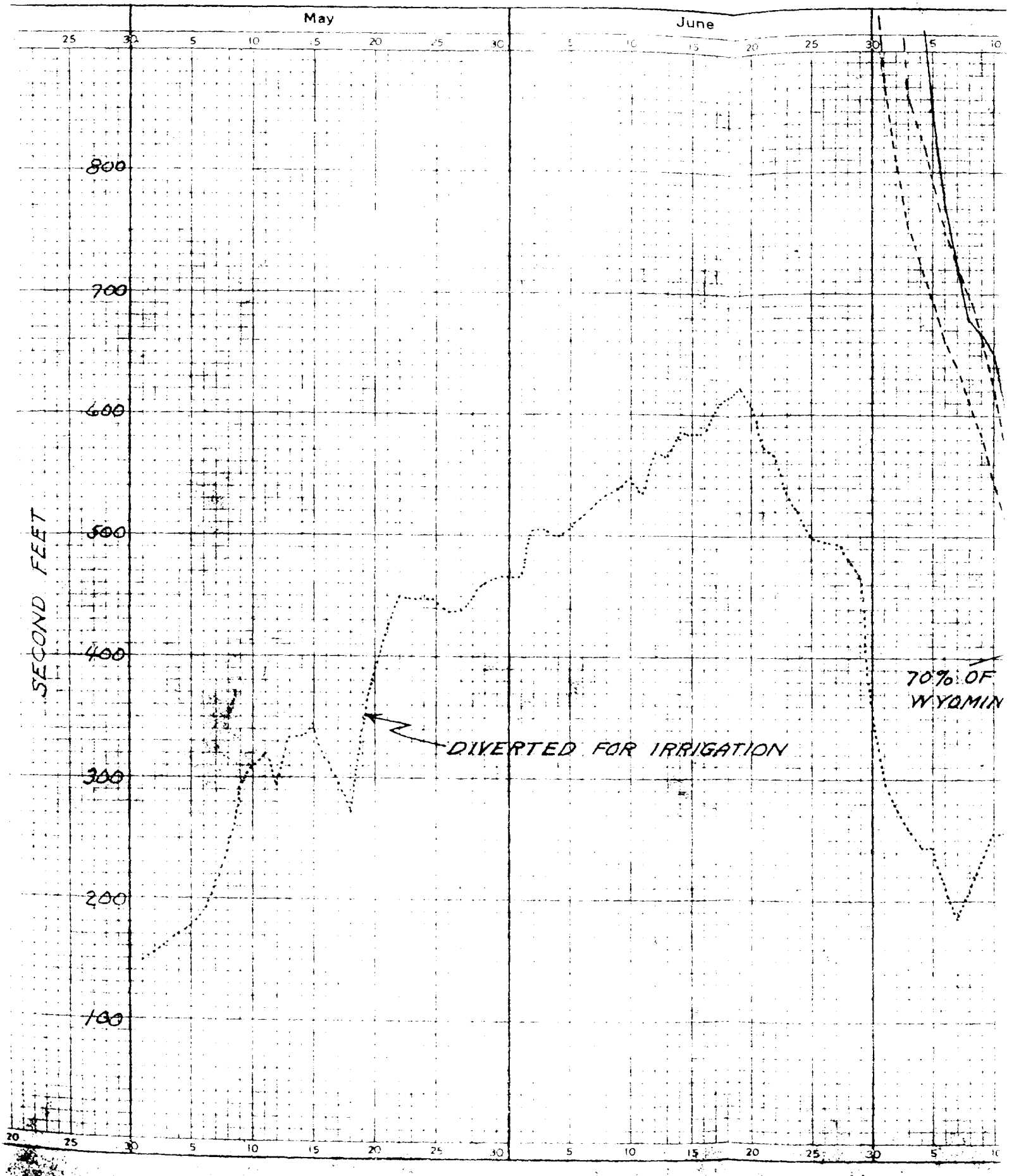

pril
May
June
20
25
30
5
10
15
20
25
30
800
700
600
500
400
300
200
100
SECOND FEET
ACTUAL DEPLETION

