J. L. Honnold

ANNUAL OPERATING PLAN

REPUBLICAN RIVER BASIN AND SMOKY HILL RIVER BASIN

1953 OPERATIONS
1954 PLAN OF OPERATION

Hydrology Division, Region 7
Bureau of Reclamation
Denver, Colorado

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION – REGION 7
DENVER, COLORADO
MARCH, 1954

7

Desirable Flows in Republican River Basin

Location	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
South Fork Republican River Bonny Dam to mouth	-	-	-	-	-	-	-	-	-	-	-	-
Confluence North & South Fork Republican River to Swanson Lake	10	10	20	* 50	* 75	* 50	25	10	10	30	30	30
Trenton Dam to mouth Frenchman Creek(Meeker Diversion Dam)	10	10	30	* 30	* 30	* 30	30	30	30	60	60	10
Frenchman Creek-Enders Dam to Palisade Diversion Dam	10	10	20	* 50	* 50	* 50	20	20	20	20	20	20
Palisade Diversion Dam to mouth of Frenchman Creek	10	10	20	* 50	* 50	* 50	20	20	20	20	20	20
Republican River-below Meeker Diversion Dam to Bartley Diversion Dam	20	20	30	* 50	* 70	* 50	40	20	20	x 75	x 75	20
Barfley Diversion Dam to Cambridge Diversion Dam	20	20	30	* 50	* 70	* 50	40	20	20	x 75	x 75	20
Medicine Creek-Medicine Creek Dam to mouth	10	10	20	* 50	* 50	* 50	25	20	10	10	10	10
Cambridge Diversion Dam to Harlan County Reservoir	20	20	40	* 100	* 150	* 100	50	20	20	x 100	x 100	20
Harlan County Dam to mouth Republican River	20	20	50	* 100	* 100	* 100	40	40	40	x 100	x 100	20

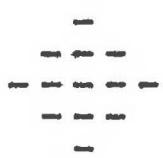
NOTE: First considerations to minimum flows
* - Second consideration
x - Third consideration

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

BUREAU OF RECLAMATION
Wilbur A. Dexheimer, Commissioner

Region 7 - Denver, Colorado
Rudolph J. Walter, Jr., Regional Director

ANNUAL OPERATING PLAN
REPUBLICAN RIVER BASIN
AND
SMOKY HILL RIVER BASIN
1953 Operations
1954 Plan of Operation



March 1954

P R E F A C E

This is the first annual report, prepared by the Bureau of Reclamation, pertaining to the operation of Federally constructed facilities in the Republican River and Smoky Hill River Basins. Its scope is limited to irrigation and such collateral purposes as are within the functions and responsibilities of the Bureau of Reclamation. It does not pertain to the operation of such facilities for flood control, this being the responsibility of the Corps of Engineers.

The Federally constructed reservoirs in these two river basins are operated in accordance with the general pattern of operating arrangements for reservoirs throughout the Missouri River Basin. These arrangements were developed jointly by the Bureau of Reclamation and the Corps of Engineers and made a matter of record in the notes prepared by the Corps of Engineers for the conference held May 12, 1949, at Omaha, Nebraska:

"Agency responsibilities with regard to functional operation scheduling of reservoirs having both flood control and irrigation storage, are as follows: Corps of Engineers will be primarily responsible for flood control operation, Bureau of Reclamation will be primarily responsible for irrigation, whichever agency constructs and maintains dam and reservoir will be primarily responsible for functional operation of reservoir for purposes other than irrigation and flood control (including arrangements with such other agencies as may be appropriate)."

The specific operation agreements between the Bureau of Reclamation and the Corps of Engineers for the various reservoirs are described on page 10 of this report. Annual operating plans for the Harlan County Reservoir are prepared by the Corps of Engineers in cooperation with the Bureau of Reclamation. There has been no irrigation development below Kanopolis Reservoir up to the present time.

