REPORT NO. 10

ANALYSIS

of

BEAR LAKE STORAGE

This report supersedes Report #8 and should be used in its place
see "Forward"

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Prepared By

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

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PREFACE

In 1943 the Geological Survey, in cooperation with the states of Idaho, Utah, and Wyoming, and the Bureau of Reclamation, began an intensive stream-flow investigation in the Bear River Basin. The purpose of this investigation was to secure adequate information on water supplies and uses within the Basin as base data for a compact among the three states on the division of the waters of the river system, and to assist the Bureau of Reclamation in determining the irrigation and power potentialities of the Basin. In 1946, the states requested Mr. Lesher S. Wing, Regional Engineer of the Federal Power Commission to assist them in drafting a tentative compact and asked the Geological Survey to authorize Mr. W. V. Iorns, Project Engineer of the U. S. Geological Survey to assist Mr. Wing in this work. At the Compact Commission meeting in December 1948, the Commission appointed an Engineering Committee to assist Mr. Wing and Mr. Iorns in the study of such engineering problems as may, from time to time, be referred to the Committee by the Compact Commission. Mr. Iorns was appointed Chairman of this committee.

The states of Idaho, Utah, and Wyoming made available, in their cooperative program with the Geological Survey, funds during the 1950-51 Biennium, to the Logan Project Office for such special investigations and stream-flow analysis work as the Commission may need in the drafting of a compact.

In carrying out this assignment, much information has been collected and studied and a series of reports prepared to make a record of findings and any conclusions reached. This report is one of the series. The observations and conclusions stated herein are entirely those of the author, and do not represent in any way those of the Geological Survey, the Bureau of Reclamation, or any of the states concerned.

W. V. Iorns

FOREWORD

Early in 1949 the Logan Project Office of the U. S. Geological Survey prepared a study of Bear Lake storage operation for the Bear River Compact Engineering Committee. The results of that study was the basis of certain conclusions in the Engineering Committee's Report dated June 15, 1949. In that report there were also included tabulations showing total storable water and storage segregation between water used for irrigation purposes and water used for power production.

The report contained little explanation of how the data were derived and many of the committee felt there should be available a more complete analysis, fully explaining the data and its derivation. This report has been prepared to fulfill that need.

In the preparation of this report, time has been available to more fully analyze the problem, which has led to a somewhat different treatment of the data and has resulted in slightly different final figures. It is not believed the differences would change the conclusions reached by the Engineering Committee as set forth in its June 15, 1949 report.

W. V. Iorns

BEAR LAKE STORAGE

The United States District Court of Idaho, Eastern Division, in a final decree filed July 14, 1920 awarded the Utah Power & Light Company the following rights:

(a) Bear River and Bear Lake.

The right to divert from the natural flow waters in the main channel of Bear River to storage in Bear Lake Reservoir, 3,000 cubic feet per second with a date of priority of March 1, 1911 and 2,500 cubic feet per second with a date of priority of September 11, 1912. This water to be diverted through the Rainbow and Dingle Inlet Canals, stored in the lake, and withdrawn as needed or required for generating electrical power and for irrigation purposes.

(b) Tributaries to Bear Lake

The right to store in Bear Lake Reservoir the natural flow of tributaries to Bear Lake, 300 cubic feet per second with a date of priority of September 1, 1912 and withdraw this stored water as needed or required for generating electrical power and for irrigation purposes.

(c) From Mud Lake and tributaries to Mud Lake

The right to store in Bear Lake Reservoir the natural flow of tributaries to Mud Lake, 200 cubic feet per second with a date of priority of September 1, 1912 and withdraw this stored water as needed or required for generating electrical power and for irrigation purposes.

The maximum storage space in Bear and Mud Lakes was not limited by the court decree granting storage privileges in these natural lakes. Bear Lake

Reservoir present capacity of 1,421,000 acre-feet is between the lower limit of the present pumping installation on Bear Lake (elevation 5902.00 ft. U.P. & L. Co. project datum) and the top of the outlet works at the Mud Lake dike (elevation 5923.65 ft. U.P. & L. Co. project datum). The rating table for the capacity of this reservoir was prepared by Mr. A. B. Purton, U. S. Geological Survey, and is based on capacities between contours shown on page 1 of Section 20 - "Water Resources, Part I, Bear River, 1922," of the Utah Power and Light Company.

Mud Lake or North Lake as it is sometimes called, is a group of shallow lakes situated at the north end of Bear Lake and separated from it by a natural causeway which was built up principally by wave action. It has a capacity of approximately 34,000 acre-feet between elevation 5919.00 feet (U.P. & L. Co. datum), which is approximately the elevation of the bottom of the drainage sloughs connecting the group of shallow lakes and elevation 5923.65 feet(U.P. & L. Co. datum) which is the top of the outlet control works at the Mud Lake dike.

The Outlet Canal is a dredged channel about fourteen miles long, extending from the pumping plant at Lifton to its junction with Bear River at a point about due east of Bern. Control gates are placed in this channel at the Mud Lake dike about seven miles north of the Lifton pumping plant. The sills of these control gates are at approximately elevation 5914 feet.

The Rainbow Inlet Canal diverts water from Bear River at Stewart Dam into Mud Lake. By operation of the Outlet gates at the dike, and the control gates in the causeway separating Mud and Bear Lakes the elevation of Mud Lake may be varied. Water can be diverted from Bear River into Mud Lake and thence returned to the river through the outlet canal, or be diverted into Bear Lake or be withdrawn from Bear Lake and emptied into Bear River. However, water can only be withdrawn by gravity from Bear Lake, while that lake is in it's top five feet of range. When the lake drops below the gravity range the water is "lifted" from Bear Lake into Mud Lake and then passed through the outlet canal by gravity to Bear River.

Mud Lake also serves as a regulating reservoir in delivering pumped Bear Lake water into the Outlet Canal. In normal operation the pumps are operated only during "dump-power" periods. The pumped water is temporarily stored in Mud Lake and released into the Outlet Canal as required. In normal operation Mud Lake is considered only as a regulating reservoir and not as a storage reservoir, although in some years it may contain some storage which is used during the irrigation season.

Prior to the time of storage development work, Bear River in times of high water, overflowed its south banks. This overflow drained into Mud Lake and then backed up into Bear Lake. However, this contribution to the lake could not have been very great as the natural channel through the causeway was early reported to have been only thirty-eight feet wide. Likewise, it is not believed that Bear Lake itself contributed much flow to Bear River because of this small outlet. The old outlet channel between Bear Lake and Bear River was a very flat, meandering, sluggish, stream which could not have carried much water. This would indicate that prior to the time of the lake's utilization as a reservoir, the tributary inflow into Bear Lake plus the unknown quantity of water contributed by submerged springs, was hardly more than sufficient to offset evaporation losses.

Water stored in Bear Lake is of an immense value in the production of electrical power and irrigation. This multiple use is made possible by the fact that most of the lands using storage are located below the major power sites on the river. Present power plants situated on the main channel of Bear River below the reservoir are as follows:

Plant	Approximate Static Head Feet
Soda	75
Grace	524
Cove	98
Oneida	146
Cutler	120
Total approximate static head	963

To assist in getting the maximum power production out of the river waters, the Power Company has constructed in connection with its diversion and power head producing works, three temporary pondage reservoirs for regulation.

Reservoir	Usable Storage Capacity Acre-Feet
Soda	11,800
Oneida	11,500
Cutler	15,300

As noted in the Bear Lake decree, the waters stored in the lake are for irrigation purposes in addition to use in generating electrical power. It is reported the Power Company has agreements in contract form, with many of the canal companies for the delivery of storage water for irrigation. Without going into details, it is understood that the various agreements provide for delivery of storage to the major canals as follows:

Canal	General Terms
Last Chance Canal	Annual delivery of storage as required
West Cache Canal	Annual delivery of up to 12,000 acre-feet
Cub River Irrig.Pump Canal	Annual delivery of up to 20,000 acre-feet
Hammond & West Side Canals	Total delivery of up to 900 cu.-ft. per sec. when required.

In addition it is understood that some form of agreement exists for a number of canals whose diversions are complicated by extreme fluctuation of the river in power production, whereby the canals receive some storage water as compensation. There are also a number of small pump canals that use principally storage water but are not believed to be covered by storage delivery contracts.

The study of Bear Lake storage operation, presents a most complex problem. At various times throughout the year water is withdrawn from the lake for power purposes, and in addition, during the irrigation season water is also withdrawn for irrigation. Most of this water is temporarily detained in varying degrees in the several pondage reservoirs for power production in the integrated power system, before being finally diverted for irrigation or wasted into Great Salt Lake. Between Bear Lake and Cutler Dam, numerous tributaries enter the river system. The waters of these, together with irrigation return flows, natural channel gains, natural channel losses, evaporation losses from pondage reservoirs, canal diversions, pondage in regulating reservoirs and extreme daily fluctuations in flow due to power plant operation makes the daily segregation of flow between storage waters and natural flow waters practically impossible.

In the administration of the Dietrich decree in Idaho, the watermaster has found it necessary to deliver natural flow water on the basis of weekly averages, adjusting his deliveries as the season progresses. In the annual reports of the Watermaster which have been published since 1923, the deliveries down the river and to the canal companies are not segregated as to natural flow and storage water in such a manner as to provide figures showing actual use of the storage water.

The Bureau of Reclamation in the late 1930's made a detailed study of Bear River flows below Bear Lake in connection with power and irrigation investigations. However, certain assumptions were made and the computations are so detailed that little information can be derived from this work in obtaining a summary picture of Bear Lake storage operation and the uses of the storage waters.

The Utah Power and Light Company reported they could not furnish figures showing river operation in which the natural flows are segregated from storage flows. Apparently their river studies are confined to power plant operation. With no available figures on uses of Bear Lake storage, it becomes necessary to derive the information from available data. After a careful study of the river system and records available, it was apparent that a daily segregation of natural flow, storage water, and storable water would be a large and laborious task. However, the study did reveal that if the problem were attacked from a storage depletion angle and the water year divided into three periods, carefully defining the objective flows and uses and making reasonable assumptions with respect to several variables, the problem could be simplified and reliable results obtained.

The information which must be extracted from these studies are:

1. If Bear Lake were dedicated entirely to irrigation purposes what would be the maximum amount of water that could have been stored annually?

2. How much of this storable water is derived from Bear River and how much from tributary inflow to Bear Lake? 191,600 63,500

3. What is the annual irrigation storage requirement of canals now depending on Bear Lake? 159,800

4. Is there any surplus storable water in Bear River at Stewart, considering only present storage developments, in excess of present irrigation storage requirements which could be stored and used above Bear Lake? 94,700 ac. ft.

5. In past operation how much of the Bear Lake storage or storable waters has been used for power production, that is, passed down the river system and wasted into Great Salt Lake?

Period divisions of the water year

1. Winter storage period: That period of the water year extending from October 1 to March 31. In this period the total flow of Bear River above Stewart Dam is considered storable in Bear Lake except for a reasonable diversion loss estimated at 40 acre-feet daily.

2. High water storage period: That period of the water year extending from April 1 to the day before the beginning of the storage draft.

During this period in most years since 1923, the major portion of the flows available at Stewart Dam were diverted to storage in Bear Lake, except actual diversion losses and water passed for prior irrigation rights downstream. In such years the flows actually diverted to the lake would be the maximum storable. In those years where more was by-passed than necessary for prior rights adjustment can be made by classing such extra water as water passed for power purposes and including it as storable water.

3. Irrigation storage delivery period: That period of the water year extending from the date storage draft on Bear Lake started until September 30, during which all natural flow in the river system is considered diverted by the irrigation canals and deficiencies in their requirements made up from storage water. Any storage water passing Cutler Dam except for a reasonable diversion loss is classed as storage water for power production.

Other Definitions

1. Bear Lake storage delivered for irrigation is defined as storage water released from Bear Lake and diverted for irrigation even though electrical power is produced as the water flows downstream to the last point of diversion for irrigation. The storage delivered to irrigation would be practically equivalent to the depletion of Bear Lake storage water between Bear Lake and Cutler Dam.
2. Bear Lake storage and storable water used for power production is defined as Bear Lake storage and storable water that is passed through the turbines at Cutler Dam for power production. During the storage period all storable water which was not stored in Bear Lake has been classed as water by-passed for power production. During the storage delivery period all Bear Lake storage water passing

Cutler Dam, except for a reasonable irrigation diversion loss, is classed as storage water used in power production. There are times in this period when the inflow between Stewart and Cutler Dams exceeds the total irrigation demand and some of the water passing the Collinston gaging station is natural flow. These periods can be identified and the water charged to power production limited to the Bear Lake storage release, taking into account the time interval required for water to move through the river system. The total annual storage and storable water used in power production is the combined total of the storage and storable water released or by-passed during the storing period and the storage actually used in power production during the storage delivery period.

3. Bear Lake net tributary inflow and evaporation: If water were not withdrawn from Bear Lake and not diverted to the lake from Bear River, the water contained in Bear Lake would be the net result of the tributary inflow less evaporation losses. Likewise the change in contents for any period of time would be the net effect of inflow and evaporation for this period of time. By algebraically subtracting the monthly Bear River diversions to Bear Lake from the monthly change in Bear Lake contents, the increase or decrease of Bear Lake storage exclusive of Bear River water can be computed. On Plate 1 are shown the monthly and annual figures of net Bear Lake evaporation and tributary inflow. Plate 2 shows graphically the net annual gains and losses and Plate 3 shows the accumulative annual gains and losses for the period 1924 to 1948. It is to be noted on Plate 1, that during the storage period there is usually a total net gain in Bear Lake while during the storage draft period, a net loss occurs.

The net gain during the storage period is added to the maximum storable from Bear River in determining the total annual maximum storable in Bear Lake. The net loss during the storage draft period is added to the amount withdrawn from the lake and diverted for irrigation in determining the total annual requirement for irrigation dependent on Bear Lake storage.

4. Diversion loss at Cutler Dam: If all water in Bear River during the storage delivery period were diverted for irrigation, there would occur under normal operations, a diversion loss at the last diversion dam on the stream which loss would be chargeable to storage. This diversion loss is reflected in the flow which occurs at the Bear River near Collinston gaging station when no water is being passed for power production. An adjustment is made in the flows passing the Collinston station in which this loss is deducted from the water used apparently in power production and a like amount charged to the irrigation storage requirement. 450 a.f daily

Assumptions

To simplify computations to the point of making this summary of Bear Lake storage operations possible, it has been necessary to assume several complicating variables as being constant or having no effect on the final results. Some of these variables have been assumed to have no effect, or the resulting effect as being too small to consider when compared to the total flows involved. Others were omitted because information was not available at the time of the preparation of this study.

It was assumed that Mud Lake was only a regulating reservoir and that its storage space had no real effect on the final determinations. Reliable information on this lake was not available at the time computations were made, however, figures are now available and its effect is discussed in a separate part of this report.

Soda, Oneida, and Cutler reservoirs are used for temporary pondage and stream flow regulation in connection with power production and irrigation water delivery to the canals. While their combined capacity is quite large, it has been assumed that their total effect is compensating and that they can be omitted without introducing too much error. At the time this assumption was made, records for Cutler reservoir prior to 1944 were not available. Changes in Soda and Oneida storage did not appear to be of sufficient magnitude to have appreciable effect and it was believed Cutler Reservoir operation would be similar . Tabulations have been prepared of their operation, which are discussed in a separate part of this report.

In the reach of the river between Bear Lake and Cutler Dam, a portion of the storage water applied to the lands will be available for re-use as return flow. Also in this same reach of the river, part of the river losses due to evaporation and other causes, are chargeable to storage waters and part are chargeable to natural flow waters. It has been assumed that the proportional effect of these will be automatically charged to storage waters by treating the river system between Bear Lake and Cutler Dam as a unit.

COMPUTATIONS FOR A TYPICAL YEAR

The explanation and computations necessary to explain the derivation of all final figures presented in this report would be most extensive and no attempt will be made to cover them fully. However, for future reference it is deemed necessary to explain in some detail the method and derivation of figures for a typical year. For this purpose the 1947 water year was picked at random and hydrographs prepared for illustration as shown on Plate 4. On Plate 5 are shown computations and summaries for the water yeas 1924 to 1948. The following is an explanation of the hydrographs on Plate 4 for the 1947 water year and figures as shown for the same water year on Plate 5.

Winter storage-period 1947 water year.- As previously defined the winter storage period extends from October 1 to March 31. The total flow at Stewart Dam as indicated by the dash-dot line on Plate 4, is the combined flows at the Bear River below Stewart Dam, Rainbow Inlet Canal and Dingle Inlet Canal gaging stations. This combined total is 120,400 acre-feet. The shaded area on the hydrograph plate indicates the maximum amount of water which could have been stored during this period, it being the total flow at Stewart less an average daily diversion loss of 40 acre-feet daily, or 7,200 acre-feet for the period October 1 to March 31, which, when deducted from the total flow at Stewart, leaves a balance of 113,200 acre-feet as the computed maximum storable in the lake during this period. The short strips of dotted hydrograph in this period shows the daily flows that were actually diverted to Bear Lake storage, computed by subtracting Outlet Canal from Rainbow and Dingle inlet canals when difference is greater than zero. The solid line sections of hydrograph shows the daily flows that were withdrawn from storage, computed by subtracting Rainbow and Dingle inlet canals from Outlet Canal when difference is greater than zero. The area under this solid line in double cross-hatching represents storage withdrawn from the lake for power production.

High Water Storage Period.- The high water storage period in 1947 extends from April 1 to July 7. In addition to the hydrograph designations as previously explained, this section has plotted on it also, the discharge at the Bear River near Collinston gaging station plotted "n" minus three days. The normal time interval for water released from Bear Lake to reach the Collinston gaging station is three days. If all of the storable water at Stewart had been diverted to Bear Lake storage, the dotted line would have followed about 20 second feet below the dot-dash line. It is to be noted that for the periods May 20 to May 30, June 1 to June 11, and June 18 to July 7 the dotted line hydrograph drops considerably below the 20 second foot difference, indicating that storable water was by-passed Bear Lake. It is also to be noted that the Bear River near Collinston hydrograph for the first period, May 20 to May 30 and part of the last period, June 21 to July 7, drops and approaches zero flow. It can therefore, be assumed that the water by-passing Bear Lake in these two periods represents natural flow water that was passed for prior irrigation rights. The amount of this water is indicated by the areas outlined in the small "/" marks.

During the other period, June 1 to 11 and the part of the last period June 18 to 20, when the dotted line dropped below the dot-dash line, there was sufficient inflow below Stewart Dam to fill all irrigation requirements. Water by-passing Bear Lake at these times could have been stored in the Lake, but as it was by-passed when not needed for prior irrigation rights, it is assumed to have been used in power production. This water is indicated by the shaded areas above the dotted line and totalled 7,800 acre-feet. For all practical purposes, this figure can be determined approximately by inspection of the daily discharges at the various gaging stations without plotting each individual year. By adding this amount (7,800 ac.-ft.) to the amount acutally diverted to Bear Lake storage in this period (180,000 ac.-ft.) the total maximum storable can be obtained (187,800 ac.-ft.) With these basic figures, the total by-passing Bear Lake and the total chargeable to diversion loss and prior irrigation rights, can be determined.