ENTRAL - DIVISION - WYOMING 1947

File No. Washington

Field

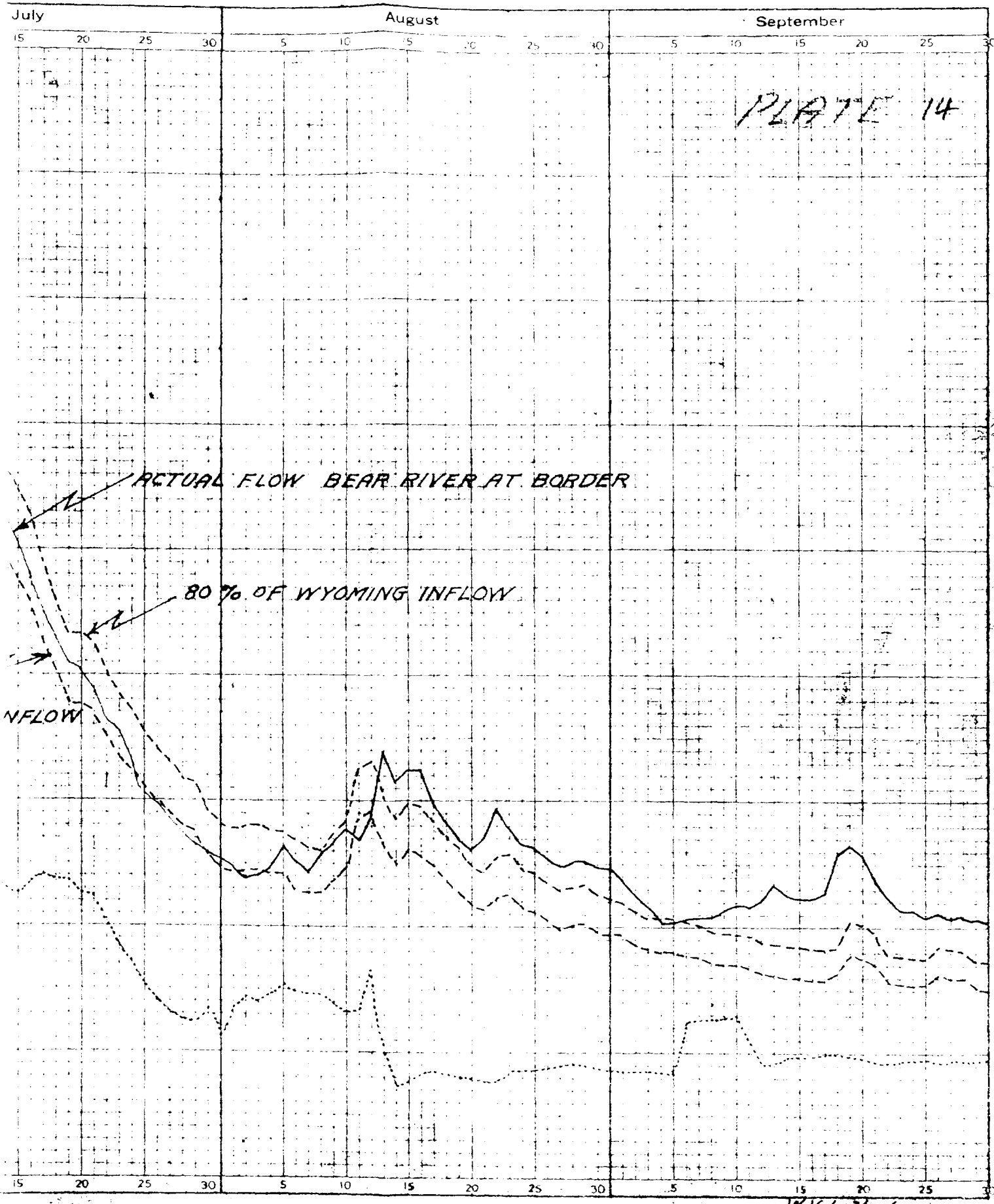



May
June
800
700
600
500
400
300
200
100
SECOND FEET
DIVERTED FOR IRRIGATION
70% OF
WYOMIN