S Y N O P S I S

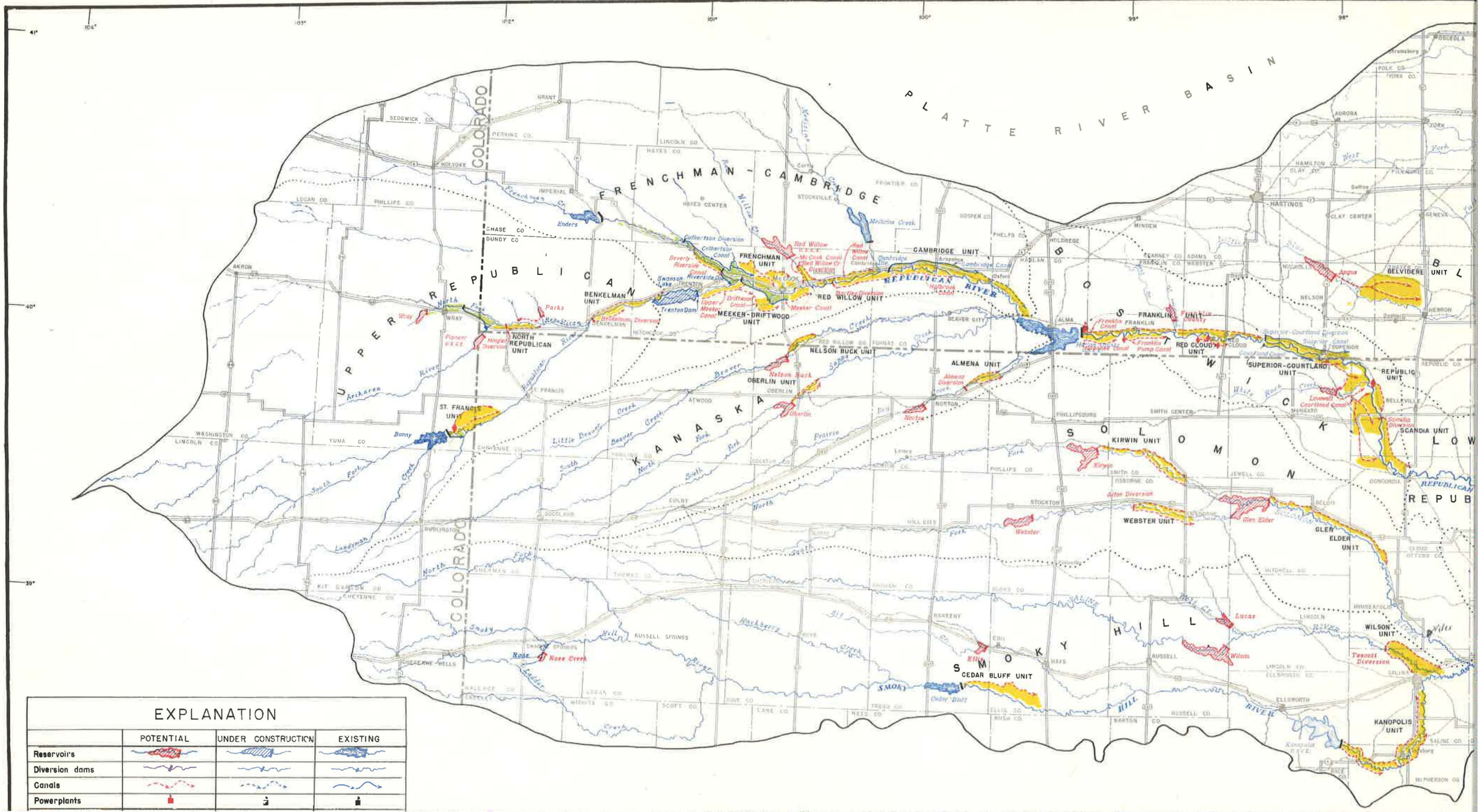
Annual Operating Plan
Republican River Basin and Smoky Hill River Basin
1953 Operations
1954 Plan of Operation

This is the first report which has been published on the annual operations plan for the reservoir system and irrigation canals in the Republican River and Smoky Hill River Basins.