Total Storage Period October 1 to End of Storage Period.- The total maximum storable which could accrue in Bear Lake during the storage period would consist of storage water that could be derived from the Bear River source plus the water which would accumulate in Bear Lake from tributary inflow. The maximum storable from the Bear River source (301,000 ac.-ft.) would be the sum of the maximum storable in the winter period (113,200 ac.-ft.)

and the maximum storable in the high water period (187,800 ac.-ft.). The maximum storable from the Bear Lake source (84,100 ac.-ft.) is computed by totalling the monthly net gains in Bear Lake as shown on Plate 1 for the portion of the year from October 1 to the end of the storage period. The total maximum storable (385,100 ac.-ft.) is the sum of the maximum storable from the Bear River source (301,000 ac.-ft.) and the maximum storable from the Bear Lake source (84,100 ac-ft.).

From the actual contents of Bear Lake on October 1 (950,800 ac.-ft.) and at the end of the storage period (1,254,000 ac.-ft.) the net actually stored in Bear Lake (303,200 ac.-ft.) is computed. The difference between the total maximum storable (385,100 ac.-ft.) which could have been accumulated and the storage actually accumulated (303,200 ac.-ft.) is a measure of storage and storable water (81,900 ac.-ft.) which was withdrawn from the lake or by-passed and apparently used for power production. On Plate 4 for the storage period from October 1 to July 7 this is represented by the double cross-hatched areas plus the portions of shaded areas lying above the dotted hydrographs.

Storage Delivery Period.- This is the period in the irrigation season that storage water is being released from Bear Lake. This storage water is used for irrigation and power production. Since the natural flow irrigation rights for canals diverting above Cutler Dam are older than any rights which use water passing the dam, it is reasonable to assume that up to the limit of the Bear Lake storage release, any water passing the dam during the storage delivery period is storage water released from Bear Lake. The canals diverting above the dam would first divert all the natural flow and make up the difference in their requirement from Bear Lake storage. If no more storage were released from the lake than necessary to fill the irrigation requirement there would be no flow past

Cutler Dam except leakage. But if more storage were released than the irrigation canals required, or if additional water was released from the lake to be passed through the Cutler plant for power purposes, then this storage would flow past and be measured at the Bear River near Collinston gaging station located below the dam and power plant.

The storage delivery period in 1947 extended from July 8 to September 30, which is the period of time that the flow in the Outlet Canal exceeded the combined flows in the Rainbow and Dingle Inlet Canals. The Bear Lake storage release on Plate 4 for 1947 is indicated by the solid line hydrograph. The normal time interval for water released from Bear Lake to reach Cutler Dam is three days. On Plate 4 the flows passing Cutler Dam (Bear River near Collinston gaging station) is plotted "n-3" days, thus superimposing on the daily Bear Lake storage release hydrograph the same water passing a downstream point. It has been previously pointed out that when storage is being released from Bear Lake all of the natural flow in the river is normally being used for prior irrigation rights. It therefore follows that any flows passing Cutler Dam not in excess of the Bear Lake storage releases must be storage water from Bear Lake. On the hydrograph plate such flows are indicated in double cross-hatching. This double cross-hatched area is storage water released from Bear Lake, passed through the turbines at Cutler Dam, and wasted into Great Salt Lake or in other words, storage water used for power production. The balance of the storage water released from Bear Lake indicated by the single hatched areas would be storage water diverted above Cutler Dam for irrigation purposes.

At times during the storage delivery period, storms occur which increases the natural flow in excess of irrigation requirements. Also at times especially near the end of the irrigation period the irrigation demand decreases. At these times the flows past Cutler Dam often exceeds the storage being released from Bear Lake. When these conditions occur, the storage chargeable to power use cannot exceed the storage being withdrawn from Bear Lake.

Due to river regulation, principally for power production, there are at times short periods of usually only a day or two when the discharges past Cutler Dam exceed the Bear Lake storage releases. It can only be assumed that for such times all of the water passing Cutler Dam is storage water used for power production even though the corresponding daily Bear Lake storage release is less.

Method of Computing and Segregating Flows for the 1947 Water Year.- During the Storage Delivery Period the Bear Lake storage release (~~113,013~~ 133,013 ac.-ft.) is computed by deducting from the flow in the Outlet Canal the total flows in the Rainbow and Dingle inlet canals for the period July 8 to September 30.

The apparent Bear Lake storage passing the Bear River near Collinston gaging station is represented by the double cross-hatched area during the storage delivery period on Plate 4. It is to be noted the double cross-hatched area is defined by the Bear River near Collinston hydrograph for the period from July 11 (plotted 11-3) to Aug. 8 (plotted 8-3); the Bear Lake storage release hydrograph Aug. 6 to Aug. 17; the Bear River near Collinston hydrograph Aug. 21 (plotted 21-3) to Sept. 17 (plotted 17-3); and the Bear Lake storage release hydrograph Sept. 15 to Sept. 30. These discharges, which is water used for power production are summarized as follows:

plotted on B.L. time

Bear River near Collinston July 1 to Aug. 8	16,221 ac.-ft.
Bear Lake storage release Aug. 6 to Aug. 17	18,363 "
Bear River near Collinston Aug. 21 to Sept. 17	34,034 "
Bear Lake storage release Sept. 15 to Sept. 30	12,038 "
Total	80,656 "

The apparent Bear Lake storage diverted for irrigation is represented by the single hatched area on Plate 4. This is the balance of the area under the Bear Lake storage release hydrograph not apparently passing the Collinston gaging station. By deducting the apparent storage passing Collinston (80,656 ac.-ft.) from the total Bear Lake storage release (133,013 ac.-ft.) the apparent storage used for irrigation (52,357 ac.-ft.) is obtained.

The diversion loss at Cutler Dam has been previously defined. In years when no Bear Lake storage is used for power production in the irrigation season, this diversion loss is equal to the actual flow passing the Collinston gaging station during the storage delivery period. No storage was used for power production during the irrigation season in water years 1931-38, 1940-42 ~~and 1944~~. In all other years since 1923, more or less storage was used in power production in this period. For such years the diversion loss past Cutler Dam is computed by multiplying the total days of storage draft by 45, which is the approximate minimum daily flow at the Collinston gaging station in acre-feet when no power is being produced. In 1947 the storage delivery period was 85 days, making a total of 3,825 acre-feet for the storage period. To determine the computed Bear Lake storage used in power production (76,800 ac.-ft.) this loss (3,825 ac.-ft.) must be deducted from the apparent storage for power passing Collinston (80,656 ac.-ft.).

On Plate 1 showing net monthly gains and losses in Bear Lake exclusive of Bear River water, it is to be noted considerable net losses occur in

Bear Lake during the storage delivery period. If Bear Lake were used entirely for irrigation purposes, these losses would be included in the total requirement for irrigation storage dependent on the lake. This net Bear Lake evaporation less tributary inflow loss is computed by totalling the monthly net losses as shown on Plate 1 for the portion of the year from the beginning of storage draft to Sept. 30. In 1947 this net loss amounted to 25,630 acre-feet.

The computed total annual storage requirement for irrigation dependent on Bear Lake storage (81,800 ac.-ft.) would be equal to the apparent Bear Lake storage used for irrigation (52,357 ac.-ft.) plus the Cutler Dam diversion loss (3,825 ac.-ft.) plus the net Bear Lake evaporation less tributary inflow loss (25,630 ac.-ft.).

SUMMARY

On Plate 5 are tabulated the resultant figures segregating Bear Lake storage waters for 1924 to 1948. These figures were derived using the method outlined in the preceding analysis. Because of the assumptions involved in the computations, these final figures can only be termed as being reasonably accurate approximations. Considering the magnitude of the study, and the factors involved, the derived data is sufficiently accurate to warrant its use in supplying information on the adequacy of Bear Lake storable supplies.

The resultant data tabulated on Plate 5 can best be illustrated graphically. This is done on Plates 6 to 12. From a study of these graphs for the water years 1924 to 1948, the following are apparent in answer to the questions on page 6:

Plate No. 6.- The maximum storable supply during the storage period from Bear Lake source has varied from a net loss of 6,700 acre-feet to a maximum supply of 128,400 acre-feet, the 25 year average being 63,000 acre-feet.

Plate No. 7.- The maximum storable supply during the storage period from Bear River source has varied between 37,700 acre-feet and 327,400 acre-feet.

the 25 year average being 191,600 acre-feet.

Plate No. 8.- The combined maximum storable supply during the storage period from Bear River and Bear Lake sources has varied from 31,000 acre-feet to 441,400 acre-feet, the 25 year average being 254,600 acre-feet.

Plate No. 9.- There has been considerable variation in storage water requirement of canals dependent on Bear Lake. The storage requirement in 1934 was over five times as great as the storage requirement in 1945, which reflects the large effect of natural inflow below Bear Lake. The arithmetic average of the 25 year period is 159,800 acre-feet. However, if the extreme drought years 1931, 1934 and 1940 were eliminated, the average would be 136,900 acre-feet.

Plate No. 10.- If all Bear Lake storable water was dedicated to filling only irrigation requirements, there would have been eight years in the 25 year period when the annual supply was less than the annual requirement. These deficiencies range from 30,000 acre-feet in 1926 to 325,000 acre-feet in 1934.

Plate No. 11.- This graph illustrates the accumulative effect of the annual ximum Bear Lake storable supplies as compared to annual irrigation storage re- rement. It is the period summation of Plate 10. In the 25 year period there a total of 2,370,700 acre-feet in excess of irrigation requirements indica- g an annual average excess of 94,800 acre-feet. In the five year period Oct. 0 to Sept. 30, 1935 there was an accumulative deficiency of 534,300 acre-feet ther deficiency period of lesser magnitude and of four years duration exten- from Oct. 1, 1938 to Sept. 30, 1942. The two deficiency periods, which have urred twice in the twenty-five year period, indicate that when the Bear Lake tents drop below about 600,000 acre-feet all storage and storable waters shou eserved for irrigation and none used in power production.

While the graph indicates that over the 25 year period there could have an accumulative storable total of 2,370,700 acre-feet in Bear Lake in s of irrigation requirements, under present use rights this is water decreed for power purposes. Through change in use this water, or a portion of it, could be utilized in providing upstream storage. However, in conjunction with such upstream storage, there would have to be considerable allowance for hold-over storage to take care of the series of drought years which have occurred twice in the period illustrated.

Plate No. 12.- This plate illustrates the Bear Lake storage and storable waters that have been actually used in power production, that is, passed through the Cutler Power Plant and wasted into Great Salt Lake. It is to be noted that during the drought years while the lake was low, very little water was used in power production.

Prior to the drought years, considerable water was used for power purposes and the lake was depleted to a point lower than advisable. In the recent good water years the lake has been built back up to a high level. It can be expected that considerable water will again be used for power purposes, but the lake should not be depleted below a safe carry-over level to insure adequate water for lands now dependent on the lake should another series of drought years occur.

MUD LAKE

Mud Lake, or North Lake as it is sometimes called, is a group of shallow lakes situated at the north end of Bear Lake. The lake is confined on the south by a natural causeway which separates it from Bear Lake and on the north by an earth fill dike. The lakes are connected by winding slough channels and dredged channels. The Outlet Canal was dredged through the west side of the group of lakes.

The Utah Power & Light Company furnished a table showing storage change in acre-feet as follows:

Change in Elevation (Project datum)	Storage change (acre-feet)
5923.00 to 5923.65	6,955
5922.00 to 5923.00	9,000
5921.00 to 5922.00	7,500
5920.00 to 5921.00	6,000
5919.00 to 5920.00	1,984

The Power Company does not consider the lake as containing any usable storage below elevation 5919.00 feet. Apparently this is the approximate elevation of the bottom of the channels connecting the lakes.

This data was plotted on cross-section paper (See Plate 13)and there appeared to be a discrepancy in the resultant area curve between elevation 5919 and 5920. It is known that at elevation 5919 there is still considerable water area and that the flat saucer beds of most of the lakes are lower than the connecting channels. A more probable area curve is shown by the dashed line extension below elevation 5920.5 feet. This extension has been used as a basis in determining a corrected rating table, which has been dated 6-26-50.

The rating table dated 6-26-50 (Plate 14), has been used in computing the tabulation of Mud Lake contents on the first of each month (See Plate 15), and the tabulation of Mud Lake change in contents during periods corresponding to the Bear Lake storage and storage draft periods (See Plate 16).

If the Mud Lake figures of contents had been available when the Bear Lake data was computed, they would have been added to the contents of Bear Lake on the first of each month in computing the monthly net Bear Lake evaporation and tributary inflow as shown on Plate 1. This table was computed by algebraically subtracting the net monthly Bear River diversion to Bear Lake storage from the monthly change in Bear Lake contents.

Net Bear Lake Evaporation and tributary inflow = Change in contents in Bear Lake - Net Bear River diversion to Bear Lake storage.

Including Mud Lake contents in this equation it becomes:

Net Bear Lake Evaporation and tributary inflow = Change in contents in Bear Lake + Change in contents of Mud Lake - Net Bear River diversion to Bear Lake storage.

In the table of segregation of Bear Lake storage and storable waters on Plate 5, columns 16, 17, 19, 27, 29, 30, 31 and 32, would need be adjusted because of the omission of Mud Lake in the first computations. In the application of this correction the following rules would apply:

Rule 1. During the storage period when water is stored in Mud Lake, add the increase in Mud Lake storage to the figures in columns 16, 17, and 19; and when there is a decrease in Mud Lake storage, subtract the decrease from the figures in the same columns.

Rule 2. During the storage draft period when water is stored in Mud Lake, subtract the increase in Mud Lake storage from the figures in columns 27, 29, and 32; and when there is a decrease in Mud Lake storage, add the decrease to the figures in the same columns.

Columns 30 and 31 would need be recomputed, using the adjusted figures.

These adjustments have been combined with adjustments for the temporary pondage reservoirs and final adjusted figures are shown on Plate 22.

TEMPORARY PONDAGE RESERVOIRS

It was assumed in the segregation of Bear Lake storage the temporary pondage reservoirs below Bear Lake were compensating insofar as their combined effect on the total seasonal segregation was concerned. As the effect of changes in Soda and Oneida Reservoirs appeared minor, it was assumed safe to conclude that the effect of Cutler Reservoir would also be minor and no material error would result if the temporary pondage reservoirs were omitted from the segregation computations. Records for Cutler Reservoir, which were not available when the segregation analysis was made, have now been made available and this study is to determine the possible effect, if any, of the pondage reservoirs on the storage segregation method as previously outlined.

Temporary pondage in the three reservoirs with attendent variable amounts of water in transit between reservoirs, cause large and erratic variations in natural inflow determinations when daily downstream segregation of storage and natural flows are attempted. The variations are so large and erratic that even weekly averages are unreasonable and probably erroneous. This was the principle cause of ruling out this method in the early segregation analysis.

It is possible at this time, to determine the resultant effect of the temporary pondage reservoirs on the segregation method adopted and apply any correction found necessary to the figures already determined. The method of determining this can best be understood by inspecting the hydrographs on Plate 4. As previously explained in the method of segregation used, only the Bear Lake storage release and the flows past the Bear River near Collinston gaging station were used in the segregation of storage apparently used for power and for irrigation. In the method used, a time interval of three days for movement of water from Bear Lake to Cutler Dam was allowed. The pondage reservoirs would be included with their respective time intervals as follows:

1st day	Bear Lake storage release
2nd day	Soda Reservoir change
3rd day	Oneida Reservoir change
4th day	Cutler Reservoir change
4th day	Bear River near Collinston

It is to be noted from the hydrographs for the periods July 8 to August 5 and August 18 to September 14 (Bear Lake dates), the determination of the storage which was charged to power were based on the Collinston hydrographs; and for the periods August 6 to August 17 and September 15 to September 30, the storage which was charged to power were based on the Bear Lake storage release hydrograph.

If water were stored in the temporary pondage reservoirs while the Collinston hydrograph was the criteria, it would have the effect of decreasing the flow past Collinston. The storage chargeable to power should therefore be increased to the extent of the increase in the pondage reservoirs. As the storage charged to irrigation was determined by subtracting storage to power from the Bear Lake storage release, the increase in the pondage reservoirs must also be deducted from the already computed storage for irrigation figures. However, the total net to power purposes could not exceed the Bear Lake storage release and the net to irrigation could not be less than zero.

If during the same periods, while the Collinston hydrograph was the criteria, water had been released from the temporary pondage reservoirs, the recorded flow past Collinston would have included this release. This additional water would not be Bear Lake storage and should therefore be deducted from the amount charged to power use. The charge to irrigation as determined should be increased a like amount. This change could be to the limit that the total net to power purposes could not be less than zero and the total net to irrigation could not exceed the Bear Lake storage release.

If water was stored in or released from the temporary pondage reservoirs while the Bear Lake storage release hydrograph was the criteria, it would have no effect on the segregation as already determined. Any water stored would come from intermediate natural inflow. Any water released would be a part of the flow passing Collinston as natural flow is sufficient to satisfy all irrigation requirements.

By considering period flows the variable element of water in transit is practically eliminated and the combined change in the three reservoirs can be used instead of their individual effect. The foregoing can be combined into two general rules for correcting the segregation as already determined.

Rule 1. When the flow at the Collinston gaging station is less than the Bear Lake storage release, any water stored in the temporary pondage reservoirs should be charged to power purposes and a like amount deducted from water charged to irrigation, to the limit that the total amount for power purposes cannot exceed the Bear Lake storage release, and the total charged to irrigation cannot be less than zero.

Rule 2. When the flow past the Collinston gaging station is less than the storage release, any water released from the temporary pondage reservoirs should be deducted from the water charged to power purposes and a like amount charged to water for irrigation purposes to the limit that the net for power purposes cannot be less than zero and the total to irrigation cannot exceed the Bear Lake storage release.

The actual application of these two rules involves going through the original computation notes, picking out the Bear Lake dates of beginning and ending of periods when the Collinston hydrograph was the criteria, computing the pondage change for these periods and applying the above rules. These corrections are summarized in the table on Plate 17.

On Plates 18 to 20 are shown the contents on October 1 and the date that storage draft started, and change in contents during the Bear Lake storage and storage draft periods for Soda, Oneida and Cutler Reservoirs. On Plate 21 these three reservoirs have been combined. It is interesting to note that in most years water is released from the temporary pondage reservoirs during the Bear Lake storage period and stored in them during the Bear Lake storage draft period.

Adjustments due to the temporary pondage reservoirs would apply to columns 28, 29, 30, and 31 on Plate 5. On Plate 22 these adjustments have been included with the Mud Lake adjustments to show corrected figures in the segregation as given on Plate 5.