VIRAL DIVISION - IDAHO 1947

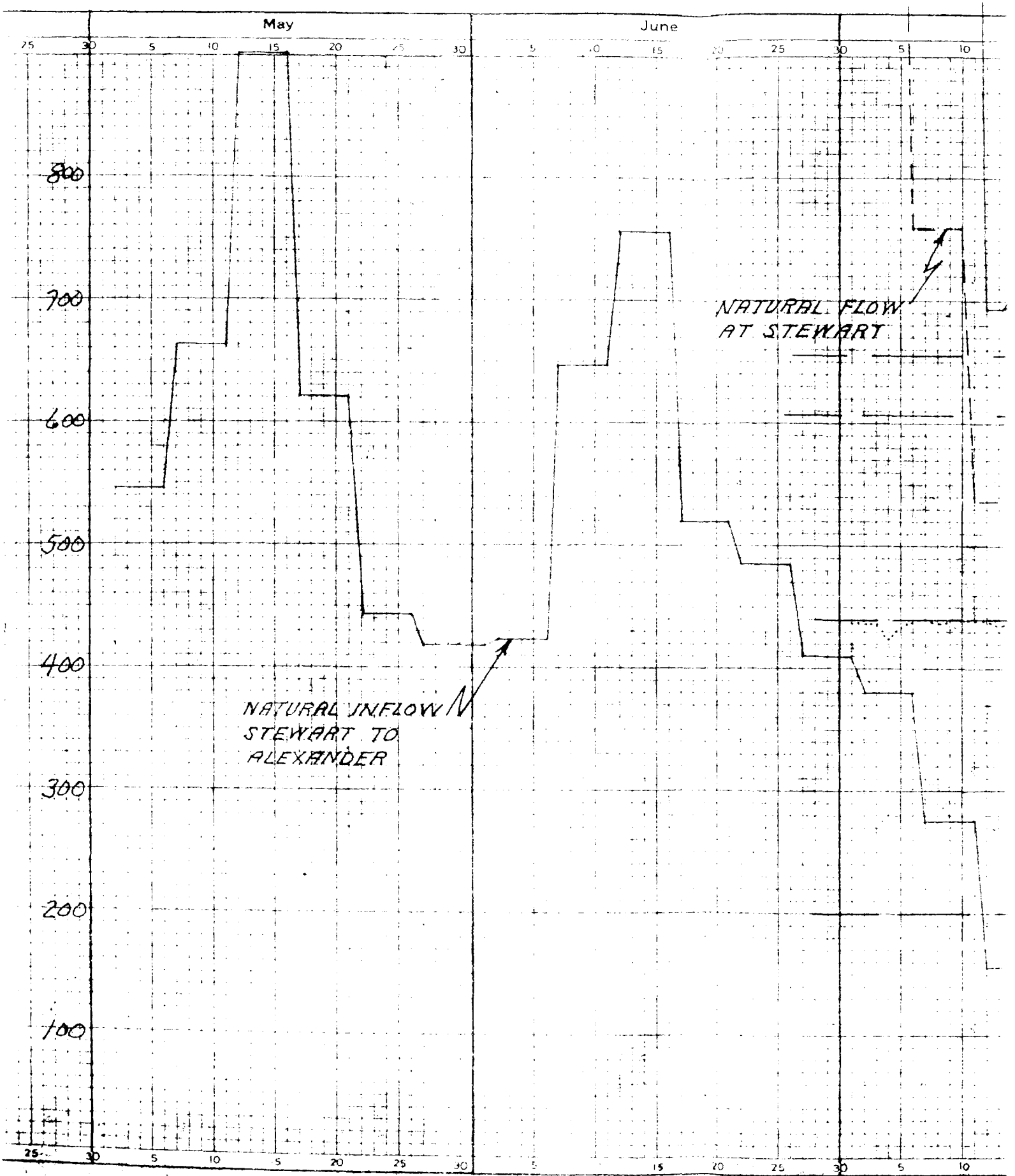
File No. Washington

Field



W.V.I. 3/22/51

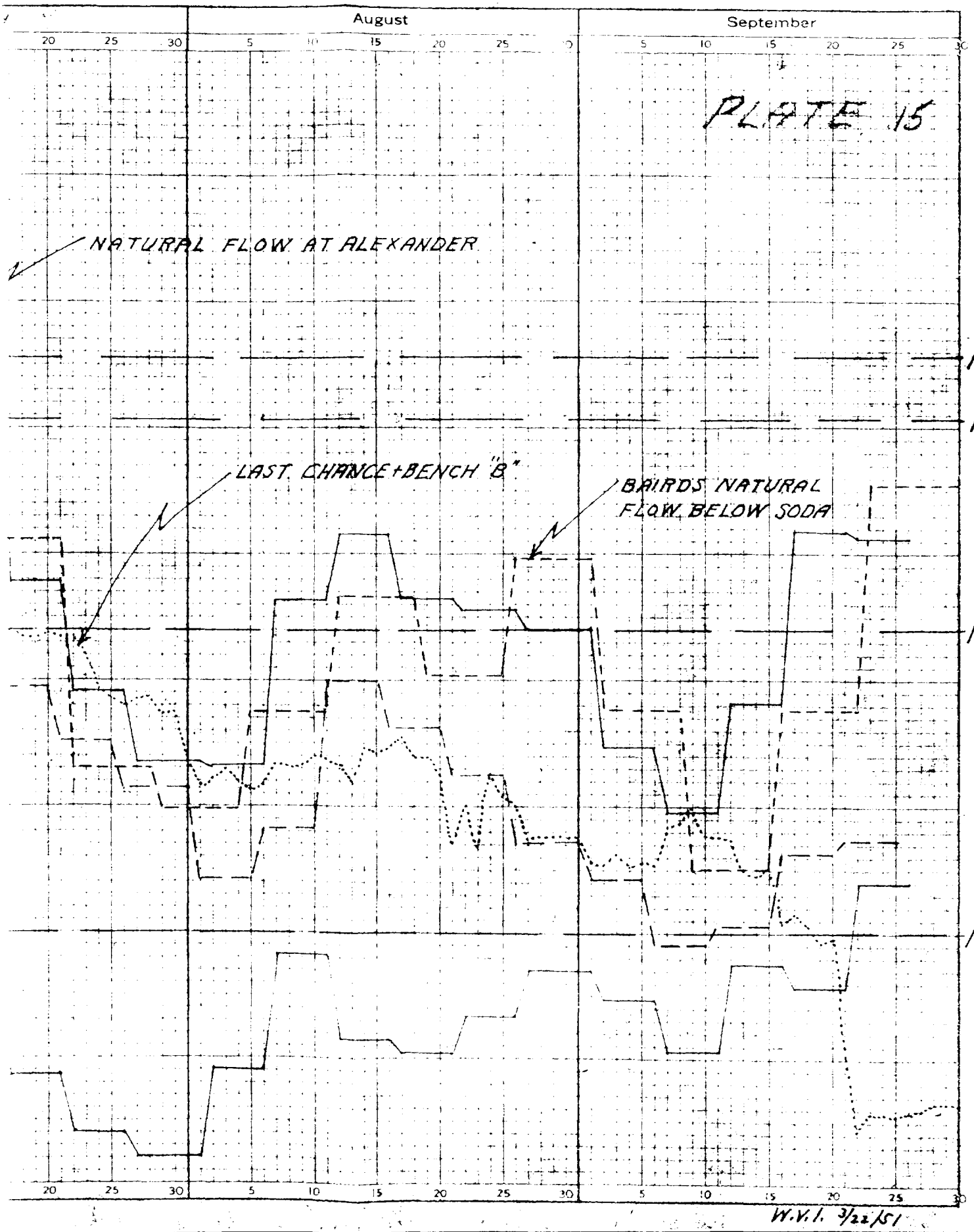
LOWELL


May
June
800
700
600
500
400