The Republican River and Smoky Hill River Basins are a part of the Kansas River Basin. Since constructed facilities for stream regulation exist only in the Republican and Smoky Hill River Basins, this report presents a plan of operation only for these two basins; however, various maps and exhibits in this report show the entire Kansas River Basin in order to indicate the relationship of the two sub-basins with the entire Kansas River Basin. At present, 7 multiple purpose reservoirs are in operation in the Kansas River Basin. They provide water for irrigation, flood control, sediment control, pollution abatement, fish and wildlife, public health and recreation purposes. Five of these reservoirs, Bonny, Swanson Lake, Enders, Harry Strunk Lake and Cedar Bluff, are operated by the Bureau of Reclamation. Two reservoirs, Harlan County and Kanopolis, are operated by the Corps of Engineers. After completion of the Bureau of Reclamation development in the Kansas River Basin, it is believed that a basin type of operation will be needed to administer the water of the basin. In such a plan, the storage reservoirs would be used to equalize the water supply so that shortages would be shared alike by all canals having storage contracts for water insofar as possible to do so. The annual operating plan will provide a means for an integrated operation to meet all the requirements of the irrigation systems. Since construction of the systems is only partially completed, the present operating plans bear little resemblance to the final operating plans. These annual plans will become more complex as systems are added.

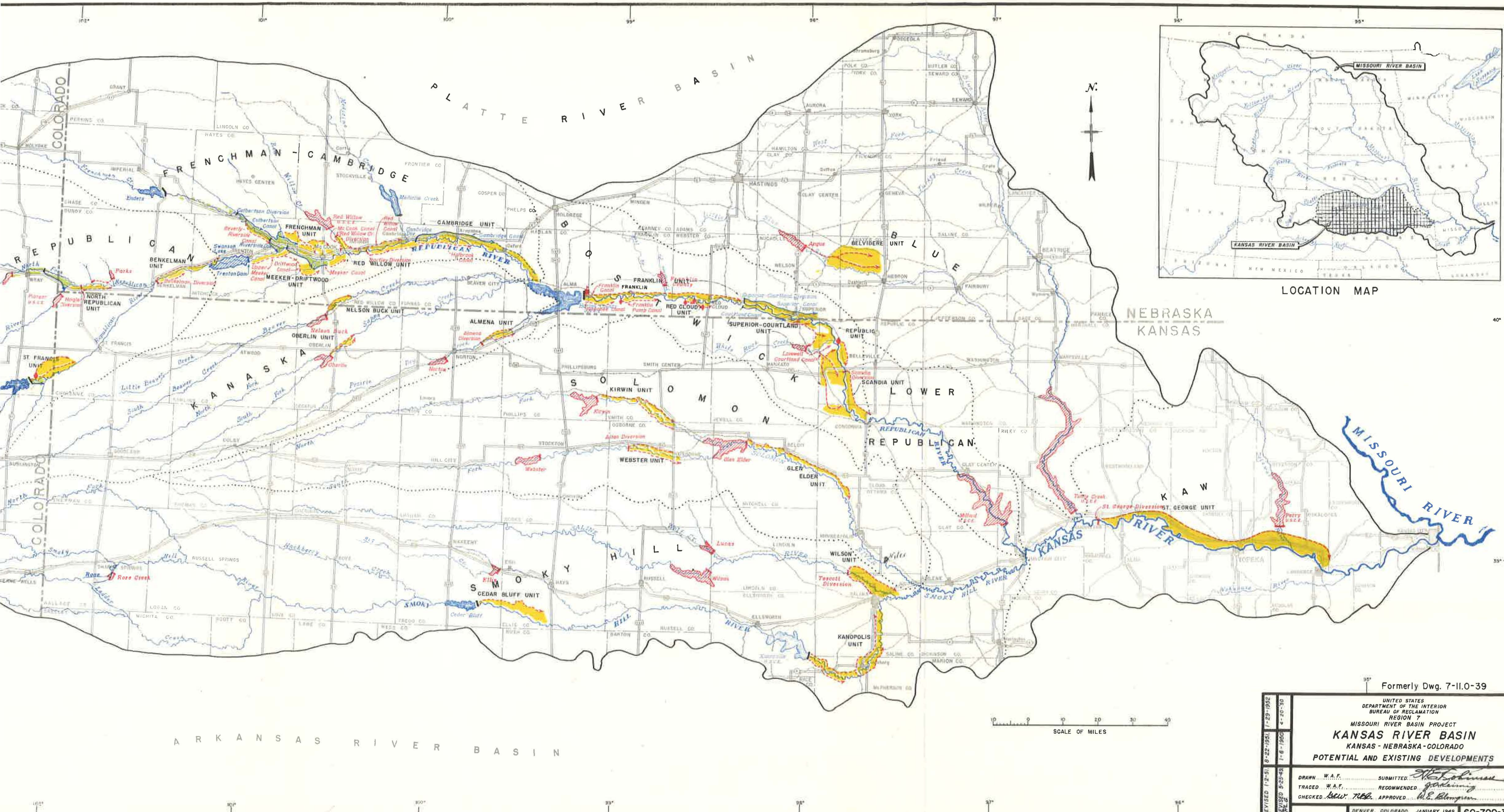
Ultimately, it is expected that approximately 295,000 acres will be irrigated in the Kansas River Basin. Acreages irrigated under Bureau operated projects amounted to approximately 6,100 acres in 1952 and 10,900 acres in 1953. It is expected that 17,400 acres will be irrigated in 1954.