MUD LAKE AND TEMPORARY PONDAGE RESERVOIR ADJUSTMENTS

On Plate 22 are shown the columns on Plate 5, to which the adjustments due to Mud Lake and the temporary pondage reservoirs have been applied. It was pointed out that due to various assumptions the segregation figures shown on Plate 5 could only be classed as reasonably accurate approximations. In the discussions on Mud Lake and Temporary Pondage Reservoirs, the most probable causes of error due to the assumptions have been investigated.

A study of the differences in the columns on Plate 22 and Plate 5 indicate that for the most part the resultant effects of the assumptions made were for the most part compensating. No material error would result if the tabulations given on Plate 5 were used without the adjustments. As the Plates 6 to 12 were already prepared before the adjustment study was made, it is not deemed of sufficient value to revise those plates for the small differences involved.

9-230

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File No. { Washington ______ District ______

Water Year	Bear Lake Change	Rainbow Inlet	Dingle Inlet	Outlet	Net Diverted	Trib. Loss or Gain	Loss or Gain from RBP. 10
1924	-235.0	224.0	6.2	491.0	-260.8	+25.8	+22.7
25	-123.5	181.0	3.3	365.0	-180.7	+57.2	+60.1
26	-335.1	73.4	3.7	364.0	-286.9	-48.2	-46.4
27	-112.9	161.0	3.5	310.0	-145.5	+32.6	+29.1
28	+100.6	265.0	3.6	177.0	+91.6	+9.0	+5.6
29	+130.5	220.0	2.9	178.0	+44.9	+85.6	+90.0
30	-63.9	115.0	1.9	176.0	-59.1	-4.8	-4.5
31	-306.6	43.0	0.6	263.0	-219.4	-87.2	-87.8
32	+168.8	199.0	0.9	81.1	+117.0	+51.8	+50.2
33	-39.0	130.0	0.1	144.0	-13.9	-25.1	-26.7
34	-335.8	36.8	0	237.0	201.2	-134.6	-132.8
35	-113.5	70.5	0.8	150.5	-79.2	-34.3	-33.6
36	+308.2	322.9	6.8	95.3	+234.4	+73.8	+73.9
37	+179.5	240.2	2.0	114.0	+128.2	+51.3	+51.4
38	+241.7	290.3	2.6	86.8	+206.1	+35.6	+35.7
39	-94.8			231.5			
40	-273.7						
41	-66.4						
42	-6.3						
43	+184.1						
44	+71.6						
45	+113.8						

GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

Net Bear Lake Evaporation and Tributary inflow other than inflow from Bear River.

Monthly and annual ~~discharge, in~~ ______ ~~of~~ ______ ~~River at~~ ______

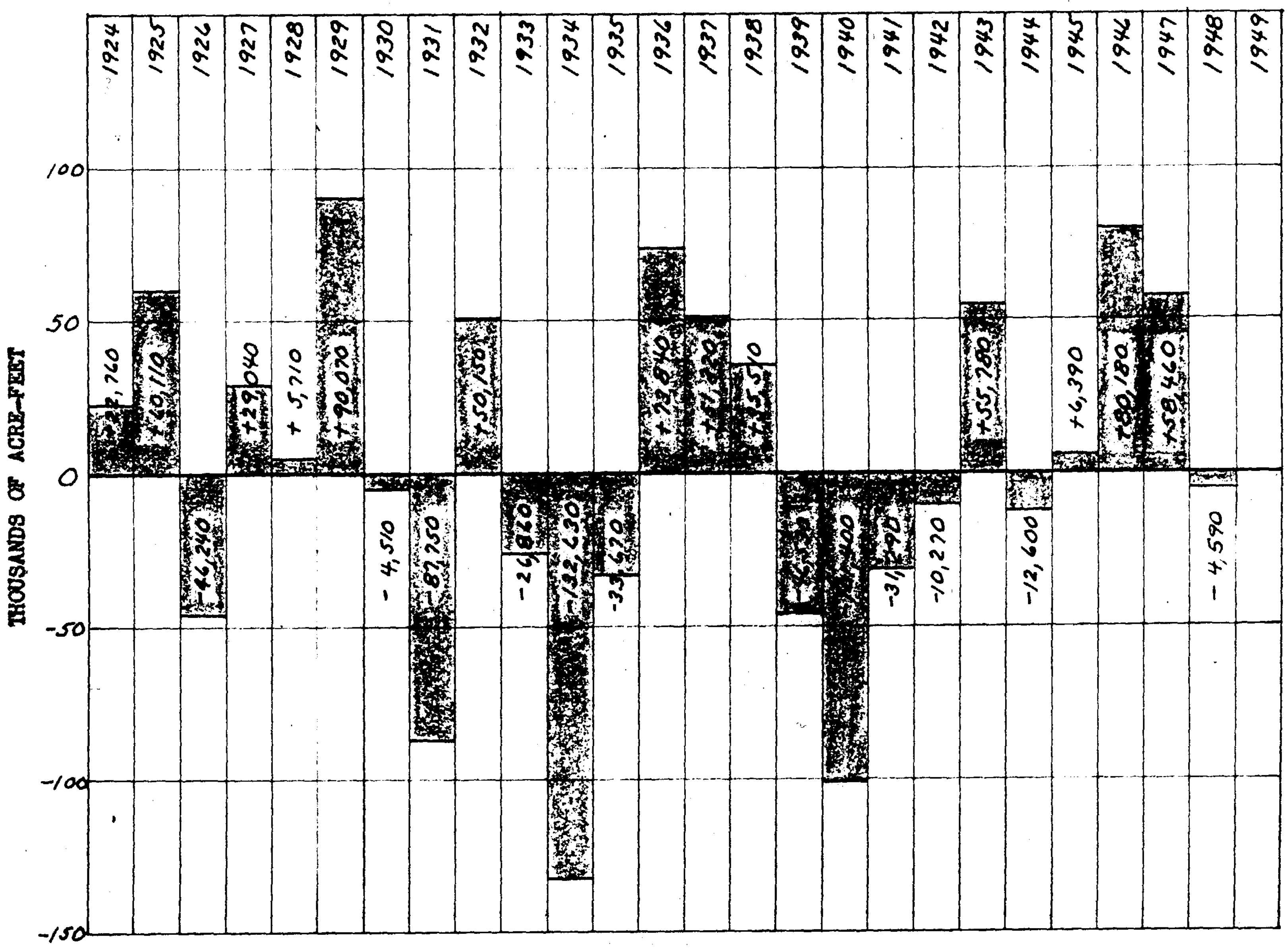
[Drainage area, ______ square miles]

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	ANNUAL
1924	←→	+13,200	→	+5,700	+14,200	+21,100	+14,400	+7,300	-3,400	-8,900	-17,600	-23,300	+22,700
1925	+1,400	-21,900	+12,500	+12,800	+13,500	+27,400	+18,900	+25,400	+7,700	-8,700	-20,600	-8,300	+60,100
1926	-26,000	-9,700	-5,900	+5,700	+14,400	+28,900	+16,700	+8,000	-17,800	-18,700	-15,400	-26,600	-46,400
1927	-14,500	-9,900	-18,400	+17,300	+18,800	+34,400	+18,000	+20,600	+14,100	-21,900	-30,200	+800	+29,100
1928	-8,900	+900	-0	-2,000	+5,400	+34,700	+13,500	+18,700	+21,300	-19,100	-25,900	-33,000	+5,600
1929	+10,400	-6,400	+7,700	+11,400	+13,700	+26,800	+35,200	+17,200	+11,500	-16,300	-14,700	-6,500	+90,000
1930	-17,400	-17,800	-400	+6,900	+13,500	+22,100	+21,200	+14,600	-8,200	-21,300	+500	-18,200	-4,500
1931	-6,200	-15,200	-5,500	+7,400	+7,400	+15,100	+12,500	+2,100	-19,900	-35,000	-26,000	-24,500	-87,800
1932	-9,100	-13,200	+5,800	+12,100	+13,100	+18,500	+38,500	+9,900	+18,200	-1,100	-18,100	-24,400	+50,200
1933	-14,500	-7,300	-5,500	+7,800	+11,700	+6,600	+27,300	+23,100	+6,600	-22,500	-34,400	-25,600	-26,700
1934	-12,700	-14,000	+3,700	+3,400	+7,900	+6,800	-3,000	-8,000	-26,100	-24,400	-28,200	-38,200	-132,800
1935	-13,400	+1,700	+500	-1,500	+14,500	+12,700	+25,000	+2,500	+8,900	-23,400	-27,800	-33,300	-33,600
1936	-17,600	-7,400	-900	+14,600	+22,200	+14,100	+33,900	+30,100	+27,200	-11,400	-8,500	-22,400	+73,900
1937	-2,800	+4,700	+2,300	+4,200	+11,300	+17,500	+27,800	+32,000	+10,100	+1,400	-32,800	-24,300	+51,400
1938	-8,200	-2,000	+3,800	-200	+5,100	+23,900	+25,400	+27,400	+7,700	-9,300	-23,500	-14,400	+35,700
1939	-17,000	-11,900	-600	+7,700	+7,600	+21,400	+13,700	+11,600	-15,000	-21,700	-26,000	-16,300	-46,500
1940	-16,500	-13,000	-2,300	+3,200	+7,400	+14,100	+2,600	-7,900	-22,000	-26,900	-34,000	-6,100	-101,400
1941	-5,100	-10,400	+300	+2,400	+3,200	+15,500	+9,300	+8,400	-18,500	+6,400	-17,900	-24,900	-31,300
1942	-3,400	-6,700	-300	+1,700	+13,100	+19,000	+18,900	+15,100	-3,700	-29,400	-19,100	-15,500	-10,300
1943	-9,900	-7,800	-4,500	+1,800	+10,600	+36,500	+35,600	+23,200	+23,600	-11,200	-20,600	-21,500	+55,800
1944	-12,800	-6,500	-3,800	+4,400	+11,900	+19,800	+32,600	+15,200	+12,600	-26,700	-36,100	-23,200	-12,600
1945	-14,100	-2,200	-4,300	+2,100	+7,900	+10,700	+15,400	+20,400	+18,400	-7,000	-20,900	-20,000	+6,400
1946	-8,600	+11,100	+4,800	+9,200	+7,800	+26,800	+40,400	+35,300	+4,600	-18,400	-9,600	-23,200	+80,200
1947	-9,300	-2,900	+14,100	-400	+18,900	+20,000	+4,500	+24,000	+16,100	-5,200	-8,400	-13,000	+58,400
1948	-17,800	-9,600	-1,600	+7,900	+11,200	+11,600	+12,300	+19,900	+18,600	-10,700	-25,900	-20,500	-4,600

1 Compilation in error - Old Content B.L. was used - See WSP 1314 1950 Compilation

PLATE 1

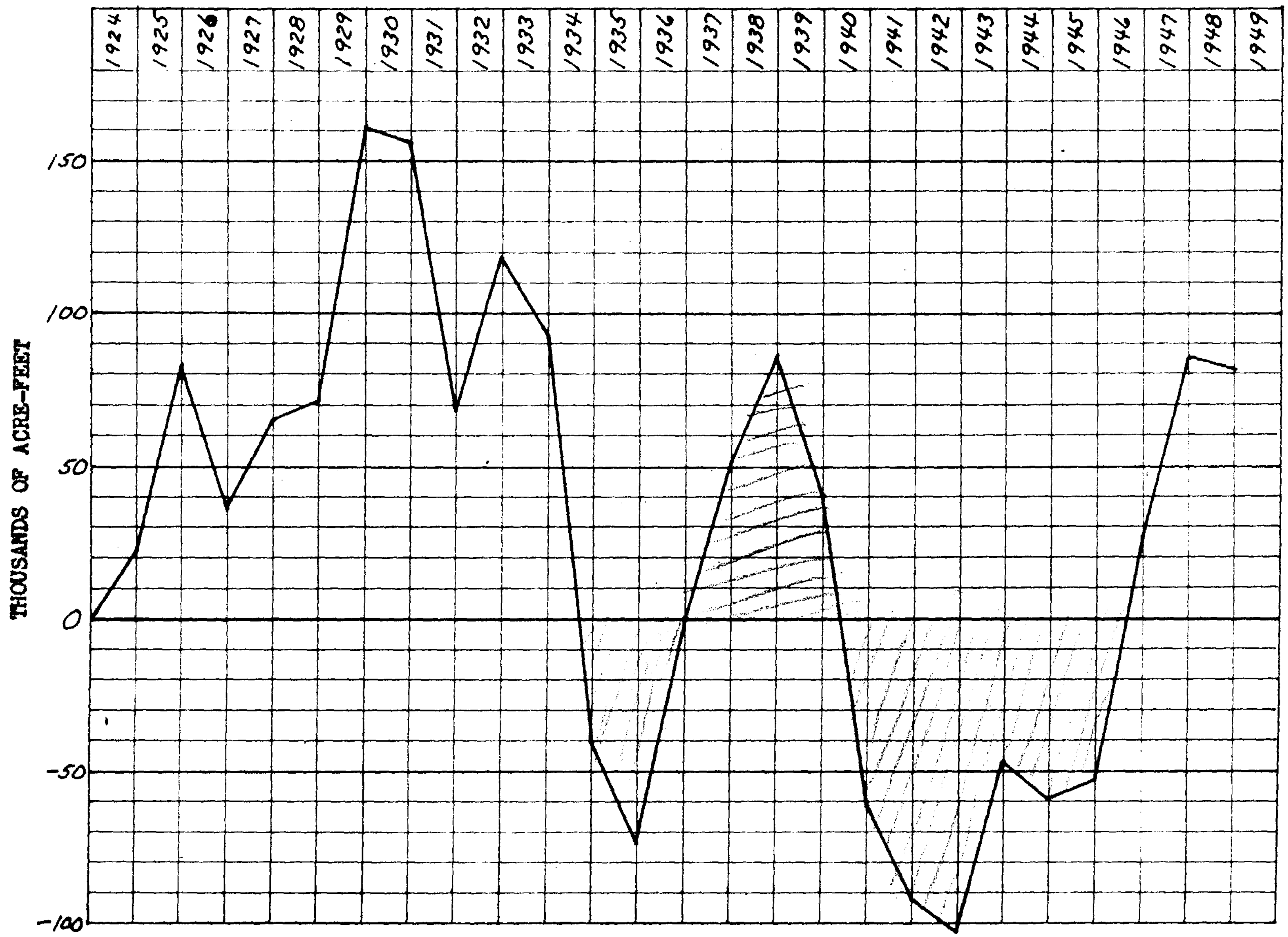
25) +81,000
3,200



ANNUAL NET BEAR LAKE TRIBUTARY INFLOW

Net annual contribution or loss to Bear Lake due to tributary inflow and evaporation exclusive of diversions to and from Bear River.

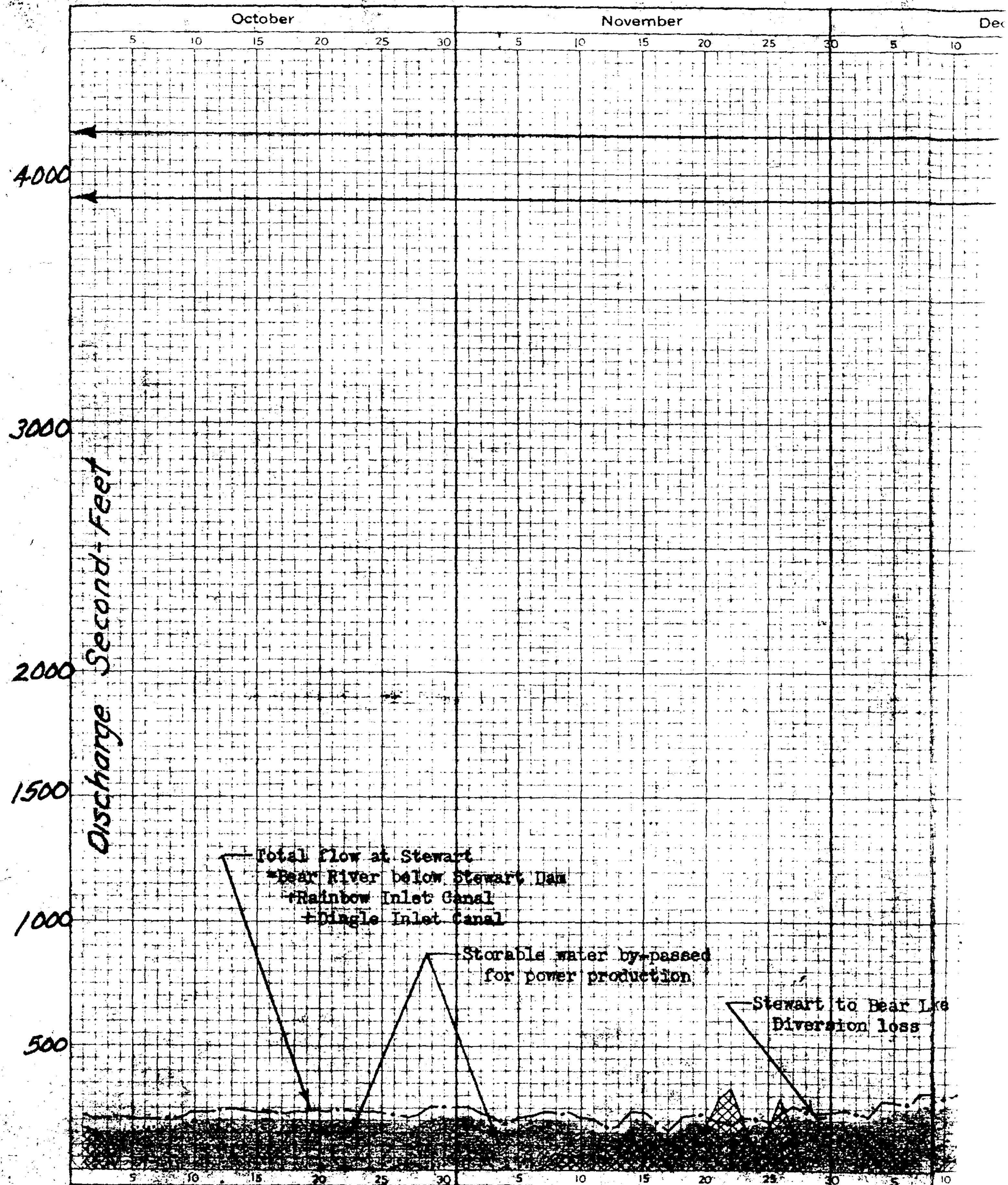
PLATE 2.