300
200
100
NATURAL FLOW AT STEWART
NATURAL INFLOW STEWART TO ALEXANDER

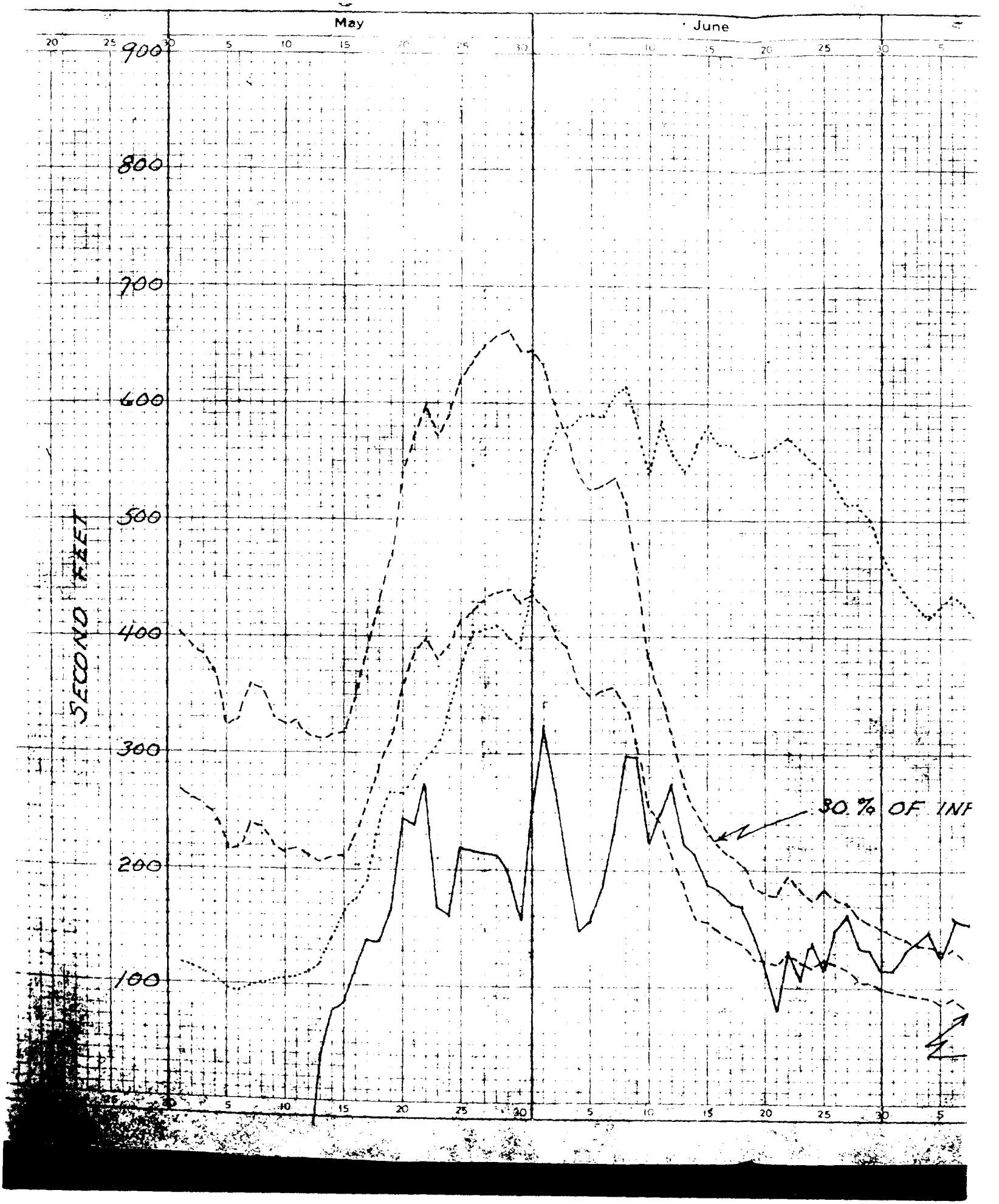
DIVISION - STEWART TO ALEXANDER - 1947

File No. [redacted]

Field [redacted]