The Operating Plan of the Bureau of Reclamation for irrigation is prepared by the Hydraulic Engineer in charge of the Hydrology and Reservoir Operations Branch whose responsibility it is to coordinate system operations. The Projects Headquarters are in McCook, Nebraska.



EXPLANATION

	POTENTIAL	UNDER CONSTRUCTION	EXISTING
Reservoirs			
Diversion dams			
Canals			
Powerplants			


PLATTE RIVER BASIN
ARKANSAS RIVER BASIN
FRENCHMAN-CAMBRIDGE
REPUBLICAN
KANASKA
BOSTWICK
SOLOMON
SMOKY HILL
LOWER REPUBLICAN
BLUE
KAW
MISSOURI RIVER
KANSAS RIVER
REPUBLICAN RIVER
NEBRASKA
KANSAS
COLORADO
CAMBRIDGE UNIT
FRENCHMAN UNIT
BENKELMAN UNIT
MEEKER-DRIFTWOOD UNIT
RED WILLOW UNIT
NORTH REPUBLICAN UNIT
NELSON BUCK UNIT
ALMENA UNIT
OBERLIN UNIT
ST. FRANCIS UNIT
FRANKLIN UNIT
RED CLOUD UNIT
SUPERIOR-COURTLAND UNIT
REPUBLIC UNIT
SCANDIA UNIT
BELVIDERE UNIT
KIRWIN UNIT
WEBSTER UNIT
GLEN ELDER UNIT
WILSON UNIT
CEDAR BLUFF UNIT
KANOPOLIS UNIT
ST. GEORGE UNIT
LOCATION MAP
MISSOURI RIVER BASIN
KANSAS RIVER BASIN
N.
SCALE OF MILES
0 10 20 30 40

Formerly Dwg. 7-11.0-39

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGION 7
MISSOURI RIVER BASIN PROJECT

KANSAS RIVER BASIN

KANSAS - NEBRASKA - COLORADO

POTENTIAL AND EXISTING DEVELOPMENTS

REVISED 1-2-51 8-22-1951 1-29-1952
REVISED 5-25-49 1-6-1950 4-20-50

DRAWN W.A.F. SUBMITTED
TRACED W.A.F. RECOMMENDED
CHECKED APPROVED

DENVER, COLORADO, JANUARY, 1949 60-700-39

GPO 82-8000853

Annual Operating Plan
Republican River Basin and Smoky Hill River Basin
1953 Operations
1954 Plan of Operation

TABLE OF CONTENTS

LIST OF TABLES

LIST OF EXHIBITS

CHAPTER I

PURPOSE OF REPORT

The purpose of this report is to advise the administrative staff, the water users, state officials, Corps of Engineers, and other interested agencies and persons of the Annual Operating Plan for the reservoir and irrigation systems in the Republican and Smoky Hill River Basins. It is hoped that this annual operating plan will provide a basis for cooperation and understanding among all concerned with the operations of the systems in the Basins. This report is intended only to deal with the water supply and its uses for the various collateral purposes.