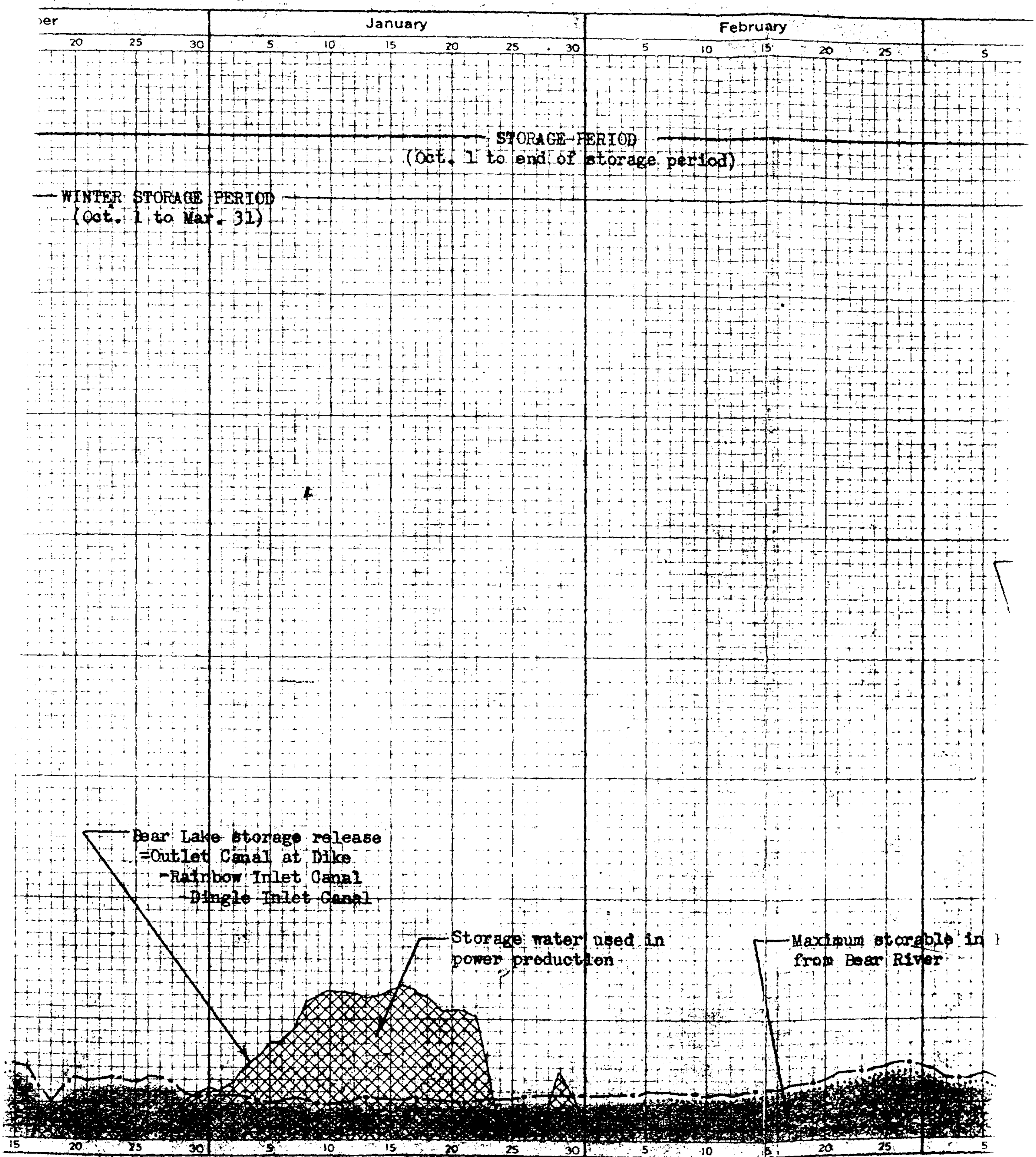
ACCUMULATIVE NET BEAR LAKE TRIBUTARY INFLOW

Annual accumulation of tributary inflow less evaporation loss in Bear Lake, exclusive of diversions to and from Bear River, beginning with zero on October 1, 1923.

PLATE 3.



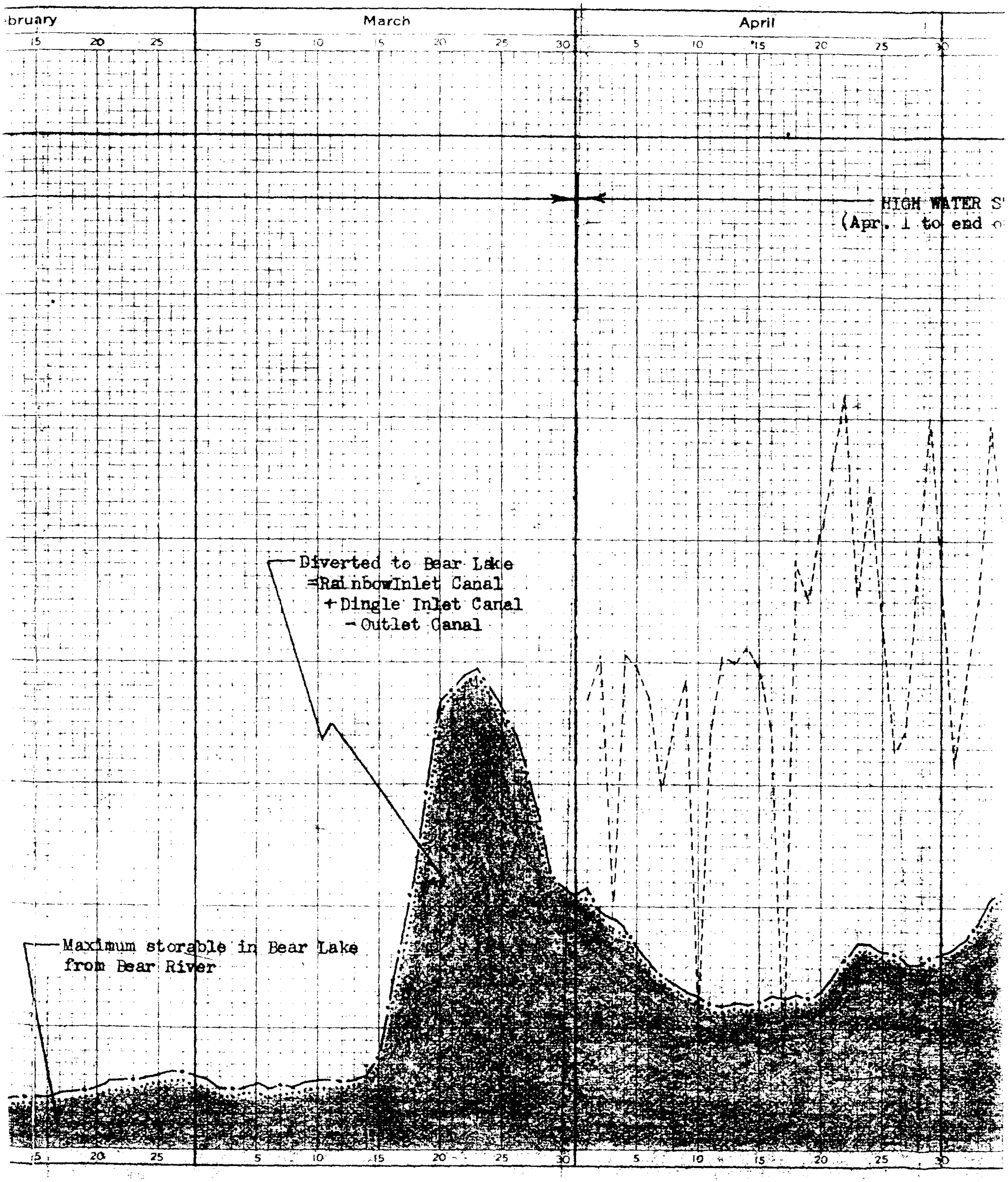
Plotted by.................Checked by.................Date.................

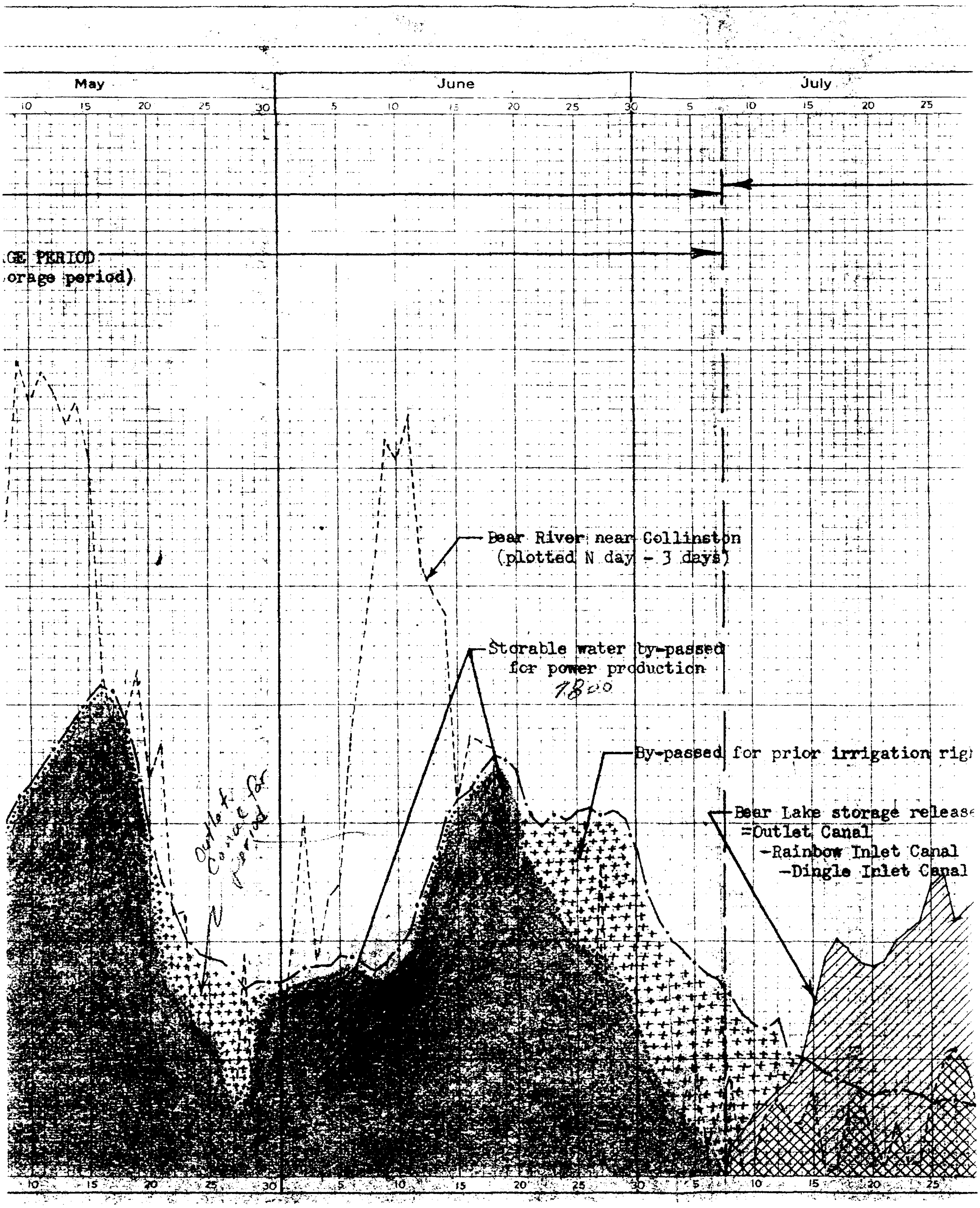


ber
January
February
20 25 30 5 10 15 20 25 30 5 10 15 20 25 5
STORAGE PERIOD
(Oct. 1 to end of storage period)
WINTER STORAGE PERIOD
(Oct. 1 to Mar. 31)
Bear Lake storage release
=Outlet Canal at Dike
-Rainbow Inlet Canal
-Dingle Inlet Canal
Storage water used in
power production
Maximum storable in
from Bear River
15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 5

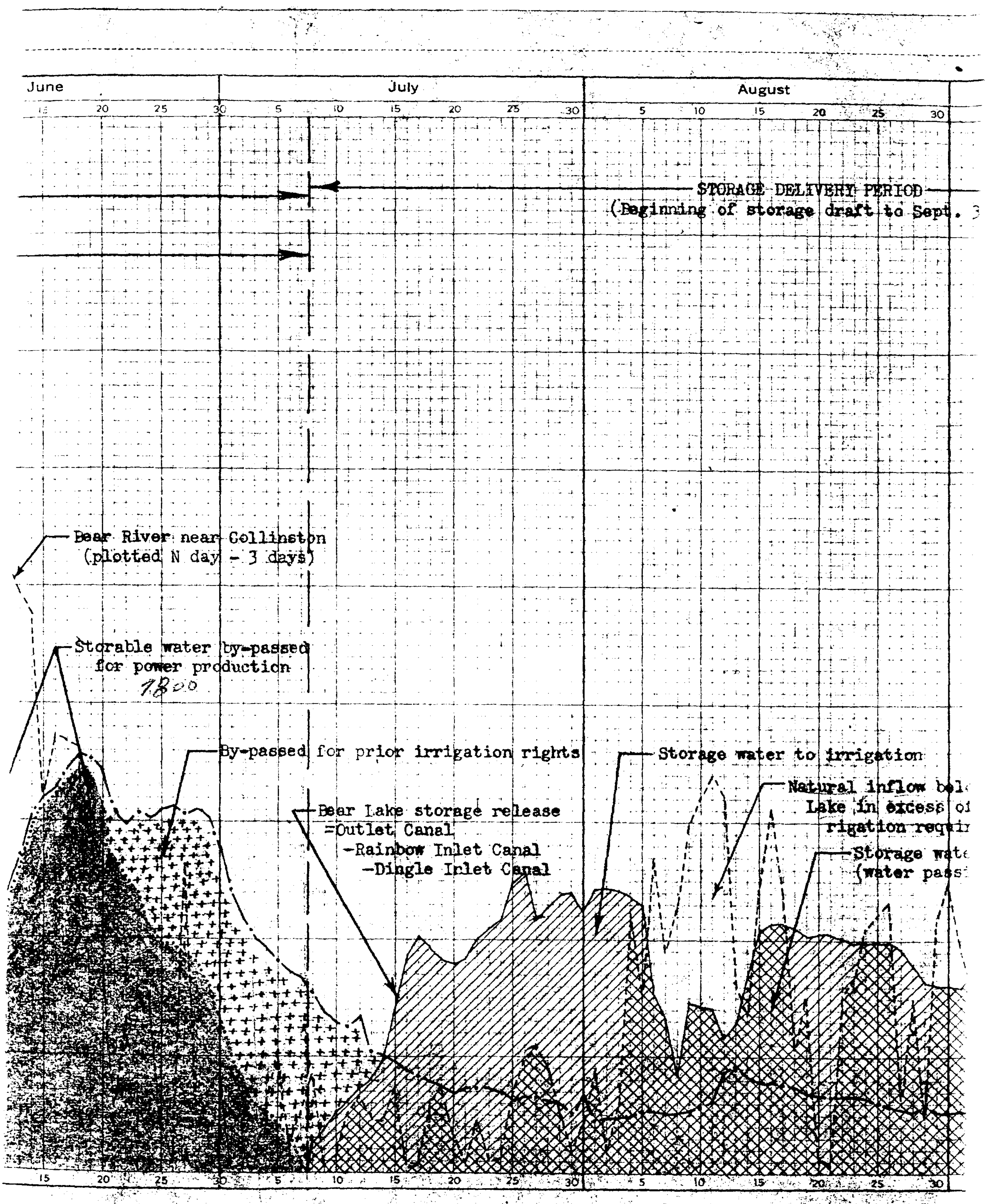
[redacted]

ORAGE OPERATION 1946-47 Water Year





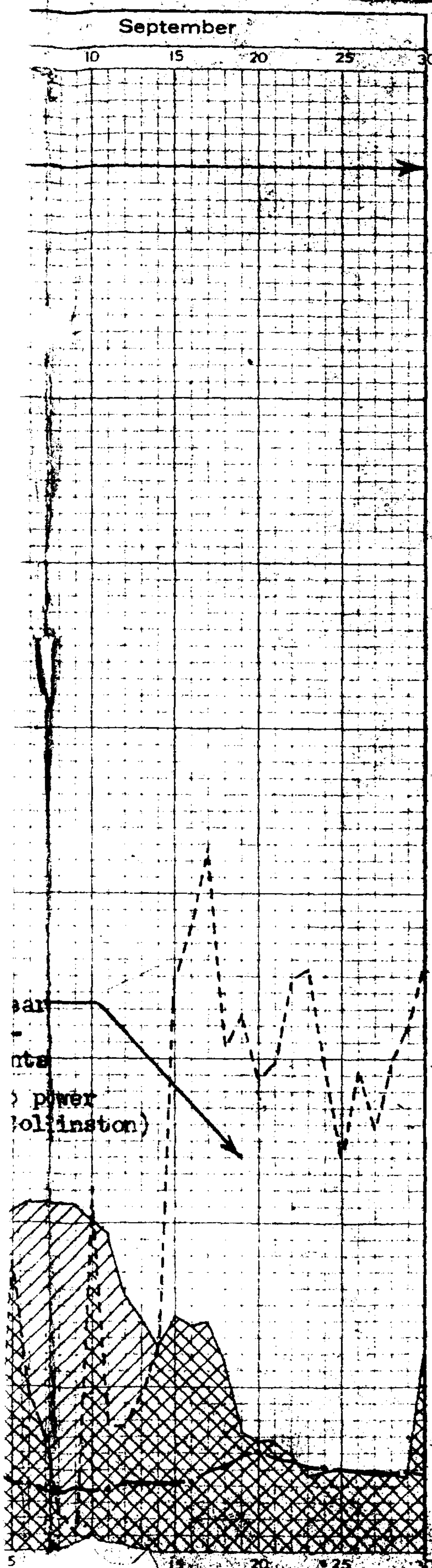
May
June
July
GE PERIOD
orage period)
Bear River near Collinston
(plotted N day - 3 days)
Storable water by-passed
for power production
7800
By-passed for prior irrigation rig
Bear Lake storage release
=Outlet Canal
-Rainbow Inlet Canal
-Dingle Inlet Canal
Outlet Canal for period



June
July
August
STORAGE DELIVERY PERIOD
(Beginning of storage draft to Sept. 3
Bear River near Collinston
(plotted N day - 3 days)
Storable water by-passed
for power production
1800
By-passed for prior irrigation rights
Storage water to irrigation
Natural inflow bel
Lake in excess of
rigation requi
Bear Lake storage release
=Outlet Canal
-Rainbow Inlet Canal
-Dingle Inlet Canal
Storage wat
(water pass