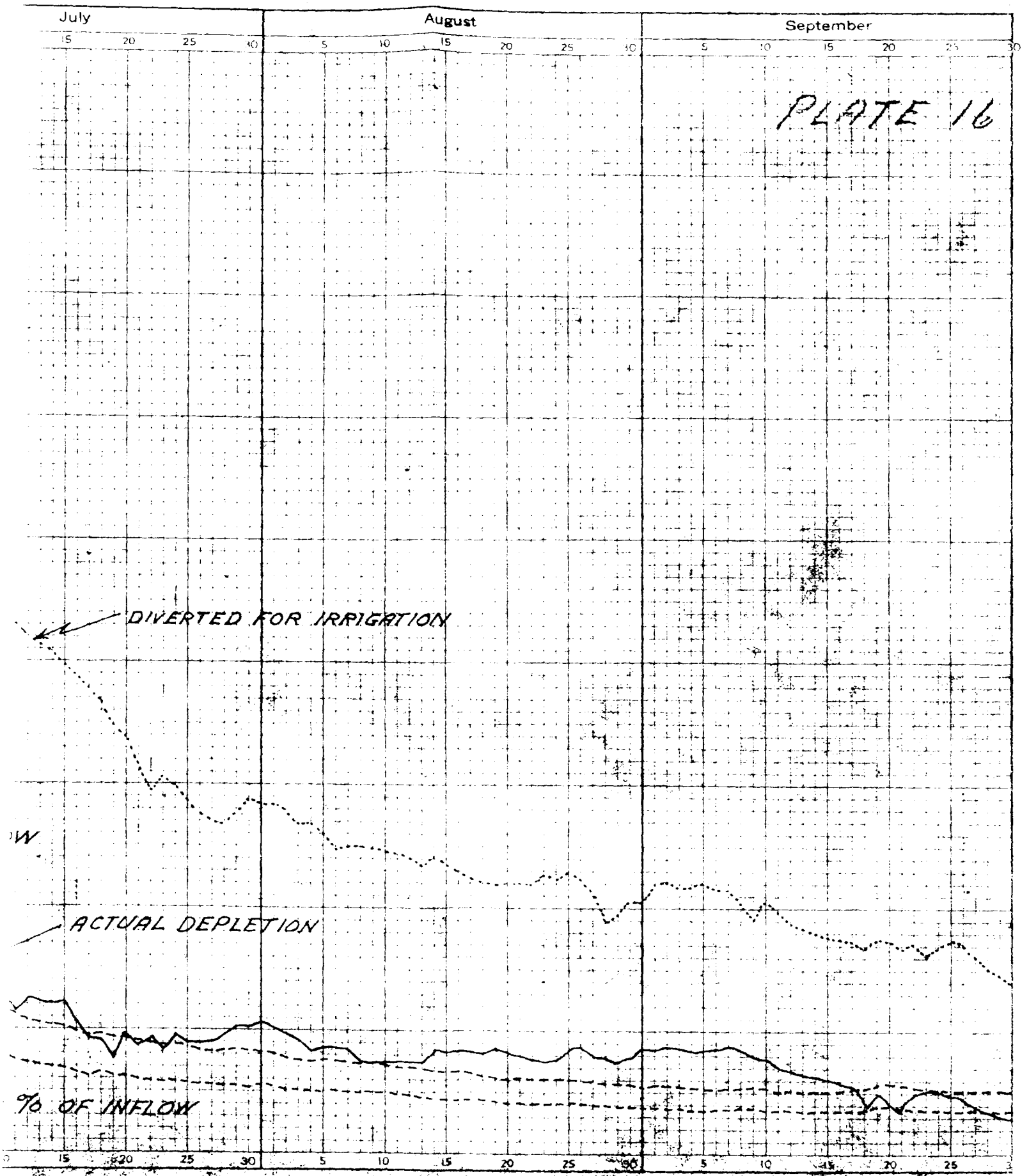
[redacted]