Since this is the initial report, it includes a discussion of the history of the development and the necessity for the development of an operating plan. The report also includes a review of the operating organization as well as a review of previous operations and a plan of operation for 1954.

CHAPTER II

REPUBLICAN RIVER BASIN AND SMOKY HILL RIVER BASIN

Location and Major Features

The Republican River Basin and the Smoky Hill River Basin are subbasins of the Kansas River Basin which drains approximately 60,000 square miles of the Great Plans Regions of Colorado, Nebraska and Kansas. The Kansas River has as its principal tributaries, the Republican, Smoky Hill and Blue Rivers. The major features of the Missouri River Basin Project Development are depicted on the basin map, Frontispiece.

These features are composed of reservoirs, diversion dams, pumping plants and canals. The reservoirs are multipurpose in nature serving irrigation, flood control, recreation, public health, pollution abatement, and fish and wildlife purposes. There are no hydroelectric power plants now in operation by the Bureau of Reclamation in the Republican and Smoky Hill River Basins. At Harlan County Dam, a bulkhead opening was provided in the dam to permit possible future power installation but no power machinery has been installed. The feasibility of this power plant is still under consideration.

The federally constructed units in the Kansas River Basin are only partially complete. The Federal planning and construction in the basin were commenced as a result of public demand after the disastrous 1935 Republican River Flood. The construction of Harlan County Dam was initiated in 1946, but the larger portion of the construction by the Bureau of Reclamation was not commenced until it was given impetus by the 1947 Flood on Medicine Creek. There are now 7 reservoirs in operation. Five of these reservoirs, Bonny, Swanson Lake, Enders, Harry Strunk Lake and Cedar Bluff, are operated by the Bureau of Reclamation. Harlan County and Kanopolis Reservoirs are the 2 reservoirs operated by the Corps of Engineers. Most of the existing irrigation systems are in the Republican River Basin. At the present time, a total reservoir capacity of 655,600 acre-feet is provided for irrigation and a total capacity of 1,433,080 acre-feet is provided for flood control. The allocations for storage for these reservoirs are shown in Table 1.

Existing Features—Republican River Basin

Upper Republican Division

Bonny Reservoir was completed and placed in operation in July 1950. This is the only reservoir on which construction has commenced in the Upper Republican Division. Bonny Reservoir provides

supplemental irrigation to irrigators under the Hale Ditch. About 700 acres are being irrigated under the Hale Ditch. This ditch is owned and maintained by private irrigators. The Hale Ditch is served directly by a pipeline from the outlet works from Bonny Reservoir. Due to the senior water rights of the Hale Ditch, during the irrigation season the natural flow which enters the reservoir must be delivered to the Hale Ditch up to its requirement. Storage water is sold to the ditch under temporary Warren Act Contracts. Ultimately, it is expected that the Bonny Reservoir will serve approximately 6,750 acres, most of which will be served through Bureau constructed canals.

Frenchman-Cambridge Division

Three reservoirs are in operation in the Frenchman-Cambridge Division. Swanson Lake, which is on the Republican River near Trenton, Nebraska, started storing water in the irrigation pool in October 1953. The dead storage pool was filled in June of 1953. Construction has not yet commenced on the Meeker-Driftwood Canal, which will take water directly from the dam and will ultimately serve approximately 16,440 acres. It is expected, however, that starting in 1954 storage water from Swanson Lake will be delivered to Meeker and Bartley Canals. Water previously purchased under Warren Act Contracts for Meeker Canal will, in the future, be delivered from Swanson Lake instead of Enders Reservoir.

Enders Reservoir, located on the Frenchman River near Enders, Nebraska, was first placed in operation in October 1950. Up to the present time, the Enders Reservoir has been used to provide storage water to the Meeker Canal which is owned and operated by the Bureau of Reclamation and to provide supplemental storage to private canals along Frenchman River. The Meeker Canal diverts from the Republican River just below the mouth of Frenchman River. The Bureau of Reclamation has not yet commenced construction of the irrigation system in the Frenchman Unit. The Culbertson Canal diverting near Palisade, Nebraska, 32 miles downstream from Enders, has the senior natural flow water right on Frenchman River for 215 second-feet. Culbertson Canal is owned and operated by private irrigators. Meeker and Riverside Canals of the Frenchman-Cambridge District with junior water rights are located downstream from the Culbertson Canal. Storage water has been sold under temporary Warren Act Contracts to private irrigators under private pumps and to private irrigators under the Riverside and Meeker Canals. The Meeker Canal serves approximately 2900 acres and has a capacity of about 50 second-feet. Starting with the 1954 Irrigation Season, storage releases for Meeker Canal will normally be made from Swanson Lake instead of Enders Reservoir.