File No. Washington
Field

PLATE 4



WATER YEAR	Date beginning of Storage Period	Date end of Storage Period	BEAR RIVER WATER							
			Oct. 1 to Mar. 31					Apr. 1 to End o		
			Total Flow at Stewart	Stewart to Bear Lake Diversion Loss	Maximum Storable from Bear River	Diverted to Bear Lake	By-passing Bear Lake	Total Flow at Stewart	Diverted to Bear Lake	By-passing Bear Lake
	1	2	3	4	5	6	7	8	9	10
1924	10/1	5/25	143,900	7,200	136,700	0	143,900	192,700	149,800	42,900
1925	10/1	6/12	82,500	7,200	75,300	0	82,500	113,900	59,900	54,000
1926	10/1	4/30	100,900	7,200	93,700	0	100,900	41,100	16,700	24,400
1927	10/1	7/4	56,500	7,200	49,300	0	56,500	173,300	129,900	43,400
1928	10/1	6/26	119,200	7,200	112,000	67,800	51,400	202,100	171,200	30,900
1929	10/1	7/5	70,400	7,200	63,200	0	70,400	213,900	177,900	36,000
1930	10/1	5/21	111,000	7,200	103,800	26,500	84,500	70,400	51,600	18,800
1931	10/1	5/6	77,400	7,200	70,200	0	77,400	12,500	8,500	4,000
1932	10/1	7/22	29,400	7,200	22,200	14,800	14,600	188,700	165,900	22,800
1933	10/1	6/27	60,700	7,200	53,500	52,900	7,800	80,000	68,100	11,900
1934	10/1	4/19	43,900	7,200	36,700	28,500	15,400	1,400	1,000	400
1935	10/1	6/23	18,800	7,200	11,600	10,200	8,600	40,700	30,500	10,200
1936	10/1	6/21	36,000	7,200	28,800	28,600	7,400	258,300	252,400	5,900
1937	10/1	6/16	67,300	7,200	60,100	35,000	32,300	177,800	170,800	7,000
1938	10/1	7/12	72,900	7,200	65,700	58,500	14,400	212,700	194,000	18,700
1939	10/1	5/15	105,800	7,200	98,600	41,700	64,100	69,000	64,300	4,700
1940	10/1	5/6	47,200	7,200	40,000	31,500	15,700	3,600	2,800	800
1941	10/1	6/22	45,100	7,200	37,900	22,000	23,100	37,700	26,100	11,600
1942	10/1	6/6	69,200	7,200	62,000	33,500	35,700	109,900	106,200	3,700
1943	10/1	6/25	66,600	7,200	59,400	27,100	39,500	200,200	182,200	18,000
1944	10/1	7/8	61,100	7,200	53,900	28,800	32,300	186,300	163,000	23,300
1945	10/1	7/5	58,600	7,200	51,400	48,100	10,500	104,700	98,100	6,600
1946	10/1	6/11	110,600	7,200	103,400	99,000	11,600	213,400	206,600	6,800
1947	10/1	7/7	120,400	7,200	113,200	39,800	80,600	217,600	180,000	37,600
1948	10/1	6/13	87,200	7,200	80,000	0	87,200	203,700	183,400	20,300
1949	10/1									

2. Last day following the high water period that sum of discharges in Rainbow and Dingle inlet canals were greater than discharge in Outlet Canal.

3. Bear River below Stewart Dam plus Rainbow Inlet Canal plus Dingle Inlet Canal for the period Oct. 1 to Mar. 31.

4. Diversion loss of 40 acre-feet daily which could be expected to occur in diverting all Bear River water to Bear Lake.

5. Column 3 minus Column 4.

6. Rainbow Inlet Canal plus Dingle Inlet Canal minus Outlet Canal for period Oct. 1 to Mar. 31 but not less than zero.

7. Column 3 minus Column 6.

8.

9.

10.

11.

Critical lake depletion

BEAR

STORAGE PERIOD

BEAR RIVER WATER											BEAR	
Oct. 1 to Mar. 31					Apr. 1 to End of Storage Period						Oct. 1 to End	
Total Flow at Stewart	Stewart to Bear Lake Diversion Loss	Maximum Storable from Bear River	Diverted to Bear Lake	By-passing Bear Lake	Total Flow at Stewart	Diverted to Bear Lake	By-passing Bear Lake	By-passed apparently for power production	Diversion loss and by-passed for prior irrigation rights	Maximum Storable from Bear River	Contents of Bear Lake on Oct. 1	Contents of Bear Lake
3	4	5	6	7	8	9	10	11	12	13	14	15
143,900	7,200	136,700	0	143,900	192,700	149,800	42,900	40,900	2,000	190,700	1,286,000	1,363
82,500	7,200	75,300	0	82,500	113,900	59,900	54,000	51,100	2,900	111,000	1,048,000	1,086
100,900	7,200	93,700	0	100,900	41,100	16,700	24,400	23,200	1,200	39,900	927,500	902
56,500	7,200	49,300	0	56,500	173,300	129,900	43,400	30,400	13,000	160,300	594,400	640
119,200	7,200	112,000	67,800	51,400	202,100	171,200	30,900	21,100	9,800	192,300	478,200	800
70,400	7,200	63,200	0	70,400	213,900	177,900	36,000	30,200	5,800	208,100	576,200	823
111,000	7,200	103,800	26,500	84,500	70,400	51,600	18,800	12,800	6,000	64,400	710,600	831
77,400	7,200	70,200	0	77,400	12,500	8,500	4,000	0	4,000	8,500	646,700	670
29,400	7,200	22,200	14,800	14,600	188,700	165,900	22,800	0	22,800	165,900	339,500	612
60,700	7,200	53,500	52,900	7,800	80,000	68,100	11,900	0	11,900	68,100	508,300	685
43,900	7,200	36,700	28,500	15,400	1,400	1,000	400	0	400	1,000	466,700	495
18,800	7,200	11,600	10,200	8,600	40,700	30,500	10,200	0	10,200	30,500	133,500	220
36,000	7,200	28,800	28,600	7,400	258,300	252,400	5,900	0	5,900	252,400	20,600	415
67,300	7,200	60,100	35,000	32,300	177,800	170,800	7,000	0	7,000	170,800	328,800	638
72,900	7,200	65,700	58,500	14,400	212,700	194,000	18,700	0	18,700	194,000	508,300	831
105,800	7,200	98,600	41,700	64,100	69,000	64,300	4,700	0	4,700	64,300	750,000	881
47,200	7,200	40,000	31,500	15,700	3,600	2,800	800	0	800	2,800	654,500	684
45,100	7,200	37,900	22,000	23,100	37,700	26,100	11,600	0	11,600	26,100	381,500	436
69,200	7,200	62,000	33,500	35,700	109,900	106,200	3,700	0	3,700	106,200	315,100	512
66,600	7,200	59,400	27,100	39,500	200,200	182,200	18,000	10,700	7,300	192,900	308,800	627
61,100	7,200	53,900	28,800	32,300	186,300	163,000	23,300	0	23,300	163,000	492,300	751
58,600	7,200	51,400	48,100	10,500	104,700	98,100	6,600	0	6,600	98,100	563,800	757
110,600	7,200	103,400	99,000	11,600	213,400	206,600	6,800	3,000	3,800	209,600	677,600	1,117
120,400	7,200	113,200	39,800	80,600	217,600	180,000	37,600	7,800	29,800	187,800	950,800	1,254
87,200	7,200	80,000	0	87,200	203,700	183,400	20,300	16,200	4,100	199,600	1,096,000	1,290

lowing the high water sum of discharges in Dingle inlet canals than discharge in .

elow Stewart Dam Inlet Canal plus Canal for the 1 to Mar. 31.

oss of 40 acre-feet could be expected to occur in diverting all Bear River water to Bear Lake.

5. Column 3 minus Column 4.

6. Rainbow Inlet Canal plus Dingle Inlet Canal minus Outlet Canal for period Oct. 1 to Mar. 31 but not less than zero.

7. Column 3 minus Column 6.

8. Bear River below Stewart Dam plus Rainbow Inlet Canal plus Dingle Inlet Canal for the period Apr. 1 to end of storage period.

9. Rainbow Inlet Canal plus Dingle Inlet Canal minus Outlet Canal.

10. Column 8 minus Column 9.

11. Portion of Column 10 which

12.

13.

14.

Release for Power ...

BEAR LAKE STORAGE

Critical lake depletion — *See plate 1* — *Both Bear River & Bear Lake Water*

STORAGE D...

...d	BEAR LAKE WATER — Oct. 1 to End of Storage Period				SUMMARY — Oct. 1 to End of Stor. Per.							
Maximum Storable from Bear River	Contents of Bear Lake on Oct. 1	Contents of Bear Lake at end of storage period	Net actually stored in Bear Lake	Maximum Storable from Bear Lake source	Maximum Storable from Bear River source	Total Maximum Storable	Storable water apparently used for power production	Date beginning of Storage Draft	Date end of Storage Draft	Bear Lake Storage Release	Apparent Bear Lake Storage passing Collinston	Apparent Bear Lake Storage ...
13	14	15	16	17	18	19	20	21	22	23	24	
190,700	1,286,000	1,363,000	77,000	74,500	327,400	401,900	324,900	5/26	9/30	261,800	127,328	134
111,000	1,048,000	1,086,000	38,000	93,100	186,300	279,400	241,400	6/13	9/30	127,062	95,344	31
39,900	927,500	902,300	-25,200	24,200	133,600	157,800	-183,000	5/1	9/30	237,483	126,954	110
160,300	594,400	640,100	45,700	77,500	209,600	287,100	241,400	7/5	9/30	110,971	56,845	54
192,300	478,200	800,900	322,700	80,800	304,300	385,100	62,400	6/27	9/30	146,970	62,704	84
208,100	576,200	823,000	246,800	124,900	271,300	396,200	149,400	7/6	9/30	77,298	16,233	61
64,400	710,600	831,700	121,100	38,000	168,200	206,200	85,100	5/22	9/30	137,448	55,709	81
8,500	646,700	670,300	23,600	16,000	78,700	94,700	-71,100	5/7	9/30	223,597	8,646	214
165,900	339,500	612,600	273,100	93,000	188,100	281,100	8,000	7/23	9/30	62,456	5,470	56
68,100	508,300	685,500	177,200	55,100	121,600	176,700	- 0	6/28	9/30	135,724	8,244	127
1,000	466,700	495,500	28,800	-6,700	37,700	31,000	-2,200	4/20	9/30	230,100	7,577	22?
30,500	133,500	220,400	86,900	48,800	42,100	90,900	-4,000	6/24	9/30	119,962	5,334	114
252,400	20,600	415,700	395,100	108,000	281,200	389,200	0	6/22	9/30	46,646	4,205	42
170,800	328,800	638,800	310,000	102,400	230,900	333,300	23,300	6/17	9/30	77,666	4,931	72
194,000	508,300	831,700	324,400	79,200	259,700	338,900	14,500	7/13	9/30	49,097	6,171	42
64,300	750,000	881,800	131,800	26,500	162,900	189,400	-57,600	5/16	9/30	154,997	14,145	140
2,800	654,500	684,200	29,700	-6,000	42,800	36,800	-7,100	5/7	9/30	205,843	8,901	196
26,100	381,500	436,600	55,100	10,000	64,000	74,000	-18,900	6/23	9/30	84,180	6,323	77
106,200	315,100	512,800	197,700	56,700	168,200	224,900	27,200	6/7	9/30	135,639	7,751	127
192,900	308,800	627,600	318,800	105,200	252,300	357,500	38,700	6/26	9/30	81,668	21,531	60
163,000	492,300	751,300	259,000	66,500	216,900	283,400	24,400	7/9	9/30	107,664	5,921	101
98,100	563,800	757,400	193,600	53,200	149,500	202,700	9,100	7/6	9/30	44,302	27,394	16
209,600	677,600	1,117,500	439,900	128,400	313,000	441,400	1,500	6/12	9/30	112,594	69,161	43
187,800	950,800	1,254,000	303,200	84,100	301,000	385,100	81,900	7/8	9/30	133,013	80,656	52
199,600	1,096,000	1,290,800	194,000	41,900	279,600	321,500	127,500	6/14	9/30	168,045	82,743	89
				63,000	*191,600*	*254,600*						*99*

...below Stewart Dam
...w Inlet Canal plus
...t Canal for the
... 1 to end of
...iod.

...et Canal plus
...t Canal minus
...l.

...nus Column 9.

... Column 10 which was apparently passed for power production.

12. Column 10 minus Column 11.

13. Column 9 plus Column 11.

14. Actual contents of Bear Lake in Acre-feet on Oct. 1 of each water year computed from mean daily elevation.

15. Actual contents of Bear Lake at end of storage period computed from mean daily elevation on day of beginning of storage draft.

16. Column 15 minus Column 14.

17. Net Bear Lake tributary inflow less evaporation during storage period.

18. Column 5 plus Column 13.

19. ...

20. ...

ng Critical period: 44,100 — irrig. season 1932
85,300 — Annual 1931-36
134,400

PLATE 5

diff. in Col 30 & 32 due to ... of Lake over 25 yr ...

ERY PERIOD | SUMMARY

Cutler Diversion Loss	Net Bear Lake Evaporation less Tributary Inflow	Computed Bear Lake Storage passing Collinston for Power production	Computed Total Annual Storage requirement for Irrigation	Excess or deficiency of annual maximum storable over total annual storage requirement for irrigation	Accumulative excess or deficiency beginning with zero on Oct. 1, 1924	Total Bear Lake storage and storable water used annually for power production	Col. 30 adj. for Mud L. & Temp Res.
26	27	28	29	30	31	32	
5,760	51,750	121,600	192,000	209,900	209,900	446,500	212,900
5,310	33,000	90,000	70,000	209,400	419,300	331,400	209,400
6,855	70,390	120,100	187,800	-30,000	389,300	303,100	-30,000
3,960	48,480	52,900	106,600	180,500	569,800	294,300	180,500
4,320	75,130	58,400	163,700	221,400	791,200	120,800	221,400
5,940	34,860	10,300	101,900	294,300	1,085,500	159,700	294,500
6,615	42,460	49,100	130,800	75,400	1,160,900	134,200	73,800
8,646	103,740	0	327,300	-232,600	928,300	71,100	-233,600
5,470	42,870	0	105,300	175,800	1,104,100	8,000	171,300
8,244	81,950	0	217,700	-41,000	1,063,100	0	-41,000
7,577	125,900	0	356,000	-325,000	738,100	2,200	-322,900
5,324	82,470	0	202,400	-111,500	626,600	4,000	-110,300
4,205	34,130	0	80,800	308,400	935,000	0	308,600
4,931	51,060	0	128,700	204,600	1,139,600	23,300	202,100
6,171	43,680	0	92,800	246,100	1,385,700	14,500	245,500
6,210	72,990	7,900	220,100	-30,700	1,355,000	65,500	-28,500
8,901	95,360	0	301,200	-264,400	1,090,600	7,100	-264,700
6,323	41,260	0	125,400	-51,400	1,039,200	18,900	-48,200
7,751	67,000	0	202,600	22,300	1,061,500	27,200	21,300
4,365	49,370	17,200	113,900	243,600	1,305,100	55,900	244,800
5,921	79,100	0	186,800	96,600	1,401,700	24,400	99,200
2,835	46,760	24,600	66,500	136,200	1,537,900	33,700	139,200
4,995	48,210	64,200	96,600	344,800	1,882,700	65,700	341,600
3,825	25,630	76,800	81,800	303,300	2,186,000	158,700	312,300
4,905	46,530	77,800	136,800	184,700	2,370,700	205,300	201,300
5,800	59,800		159,800	94,800	ave	103,000	96,300

...mn 17 plus Column 18. 136,900 leaving out 1934-40

...mn 19 minus Column ... In water years 1933 ... 1936 this resulted in ...l negative amounts ...ably caused by small ...ors in Bear Lake elevations used or in some in...w or outflow being tem...arily stored in Mud Lake. ...these years the resultant ...ure was assumed to be zero.

254,000 14,300 no depletion

21. First day following the high water period that discharge in Outlet Canal was greater than sum of discharges in Rainbow and Dingle Inlet canals.

22. Assumed to be in all cases Sept. 30. In 1929, 1932, 1937, 1938, 1941 and 1945 actual storage draft ended prior to Sept. 30, but storage which accumulated in late September was so small that the error introduced is negligible when Sept. 30 date is used.

23. Discharge in Outlet Canal minus sum of discharges in Rainbow and Dingle inlet canals during the storage draft period.

24. Discharge passing Bear River at Collinston gaging station but not exceeding Bear Lake storage releases allowing for a three day time lag during storage draft period.

25. Column 23 minus Column 24.

26. Diversion loss past Cutler Dam which would occur if all Bear River and Bear Lake water were used for irrigation. In 1931 to 1938, 1940 to 1942, and 1944 this is the actual flow passing Collinston during the storage delivery period. In all other years this loss based on the total days of storage delivery at 45 acre-feet daily.

27. Net Bear Lake evaporation loss less tributary inflow during storage release period.

28. Column 24 minus Column 26.

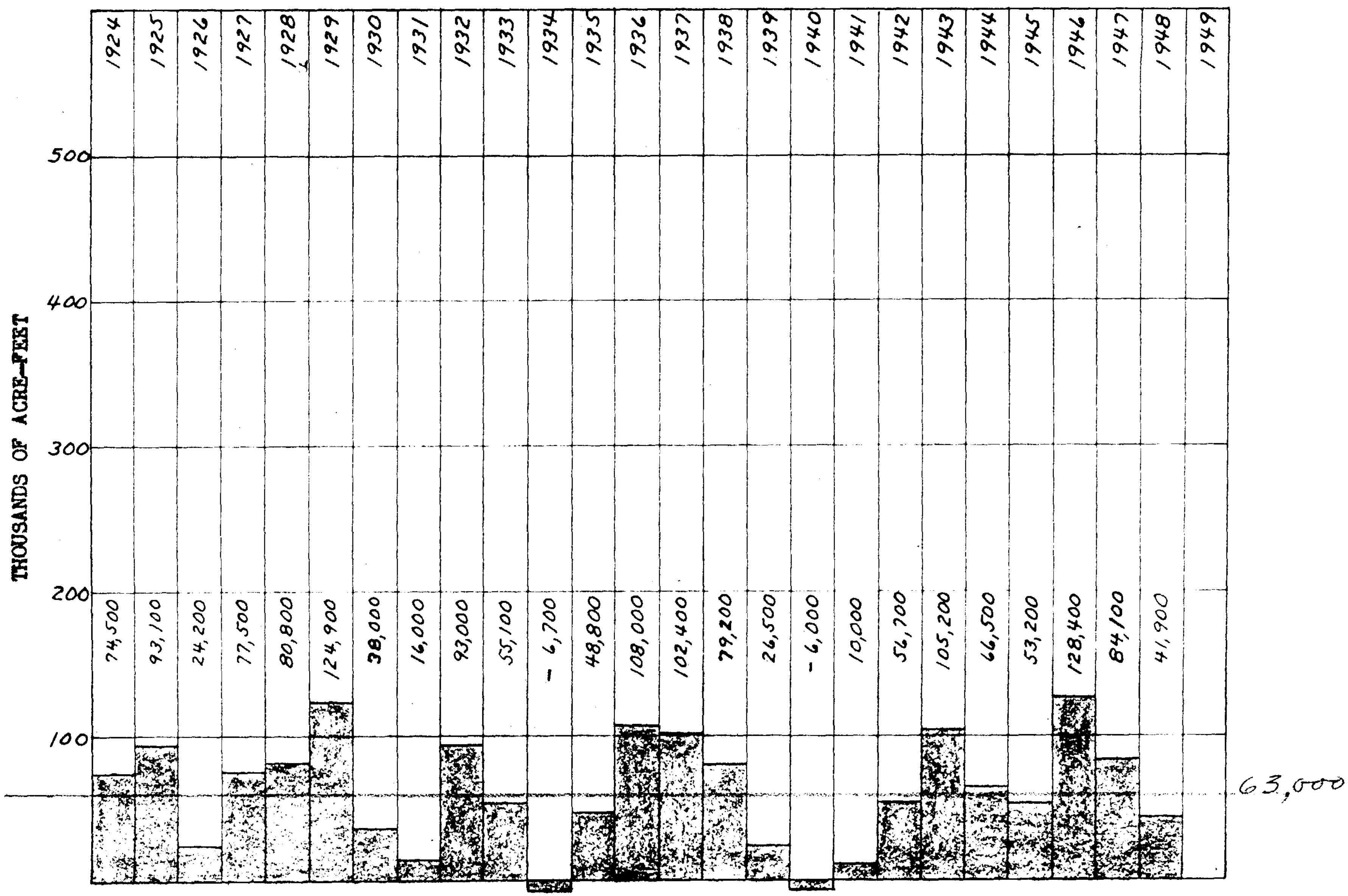
29. Column 25 plus Column 26 plus Column 27.