May
June
900
800
700
600
500
400
300
200
100
SECOND FEET
30 % OF INF

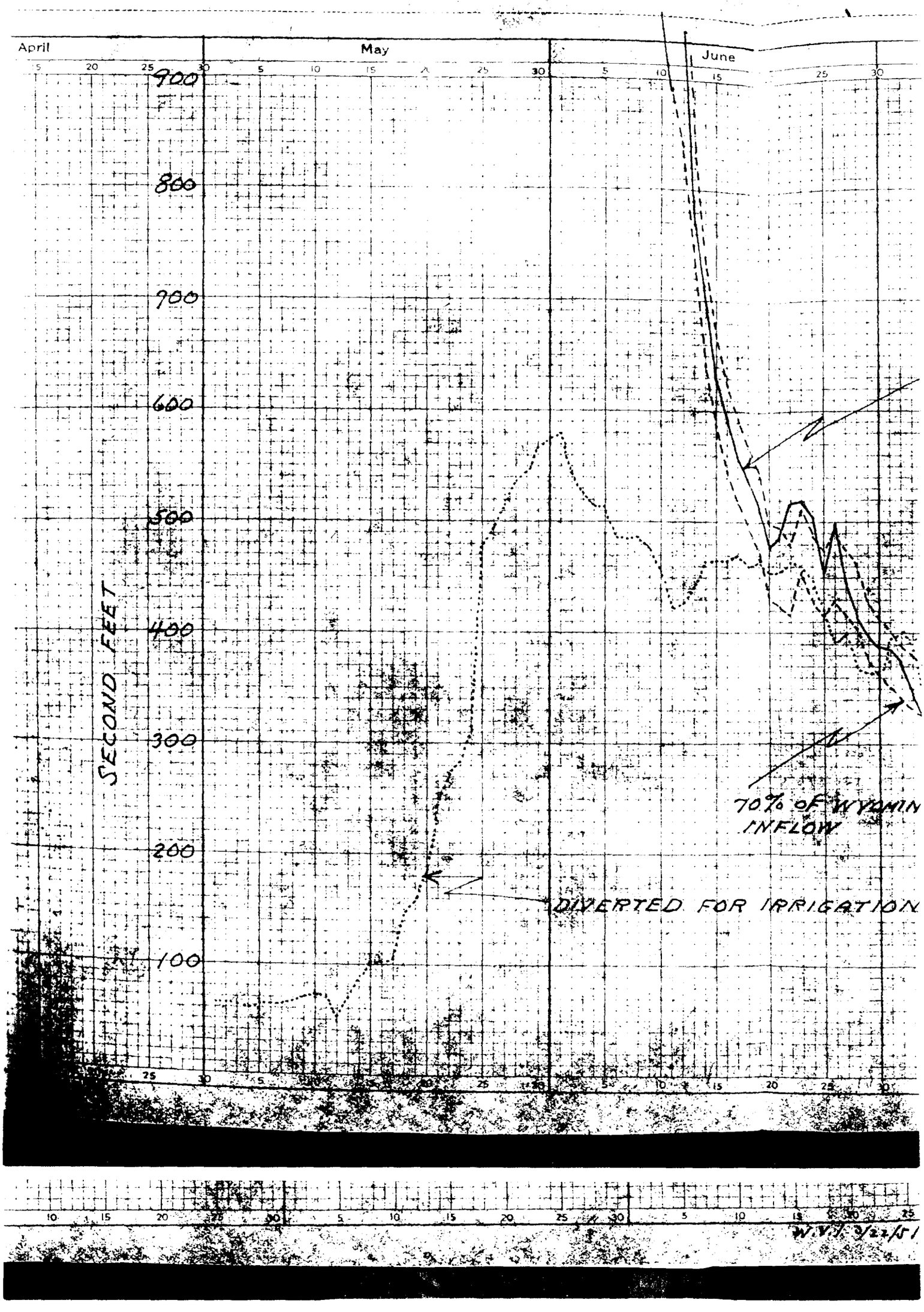
L DIVISION - WYOMING 1948

File No. Washington

Field

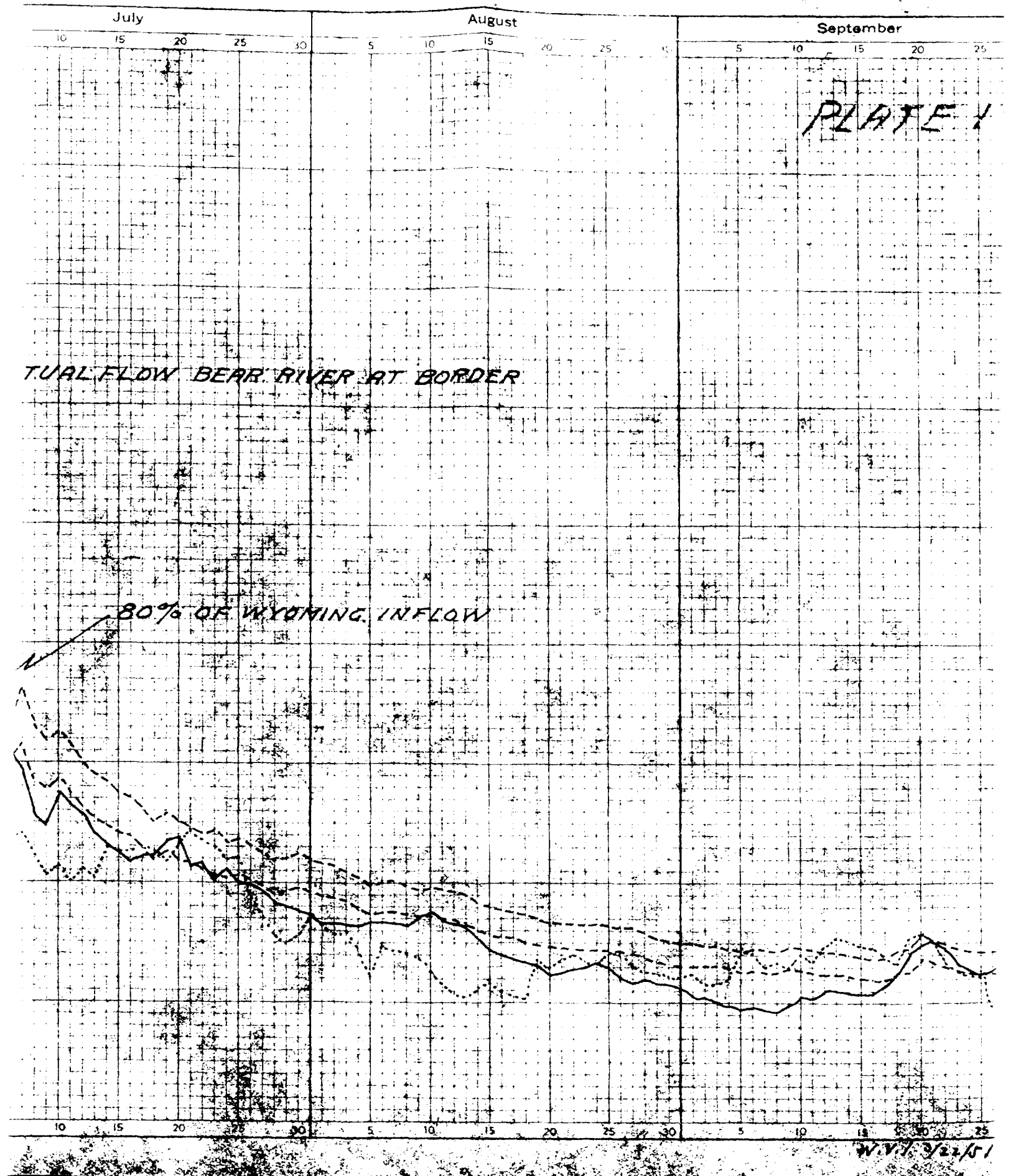


W.V.I. 3/23/51