30. Column 19 minus Column 29.

31. Algebraic summation of Column 30.

32. Column 20 plus Column ~~29~~ 28.

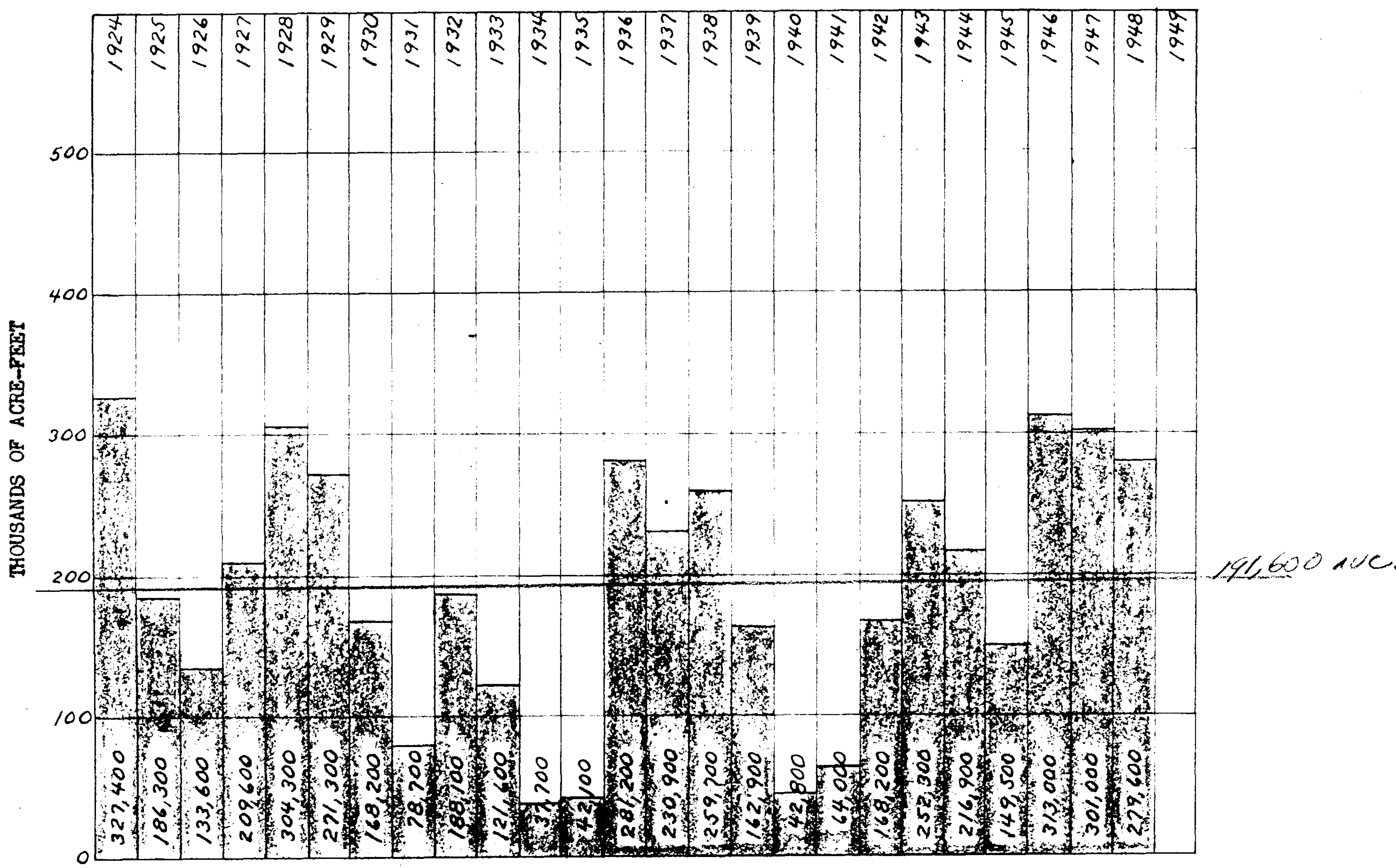
12 years in which no power water used during irrig. season.



MAXIMUM STORABLE ANNUALLY IN BEAR LAKE FROM BEAR LAKE NET TRIBUTARY INFLOW

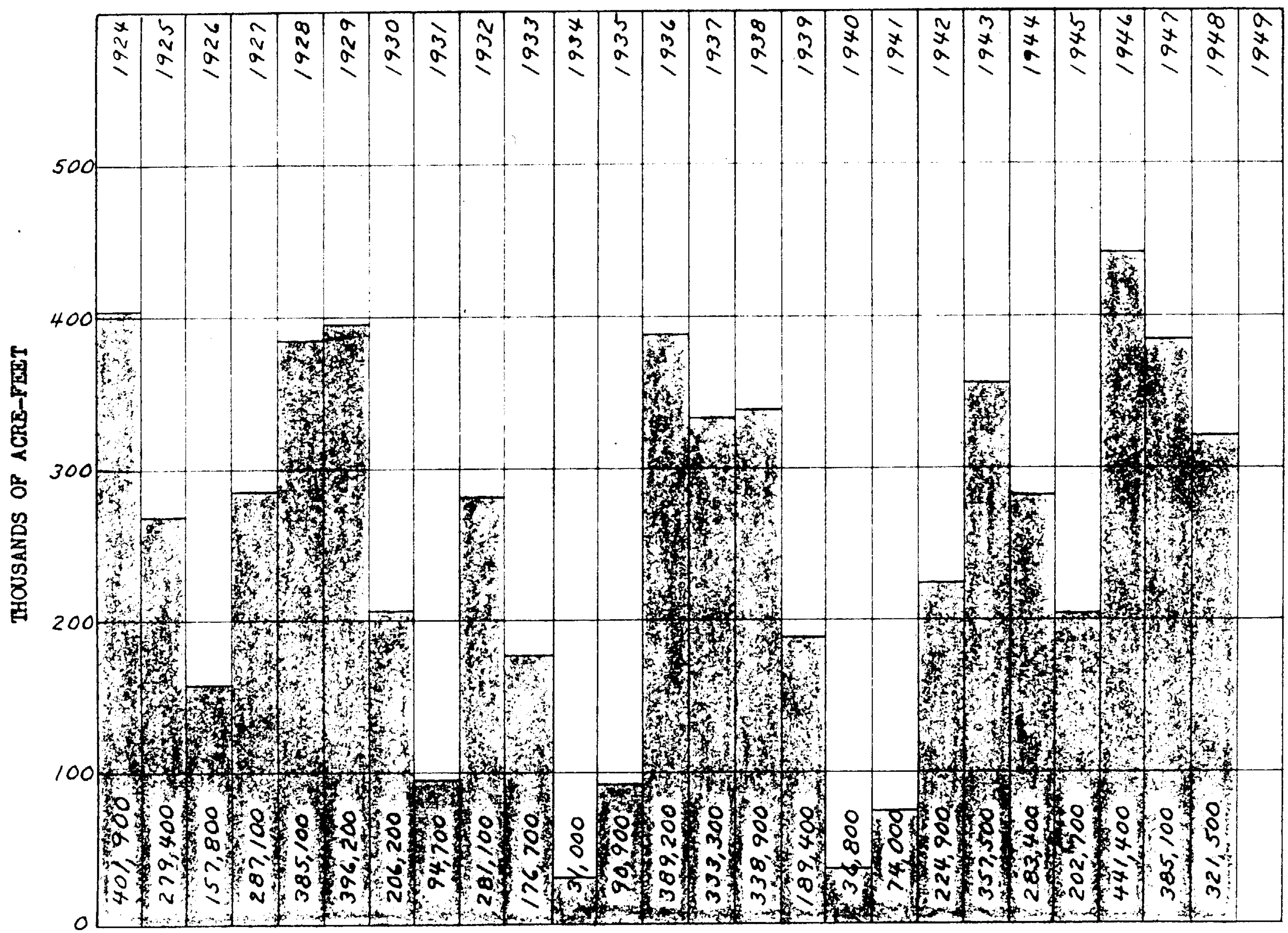
Maximum net amount of water that accrued annually from Bear Lake tributary inflow less evaporation losses during a storage period extending from October 1st to the date storage draft began the following summer.

PLATE 6.



MAXIMUM STORABLE ANNUALLY IN BEAR LAKE FROM BEAR RIVER

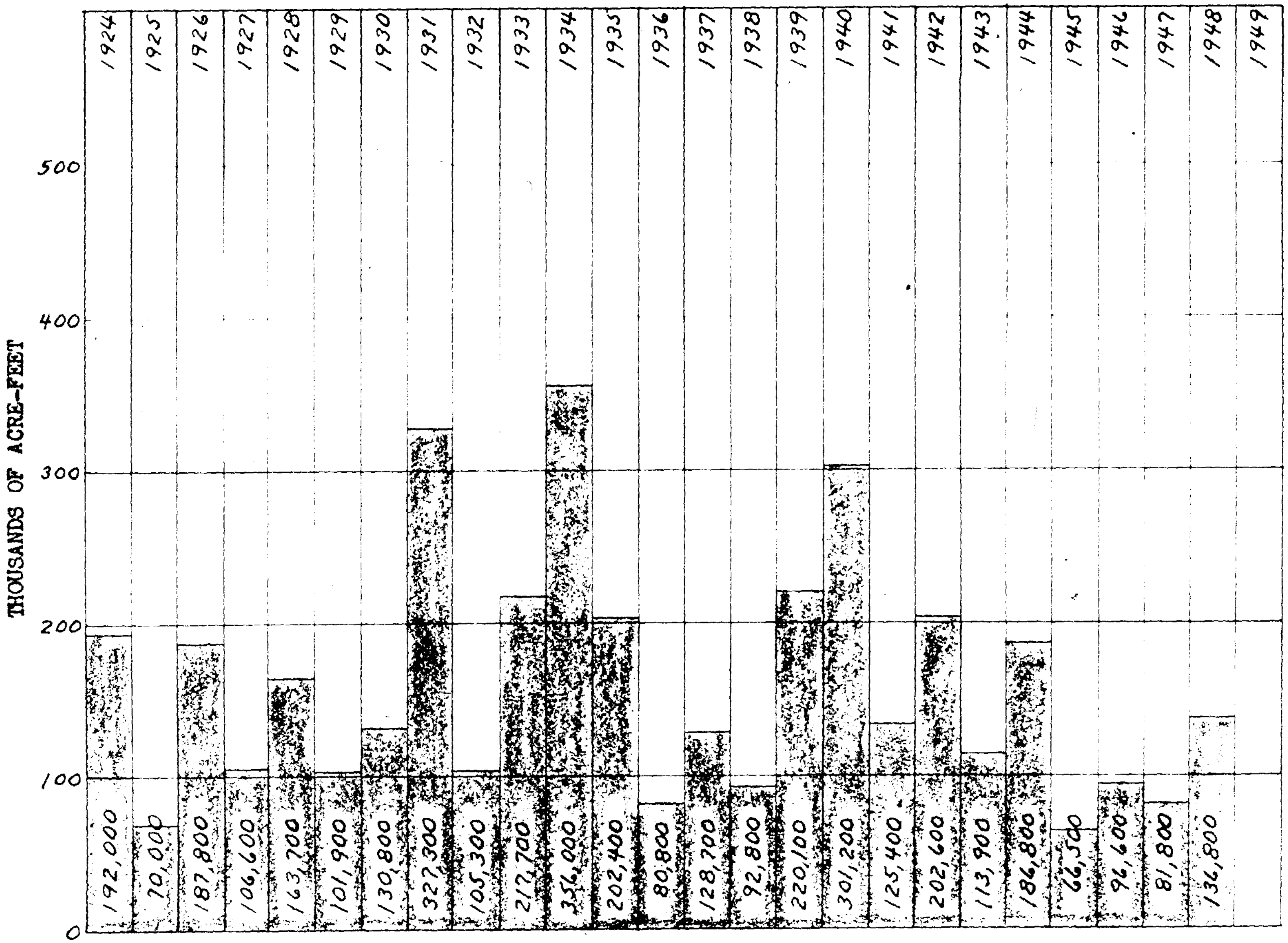
Maximum amount of water that could be stored annually in Bear Lake from Bear River source during a storage period extending from October 1st to date storage draft began the following summer.



MAXIMUM STORABLE ANNUALLY IN BEAR LAKE

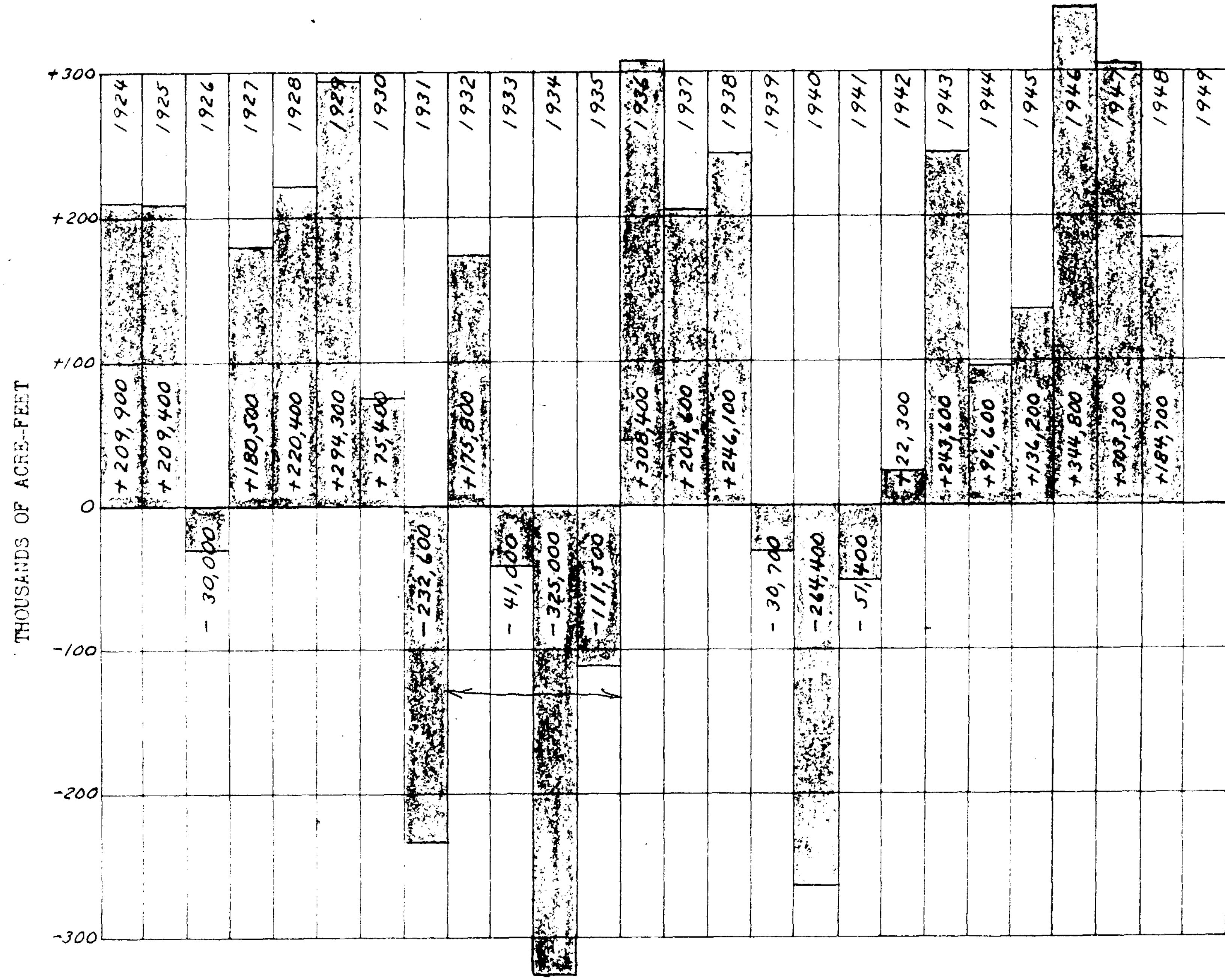
Maximum amount of water that could be stored annually in Bear Lake from Bear River source and from Bear Lake net tributary inflow during a storage period extending from October 1st to date storage draft began the following summer.

PLATE 8.



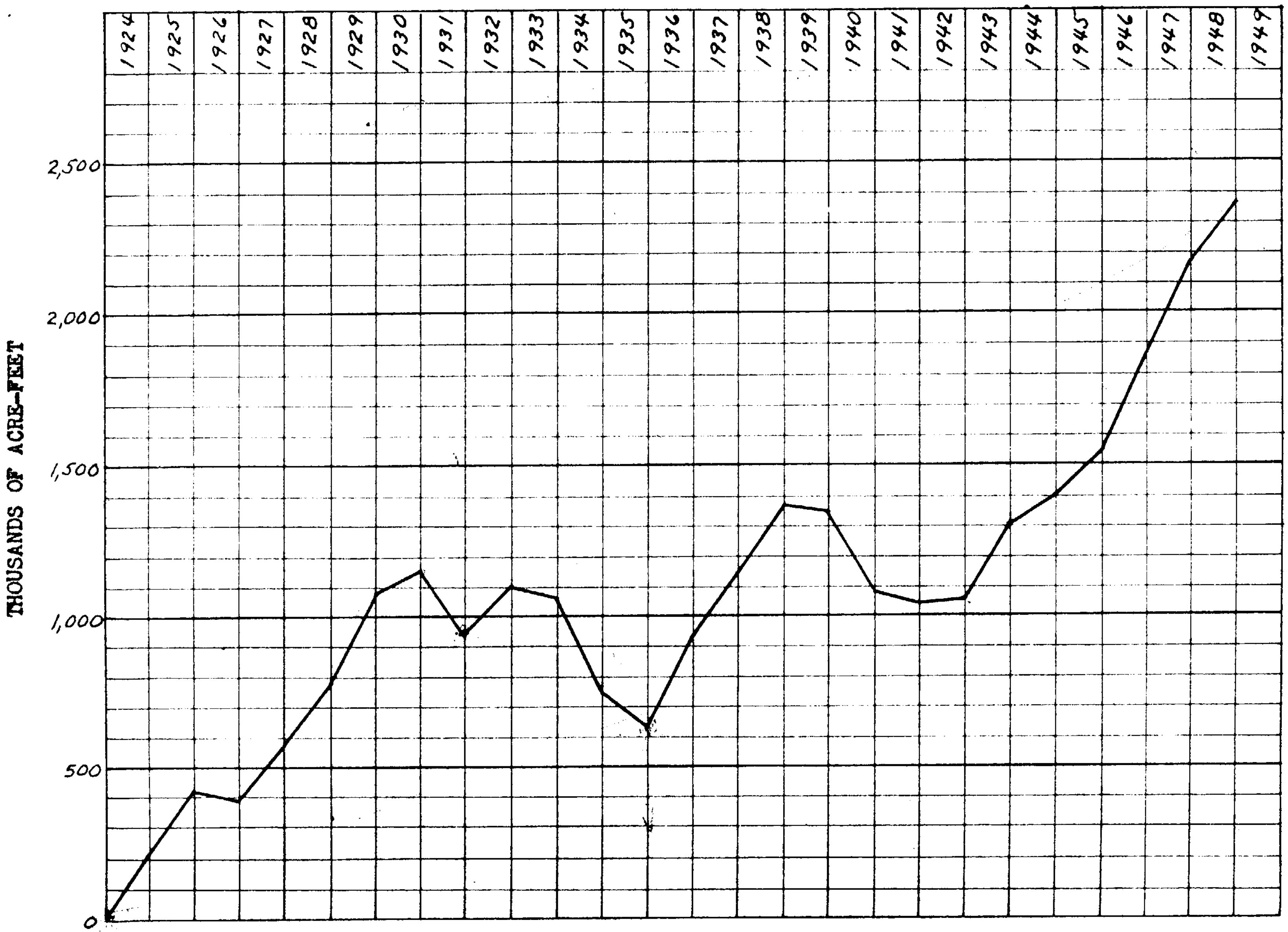
TOTAL STORAGE REQUIREMENT FOR IRRIGATION BELOW BEAR LAKE

The storage requirement for irrigation below Bear Lake is the sum of the net evaporation inflow loss from Bear Lake during the storage draft period, the storage released from the Lake and delivered to canals, and the diversion loss at Cutler Dam during the storage delivery period.



Annual surplus or deficiency of Bear Lake annual storable supply over annual irrigation storage requirement of canals below Bear Lake.

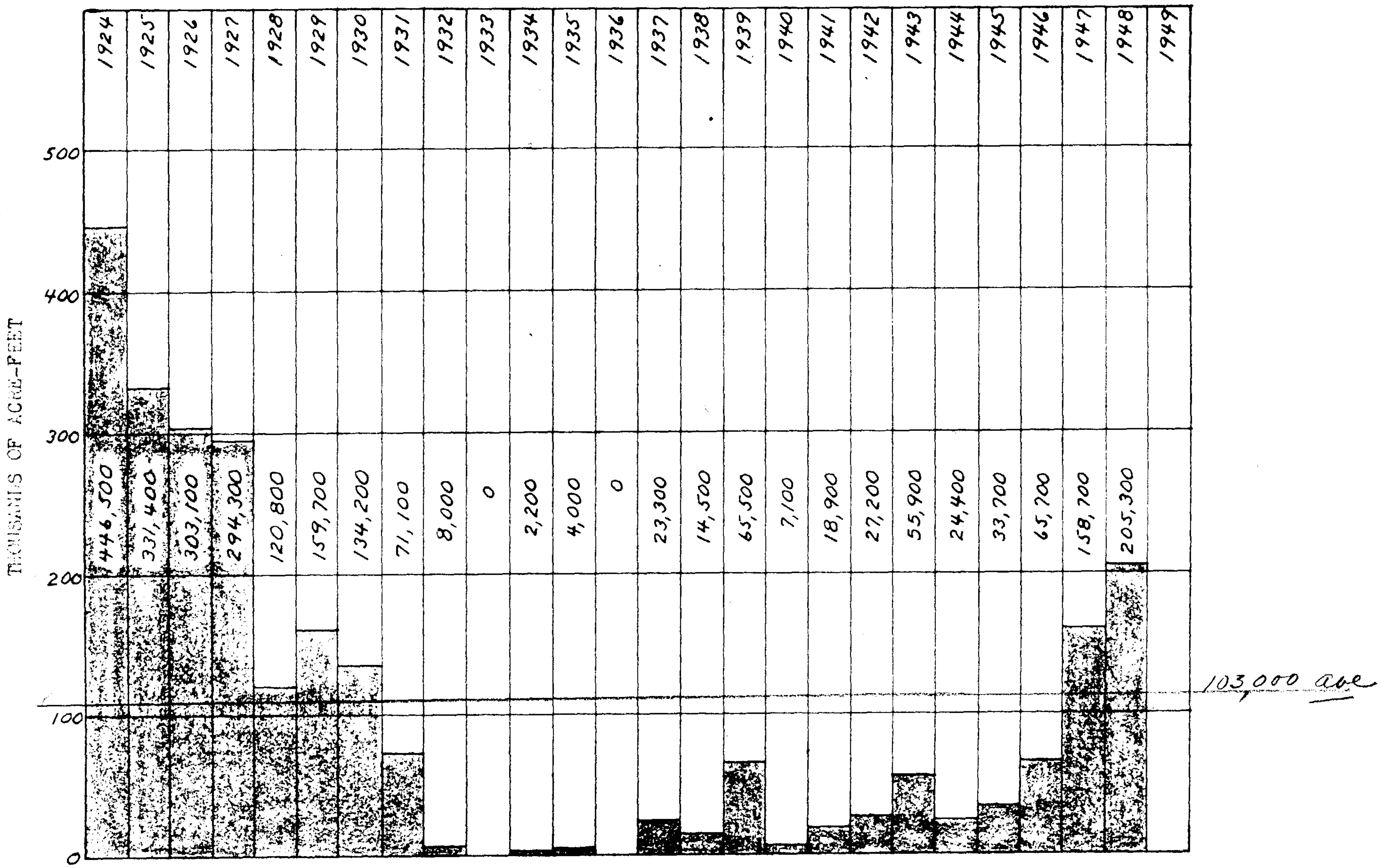
PLATE 10.



BEAR LAKE SURPLUS STORAGE

Annual accumulative surplus storable water in Bear Lake over irrigation storage requirements below Bear Lake beginning with zero storage on October 1, 1923.

PLATE 11.



BEAR LAKE STORAGE AND STORABLE WATER USED IN POWER PRODUCTION

Annual use of Bear Lake storage and Bear Lake storable water in power production at Cutler Power Plant.

PLATE 12.

9-279
(March 1949)

UNITED STATES DEPARTMENT OF THE IN... ...CAL SURVEY (WATER RESOURCES DIVISION)

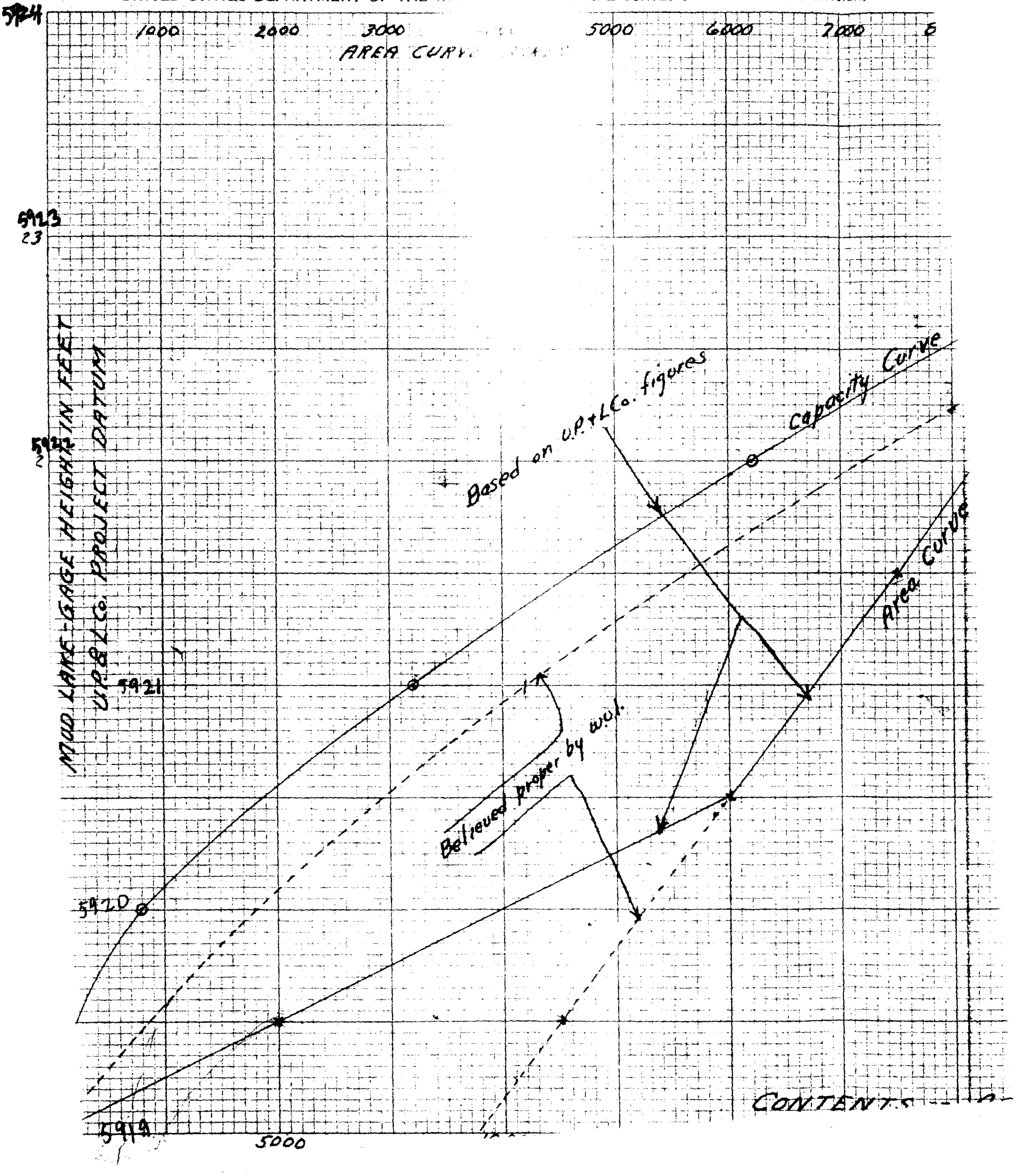
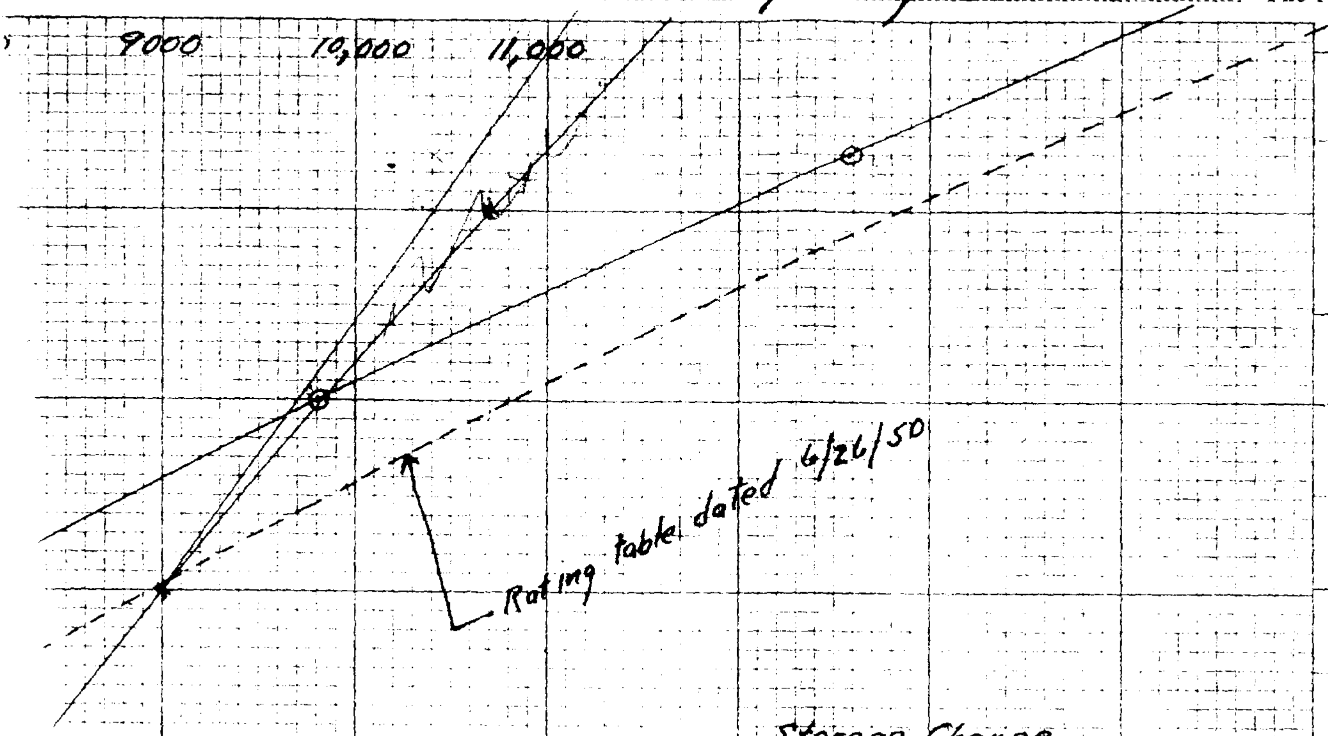


PLATE 13

RATING CURVE FOR *Mud Lake Capacity Curve*

File No. { Washington ______ Field ______



Storage Change
Power Co. Data

Change in Elev.	Ac.-Ft. Mud Lake	[illegible]
5923.00 to 5923.65	6,955	7,500
5922.00 to 5923.00	9,000	11,500
5921.00 to 5922.00	7,500	10,000
5920.00 to 5921.00	6,000	5500
5919.00 to 5920.00	1,984	4500

Rated as no storage below 5919

Year, ______
Meas. Nos., ______
Max. G. H., ______
Min. G. H., ______
Plotted by ______
Checked by ______

______ by:
______ Office Engineer.
______ District Engineer.

[...]TING OFFICE 16-55146-1

PLATE 14

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

File No. Washington .... Field ....

Rating table for MUD LAKE AT Lifton, Idaho Capacity Table

........, from ...., 19...., to ...., 19....

Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference
Feet	Ac.-ft.	Ac.-ft.	Feet	Ac.-ft.	Ac.-ft.	Feet	Ac.-ft.	Ac.-ft.	Feet	Ac.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
.00	Call all readings below 5919 zero storage		20.00	4,500	550	22.00	18,000	800	24.00	37,700		.00		
.10			.10	5,050	550	.10	18,800	800	.10			.10		
.20			.20	5,600	550	.20	19,600	900	.20			.20		
.30			.30	6,150	550	.30	20,500	900	.30			.30		
.40			.40	6,700	600	.40	21,400	900	.40			.40		
.50			.50	7,300	600	.50	22,300	900	.50			.50		
.60			.60	7,900	650	.60	23,200	900	.60			.60		
.70			.70	8,550	650	.70	24,100	900	.70			.70		
.80			.80	9,200	650	.80	25,000	1000	.80			.80		
.90			.90	9,850	650	.90	26,000	1000	.90			.90		
.00	0	400	21.00	10,500	650	23.00	27,000	1000	.00			.00		
.10	400	400	.10	11,150	650	.10	28,000	1000	.10			.10		
.20	800	450	.20	11,800	700	.20	29,000	1000	.20			.20		
.30	1250	450	.30	12,500	700	.30	30,000	1100	.30			.30		
.40	1700	450	.40	13,200	800	.40	31,100	1100	.40			.40		
.50	2150	450	.50	14,000	800	.50	32,200	1100	.50			.50		
.60	2600	450	.60	14,800	800	.60	33,300	1100	.60			.60		
.70	3050	450	.70	15,600	800	.70	34,400	1100	.70			.70		
.80	3500	500	.80	16,400	800	.80	35,500	1100	.80			.80		
.90	4000	500	.90	17,200	800	.90	36,600	1100	.90			.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on .... discharge measurements made during ....

....

...d is .... well defined between .... second-feet and .... second-feet.

Based on proper lower extention of Area curve using UP.&L. Co. base data.

Computed by W.V.L.

Checked by ....

Date 6/26/50

March, 1915

U. S. GOVERNMENT PRINTING OFFICE 6—7347

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

MUD LAKE - Contents in acre-feet on first of each month.