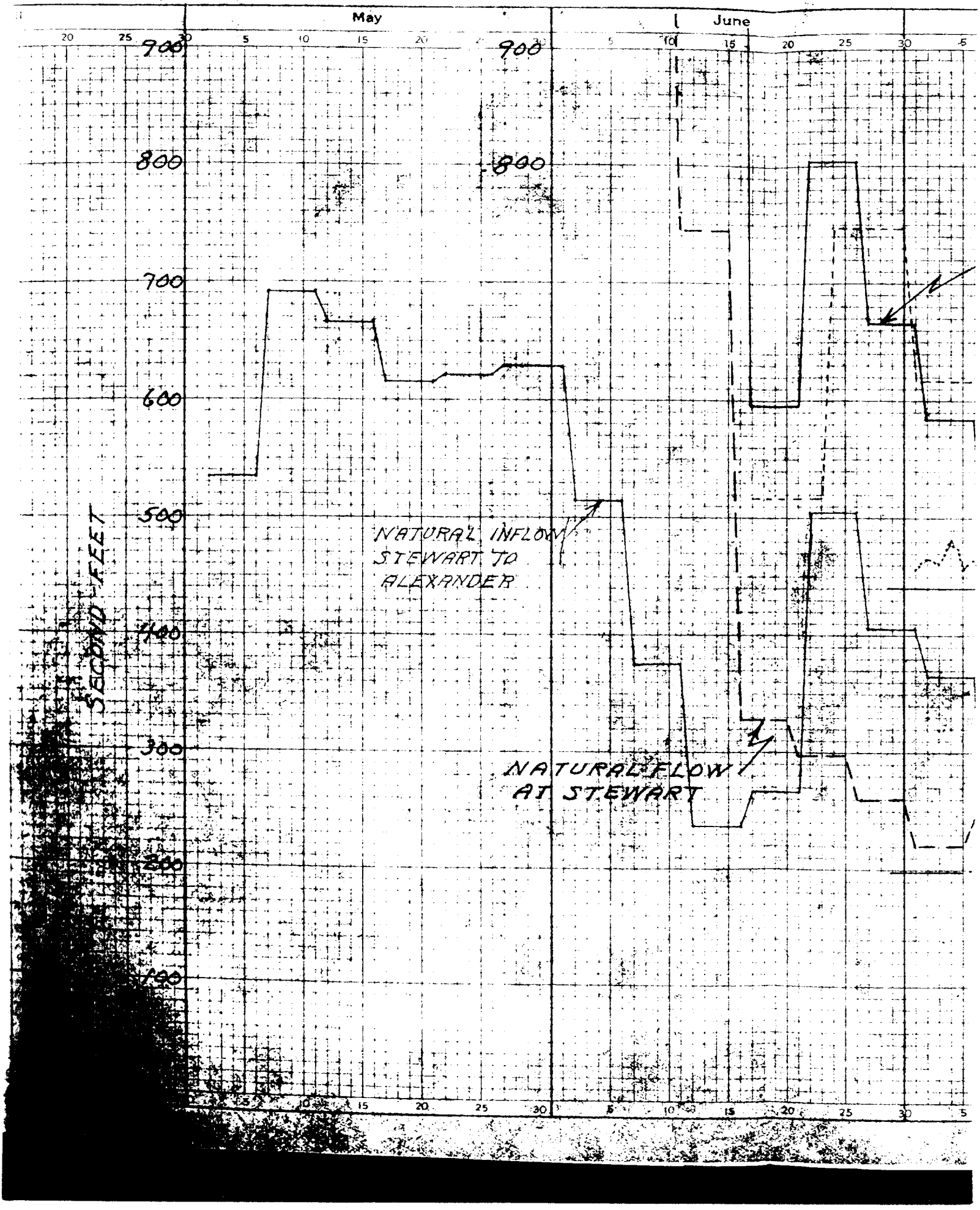

April
May
June
900
800
700
600
500
400
300
200
100
SECOND FEET
70% OF WYOMIN
INFLOW
DIVERTED FOR IRRIGATION
W.V.P. 3/22/51

CENTRAL DIVISION - IDAHO 1948

File No. Washington
Field



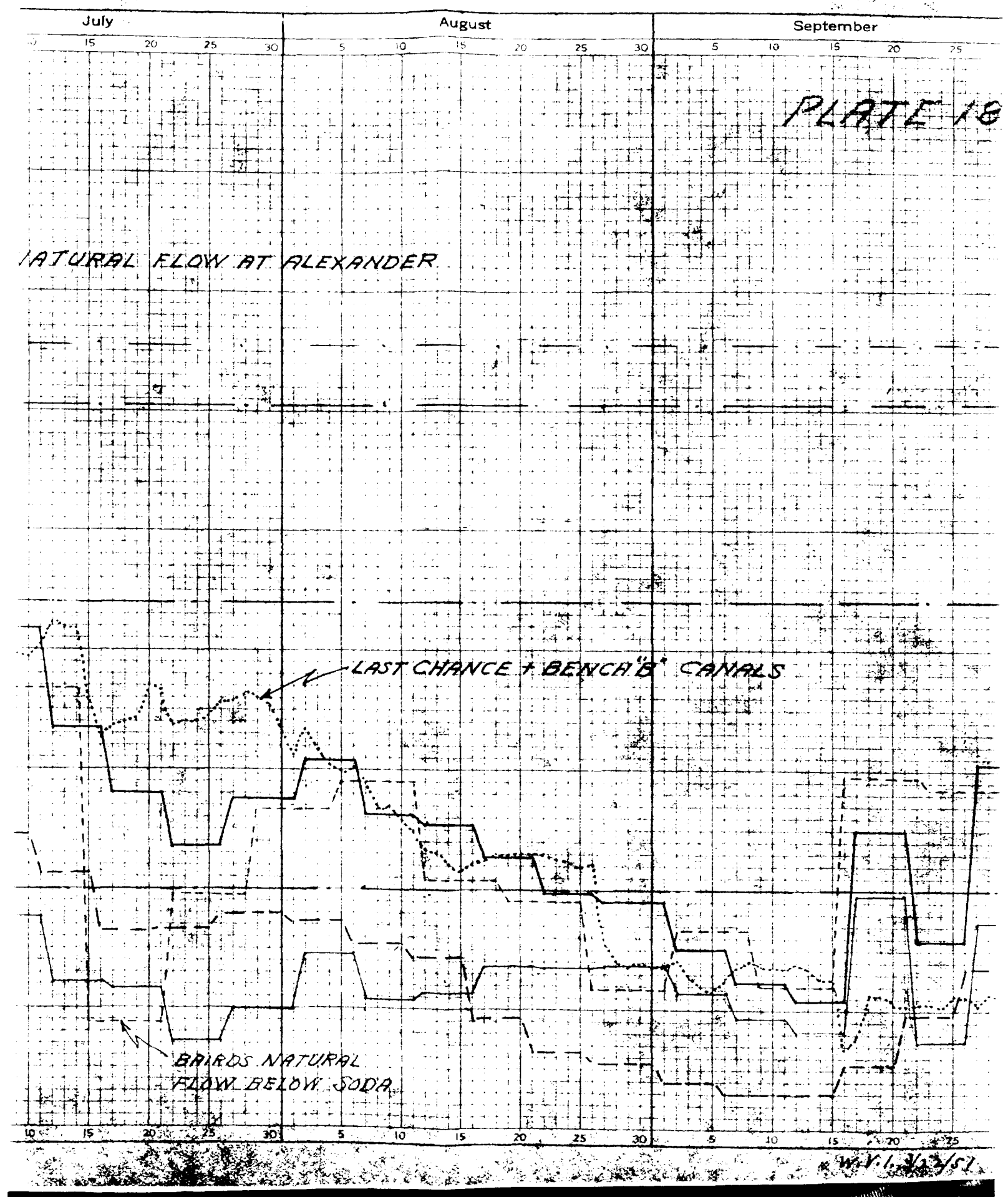
LOWER DIVI


May
June
900
800
700
600
500
400
300
200
100
SECOND FEET
NATURAL INFLOW STEWART TO ALEXANDER
NATURAL FLOW AT STEWART

ON - STEWART TO ALEXANDER - 1948

File No. Washington
Field

PLATE 16



W.V.L. 3/23/51