~~Monthly and annual discharge, in ______, of ______ River at ______~~

[Drainage area, ______ square miles]

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	ANNUAL
1924	16,600	16,900	11,000	7,900	5,700	5,800	6,900	20,900	25,200	19,000	9,500	0	
1925	0	0	10,500	10,200	10,800	3,600	-	0	0	0	0	0	
1926	0	7,900	11,800	10,500	10,900	4,900	-	0	0	0	0	0	
1927	0	2,200	11,000	9,200	10,200	7,900	0	-	-	-	0	0	
1928	0	-	6,200	-	-	-	-	-	-	0	0	0	
1929	0	0	5,400	4,800	-	2,500	-	-	-	-	0	0	
1930	1,600	3,200	4,100	5,000	4,000	4,800	0	0	0	0	200	1,300	
1931	3,000	3,800	4,200	4,900	4,900	4,600	0	100	0	0	0	200	
1932	4,500	4,700	5,000	4,700	4,700	4,800	1,100	0	0	100	0	0	
1933	0	0	1,900	5,000	4,500	4,400	2,000	100	200	0	1,800	1,600	
1934	2,300	3,400	5,300	5,700	5,600	5,600	4,700	3,800	3,000	4,400	3,800	3,600	
1935	4,600	6,600	6,900	6,400	5,500	6,000	2,200	3,200	5,700	1,000	0	0	
1936	4,500	4,800	5,600	5,700	4,700	4,600	0	2,700	8,200	2,600	4,800	0	
1937	4,500	5,500	4,000	5,000	5,100	5,100	0	5,300	0	0	0	0	
1938	4,600	4,500	5,600	5,200	5,500	5,300	0	0	500	0	0	100	
1939	0	1,500	5,500	5,800	5,900	6,200	0	1,300	0	2,500	2,300	2,100	
1940	3,000	2,600	5,100	5,400	6,000	5,900	3,100	2,900	2,400	3,200	3,300	6,400	
1941	5,400	4,700	5,300	5,600	5,200	5,300	2,500	2,300	2,200	5,300	4,800	4,100	
1942	4,400	5,900	6,300	6,600	6,400	5,900	0	4,400	3,400	1,200	4,000	3,900	
1943	0	0	0	3,200	5,200	6,200	1,900	2,100	3,800	3,000	200	1,700	
1944	2,200	4,400	4,800	4,700	5,600	5,800	2,000	1,800	2,700	4,600	2,700	2,700	
1945	1,200	4,800	5,400	5,600	5,200	5,900	2,400	0	2,000	2,400	1,200	2,300	
1946	4,200	5,900	5,200	6,000	4,600	5,000	5,000	2,200	3,800	0	1,500	2,600	
1947	2,600	5,300	5,900	4,600	6,000	6,200	4,800	9,700	9,300	11,900	5,400	2,100	
1948	500	5,400	6,000	6,000	5,800	6,500	3,800	19,300	19,100	12,600	6,000	500	
1949	0	4,500	6,300	5,900	5,300	6,400	4,200	12,600	12,600	9,200	0	4,900	

PLATE 15

MUD LAKE - Contents Oct. 1 and date that Storage Draft started and change in contents during Bear Lake Storage and Storage Draft periods

Water Year	Date	Contents Ac.-Ft.	Date Begin. of Storage Draft	Contents Ac.-Ft.	Increase during Storage Period Ac.-Ft.	Increase during draft Period Ac.-Ft.
1924	Oct. 1	16,600	May 26	24,600	8,000	-24,600
1925	Oct. 1	0	June 13	0	0	0
1926	Oct. 1	0	May 1	0	0	0
1927	Oct. 1	0	July 5	0	0	0
1928	Oct. 1	0	June 27	0	0	0
1929	Oct. 1	0	July 6	0	0	1,500
1930	Oct. 1	1,600	May 22	0	-1,600	3,000
1931	Oct. 1	3,000	May 7	0	-3,000	4,500
1932	Oct. 1	4,500	July 23	0	-4,500	0
1933	Oct. 1	0	June 28	0	0	2,300
1934	Oct. 1	2,300	Apr. 20	4,400	2,100	200
1935	Oct. 1	4,600	June 24	5,800	1,200	-1,300
1936	Oct. 1	4,500	June 22	4,700	200	-200
1937	Oct. 1	4,500	June 17	2,000	-2,500	2,600
1938	Oct. 1	4,600	July 13	4,000	-600	-4,000
1939	Oct. 1	0	May 16	2,200	2,200	800
1940	Oct. 1	3,000	May 7	2,700	-300	2,700
1941	Oct. 1	5,400	June 23	8,600	3,200	-4,200
1942	Oct. 1	4,400	June 7	3,400	-1,000	-3,400
1943	Oct. 1	0	June 26	3,200	3,200	-1,000
1944	Oct. 1	2,200	July 9	4,800	2,600	-3,600
1945	Oct. 1	1,200	July 6	4,200	3,000	0
1946	Oct. 1	4,200	June 12	1,000	-3,200	-1,600
1947	Oct. 1	2,600	July 8	11,600	9,000	-11,100
1948	Oct. 1	500	June 14	17,100	16,600	-17,100
1949	Oct. 1	0				

PONDAGE RESERVOIR CORRECTIONS TO SEGREGATION METHOD IN ACRE-FEET

Year	Bear Lake dates Collinston hydrograph used	Total pondage reservoir change + stored - released	Corrections to Computed Storage segregation: Power Storage	Irrigation Storage
1924	6/7 - 9/20	-	0	0
1925	6/23 - 8/30	-	0	0
1926	5/27 - 9/27	-	0	0
1927	7/5 - 9/11	-	0	0
1928	6/27 - 9/19	+ 6,300	+ 6,300	- 6,300
1929	7/6 - 9/1	+ 7,600	+ 7,600	- 7,600
1930	6/8 - 8/10	+ 7,300	+ 7,300	- 7,300
1931	5/7 - 10/1	+ 10,000	+ 10,000	- 10,000
1932	6/23 - 10/1	+ 11,000	+ 11,000	- 11,000
1933	6/28 - 10/1	+ 13,100	+ 13,100	- 13,100
1934	4/20 - 10/1	+ 11,200	+ 11,200	- 11,200
1935	6/24 - 10/1	+ 9,700	+ 9,700	- 9,700
1936	6/22 - 10/1	+ 12,800	+ 12,800	- 12,800
1937	6/17 - 10/1	- 1,500	0	0
1938	7/13 - 9/26	- 11,700	0	0
1939	5/6 - 9/10	+ 18,700	+ 18,700	- 18,700
1940	5/7 - 9/17	+ 22,000	+ 22,000	- 22,000
1941	5/25 - 9/21	+ 5,300	+ 5,300	- 5,300
1942	6/7 - 9/23	+ 14,900	+ 14,900	- 14,900
1943	6/26 - 9/24	+ 11,000	+ 11,000	- 11,000
1944	9/9 - 9/25	+ 11,200	+ 11,200	- 11,200
1945	7/6 - 9/6	+ 500	+ 500	- 500
1946	6/12 - 8/26	+ 8,100	+ 8,100	- 8,100
1947	7/8 - 8/6; 8/17-9/15	+ 12,100 ; + 9,800	+ 21,900	- 21,900
1948	7/1 - 9/18	+ 12,400	+ 12,400	- 12,400
1949				

Note: Cutler Reservoir was not placed in operation until 1928. As the Soda and Oneida Reservoirs changes are minor, it has been assumed that no correction is warranted for 1924 to 1927.

SODA RESERVOIR - Contents Oct. 1 and date that Storage Draft started and change in contents during Bear Lake Storage and Storage Draft Periods.

Water Year	Contents Oct. 1 Acre-Feet	Date Begin. of Storage Draft	Contents Begin. of Storage Draft	Increase during Storage Period Ac.-Ft.	Increase during Draft Period Ac.-Ft.
1924		5/27			
1925	6,480	6/14	10,390	3,910	120
1926	10,510	5/2	9,880	- 630	1,250
1927	11,130	7/6	10,100	-1,030	-500
1928	9,600	6/28	9,600	0	-950
1929	8,650	7/7	9,310	660	990
1930	10,300	5/23	8,560	-1,740	2,890
1931	11,450	5/8	8,060	-3,390	2,920
1932	10,980	7/24	8,320	-2,660	2,400
1933	10,720	6/29	9,300	-1,420	1,970
1934	11,270	4/21	10,400	-870	760
1935	11,160	6/25	11,100	-60	710
1936	11,810	6/23	11,070	-740	160
1937	11,230	6/18	11,060	-170	120
1938	11,180	7/14	10,600	-580	-3,880
1939	6,720	5/17	7,580	860	930
1940	8,510	5/8	5,980	-2,530	4,670
1941	10,650	6/24	10,040	-610	200
1942	10,240	6/8	6,610	-3,630	2,560
1943	9,170	6/27	11,090	1,920	-340
1944	10,750	7/10	10,010	-740	160
1945	10,170	7/7	9,470	-700	1,060
1946	10,530	6/13	8,800	-1,730	1,560
1947	10,366	7/9	10,380	20	30
1948	10,410	6/15	7,870	-2,540	

ONEIDA - Contents Oct. 1 and date that Storage Draft started and change in contents during Bear Lake Storage and Storage Draft Periods.

Water Year	Contents Oct. 1 Acre-Feet	Date Begin. of Storage Draft	Contents Begin. of Storage Draft	Increase during Storage Period Ac.-Ft.	Increase during Draft Period Ac.-Ft.
1924	10,630	5/28			
1925	10,830	6/15			
1926	9,790	5/3			
1927	10,630	7/7			
1928	9,790	6/29	9,360	-430	620
1929	9,980	7/8	9,270	-710	1,410
1930	10,680	5/24	10,230	-450	-100
1931	10,130	5/9	10,780	650	-650
1932	10,130	7/25	8,330	-1,800	1,600
1933	9,930	6/30	10,030	100	-190
1934	9,840	4/22	8,950	-890	1,680
1935	10,630	6/26	10,880	250	-250
1936	10,630	6/24	10,230	-400	500
1937	10,730	6/19	10,580	-150	-1,030
1938	9,550	7/15	9,880	330	-140
1939	9,740	5/18	6,070	-3,670	4,560
1940	10,630	5/9	9,740	-890	690
1941	10,430	6/25	8,770	-1,660	830
1942	9,600	6/9	8,550	-1,050	1,330
1943	9,880	6/28	10,030	150	800
1944	10,830	7/11	7,940	-2,890	1,800
1945	9,740	7/8	9,840	100	1,090
1946	10,930	6/14	9,360	-1,570	-640
1947	8,720	7/10	8,950	230	-270
1948	8,680	6/16	10,530	1,850	

CUTLER RESERVOIR - Contents Oct. 1 and date that Storage Draft started and change in contents during Bear Lake Storage and Storage Draft Periods.

Water Year	Contents Oct. 1 **Acre-Feet**	Date Begin. of Storage Draft	Contents Begin. of Storage Draft	Increase during Storage Period Ac.-Ft.	Increase during Draft Period Ac.-Ft.
1924		5/29			
1925		6/16			
1926		5/4			
1927		7/8			
1928	3,360	6/30	2,120	-1,240	6,430
1929	8,550	7/9	7,890	-660	4,650
1930	12,540	5/25	11,410	-1,130	-10,160
1931	1,250	5/10	4,630	3,380	7,690
1932	12,320	7/26	0	-12,320	7,010
1933	7,010	7/1	7,010	0	11,280
1934	18,290	4/23	4,930	-13,360	8,740
1935	13,670	6/27	7,010	-6,660	9,210
1936	16,220	6/25	4,330	-11,890	12,170
1937	16,500	6/20	18,600	2,100	-620
1938	17,980	7/16	16,500	-1,480	-9,640
1939	6,860	5/19	6,560	-300	11,730
1940	18,290	5/10	1,900	-16,390	12,060
1941	13,960	6/26	6,710	-7,250	4,260
1942	10,970	6/10	8,990	-1,980	7,510
1943	16,500	6/29	7,450	-9,050	10,220
1944	17,670	7/12	4,630	-13,040	11,300
1945	15,930	7/9	7,890	-8,040	-1,630
1946	6,260	6/15	10,530	4,270	1,450
1947	11,980	7/11	3,700	-8,280	7,710
1948	11,410	6/17	8,770	-2,640	6,310
1949	15,080				

COMBINED STORAGE AND RELEASE OF PONDAGE RESERVOIRS

Water Year	Stored during Storage Period: Soda Res. Ac.-Ft.	Oneida Res. Ac.-Ft.	Cutler Res. Ac.-Ft.	Total	Released during Storage Delivery Period: Soda Res. Ac.-Ft.	Oneida Res. Ac.-Ft.	Cutler Res. Ac.-Ft.	Total
1924								
1925	3,910				-120			
1926	-630				-1,250			
1927	-1,030				500			
1928	0	-430	-1,240	-1,670	950	-620	-6,430	-6,100
1929	660	-710	-660	-710	-990	-1,410	-4,650	-7,050
1930	-1,740	-450	-1,130	-3,320	-2,890	100	10,160	7,370
1931	-3,390	650	3,380	640	-2,920	650	-7,690	-9,960
1932	-2,660	-1,800	-12,320	-16,780	-2,400	-1,600	-7,010	-11,010
1933	-1,420	100	0	-1,320	-1,970	190	-11,280	-13,060
1934	-870	-890	-13,360	-15,120	-760	-1,680	-8,740	-11,180
1935	-60	250	-6,660	-6,470	-710	250	-9,210	-9,670
1936	-740	-400	-11,890	-13,030	-160	-500	-12,170	-12,830
1937	-170	-150	2,100	1,780	-120	1,030	620	1,530
1938	-580	330	-1,480	-1,730	3,880	140	9,640	13,660
1939	860	-3,670	-300	-3,110	-930	-4,560	-11,730	-17,220
1940	-2,530	-890	-16,390	-19,810	-4,670	-690	-12,060	-17,420
1941	-610	-1,660	-7,250	-9,520	-200	-830	-4,260	-5,290
1942	-3,630	-1,050	-1,980	-6,660	-2,560	-1,330	-7,510	-11,400
1943	1,920	150	-9,050	-6,980	340	-800	-10,220	-10,680
1944	-740	-2,890	-13,040	-16,670	-160	-1,800	-11,300	-13,260
1945	-700	100	-8,040	-8,640	-1,060	-1,090	1,630	-520
1946	-1,730	-1,570	4,270	970	-1,560	640	-1,450	-2,370
1947	20	230	-8,280	-8,030	-30	270	-7,710	-7,470
1948	-2,540	1,850	-2,640	-3,330			-6,310	

COLUMNS ON PLATE 5 ADJUSTED FOR MUD LAKE AND TEMPORARY PONDAGE RESERVOIRS

ACRE-FEET

Year	Mud Lake Adjustment (a)	Mud Lake Adjustment (b)	Temporary Pondage Reservoirs Adjustment (c)	Plate 5 - Adjusted Columns of Figures: Col. 16 (+a)	Col. 17 (+ a)	Col. 19 (+ a)	Col. 27 (+ b)	Col. 28 (+ c)	Col. 29 (+ b - c)	Col. 32 (+ b)	Col. 30 Adj. Col. 19 - Adj. Col. 30	Col. 31 summation of recomputed Col. 30
1924	+8,000	+24,600	0	85,000	82,500	409,900	76,350	121,600	216,600	471,100	217,900	217,900
1925	0	0	0	38,000	93,100	279,400	33,000	90,000	70,000	331,400	209,400	427,300
1926	0	0	0	25,200	24,200	157,800	70,390	120,100	187,800	303,100	-30,000	397,300
1927	0	0	0	45,700	77,500	287,100	48,480	52,900	106,600	294,300	180,500	577,800
1928	0	0	6,300	322,700	80,800	385,100	75,130	64,700	157,400	120,800	221,400	799,200
1929	0	-1,600	7,600	246,800	124,900	396,200	33,260	17,900	92,700	158,100	294,300	1,093,500
1930	-1,600	-3,000	7,300	119,500	36,400	204,600	39,460	56,400	120,500	131,200	73,800	1,167,300
1931	-3,000	-4,500	10,000	20,600	13,000	93,700	99,240	10,000	312,800	66,600	-233,600	933,700
1932	-4,500	0	11,000	268,600	88,500	276,600	42,870	11,000	94,300	8,000	171,300	1,105,000
1933	0	-2,300	13,100	177,200	55,100	176,700	79,650	13,100	202,300	0	-41,000	1,064,400
1934	+2,100	- 200	11,200	30,900	-4,600	33,100	125,700	11,200	344,600	2,000	-322,900	741,100
1935	+1,200	+1,300	9,700	88,100	50,000	92,100	81,170	9,700	194,000	5,300	-110,300	630,800
1936	+ 200	+ 200	12,800	395,300	108,200	389,400	34,330	12,800	68,200	200	308,600	939,400
1937	-2,500	-2,600	0	307,500	99,900	330,800	48,460	0	126,100	20,700	202,100	1,141,500
1938	- 600	+4,000	0	323,800	78,600	338,300	47,680	0	96,800	18,500	245,500	1,387,000
1939	+2,200	- 800	18,700	134,000	28,700	191,600	72,190	26,600	200,600	64,700	-28,500	1,358,500
1940	- 300	-2,700	22,000	29,400	-6,300	36,500	92,660	22,000	276,500	4,400	-264,700	1,093,800
1941	+3,200	+4,200	5,300	58,300	13,200	77,200	45,460	5,300	124,300	23,100	-48,200	1,045,600
1942	-1,000	+3,400	14,900	196,700	55,700	223,900	70,400	14,900	191,100	30,600	21,300	1,066,900
1943	+3,200	+1,000	11,000	322,000	108,400	360,700	50,370	28,200	103,900	56,900	246,800	1,313,700
1944	+2,600	+3,600	11,200	261,600	69,000	286,000	82,700	11,200	179,200	28,000	99,200	1,412,900
1945	+3,000	0	500	196,600	56,200	205,700	46,760	25,100	66,000	33,700	139,200	1,552,100
1946	-3,200	+1,600	8,100	436,700	125,200	438,200	49,810	72,300	90,100	67,300	341,600	1,893,700
1947	+9,000	+11,100	21,900	312,200	93,100	394,100	36,730	98,700	71,000	169,800	312,300	2,206,000
1948	+16,600	+17,100	12,400	210,600	58,500	338,100	63,630	90,200	141,500	222,400	201,300	2,407,300
1949												
											96,300	

64

,e *Memorandum* • UNITED STATES GOVERNMENT

: W. V. Iorns
Salt Lake City, Utah

DATE: December 11, 1958

ROM : Engineer-in-Charge
Logan, Utah

SUBJECT: Compact Report No. 10

Enclosed herewith are original Plates 1-22 for Report No. 10 to the Bear River Compact Commission. Please note on Plate 5, the following correction to column descriptions: (32) Column 20 plus Column 28. This correction has been made on the original.

The derivation of the Irrigation Reserve as finally used in the Compact, can be secured in either of the following two analyses:

<u>First Breakdown</u>

	Ac.Ft.
Irrigation Draft during six irrigation seasons, 1930-35:	860,300 *
Storable inflow to Bear Lake during critical period:	668,700 **
Deficiency of storable flow over irrigation demand:	191,600
Lake losses during six delivery periods (evaporation plus power water):	485,000 ***
Reserve required	676,600
Unavoidable releases during period	5,000
Net Reserve without upstream storage (5912.91 ft)	681,600

* Report 25, Plate 3, Col. 15 - Total of six years which is the same as Col. 25 + Col. 26 of Report 10 (Period = May 21, 1930 - Sept. 30, 1935)

** Report 25, Plate 3, Col. 6 - Total of five years (1931-35). This is actual change in contents (storage period) plus storable flows used for power at Cutler. Some of these figures vary slightly from Col. 19 Report 10, since contents on Sept. 30 used in one case and Oct. 1st in other.

*** Report 25, Plate 3, Col. 13 - Actual change in contents minus irrigation releases for six storage delivery periods. ~~This checks closely, Col. 29 minus (Col. 25 + Col. 26) of Report No. 10.~~