Harry Strunk Lake is located on Medicine Creek about nine miles upstream from Cambridge, Nebraska. This reservoir was completed and commenced storing water in August 1949. This reservoir provides water for the Cambridge Canal which was initially placed in

operation in 1950. The Cambridge Canal, having a capacity of 325 second-feet, diverts from the Republican River a short distance below the mouth of Medicine Creek. Cambridge Canal will be completed about May 1, 1954, and will ultimately serve about 15,600 acres. A portion of the lateral system of Cambridge Canal was first used during the 1953 Irrigation Season. Canalside deliveries were made during the 1951 and 1952 Irrigation Seasons to small acreages.

Kanaska Division

No construction has been commenced.

Bostwick Division

The Bostwick Division is being developed along the Republican River east of the Harlan County Reservoir in Nebraska and Kansas. The Harlan County Reservoir, located near Republican City, which was constructed by the Corps of Engineers, commenced to store water for the first time in November 1952 and was usable for the first time for irrigation purposes during the Irrigation Season of 1953.

The construction of canals in the Bostwick Division is far from completion. The Superior Canal, Courtland Canal in Nebraska and the Franklin South Side Pump Canal are the only canals completed at the present time. The Superior Canal was used for the first time in 1951, the Courtland Canal in 1952 and the Franklin Pump Unit in 1953. A portion of the Franklin Canal which diverts water directly out of Harlan County Reservoir will be placed in operation in 1954. The canals have the following capacities at their headgates; Superior Canal, 139 second-feet; Courtland Canal, 751 second-feet; Franklin Pump, 42 second-feet and Franklin Canal, 230 second-feet. The lateral distribution systems under the Superior, Courtland, and Franklin South Side Pump canals were not usable until the 1953 season. Only canalside deliveries were made prior to the 1953 season.

Lower Republican Division

No construction has been commenced.

Existing Features - Smoky Hill River Basin

Solomon Division

At the present time, Kirwin Dam on the North Fork Solomon River at Kirwin, Kansas, and Webster Dam on the South Fork Solomon River at Webster, Kansas, are under construction. No construction has commenced on the irrigation systems to be served from either of these two reservoirs.

Smoky Hill Division

Two reservoirs, the Cedar Bluff and the Kanopolis, are completed in this division. The construction of the irrigation systems has not been commenced. Cedar Bluff Reservoir, constructed by the Bureau of Reclamation, is located on the Smoky Hill River about 15 miles southeast of Ellis, Kansas. The reservoir was completed in October 1950 and commenced to store water in November 1951. The Bureau of Reclamation installed a pump on the Smoky Hill River during the 1952 Irrigation Season to deliver water to a development farm in the Cedar Bluff Project area. The pump is located 6 miles downstream from Cedar Bluff Dam. Ultimately, the reservoir will serve 11,500 acres in the Cedar Bluff Project.

The Kanopolis Reservoir, which was constructed and is operated by the Corps of Engineers, is on the Smoky Hill River near Langley, Kansas. The reservoir will ultimately serve approximately 35,000 acres between the reservoir and Salina, Kansas.

CHAPTER III

DEVELOPMENT OF AN ANNUAL OPERATING PLAN

Need for an Operating Plan

The planning of systems in the Kansas River Basin has been carried on with the general objective being that a basin type of operation would be needed after completion of all of the irrigation systems. The Bureau proposes a basin plan of operation wherein the storage reservoirs will be used to equalize the water supply so that the shortages will be reduced to a minimum and the water will be shared alike by all the lands having storage contracts for water. Early in the planning stages of development in the Kansas River Basin, need was recognized for a compact between the three states, Colorado, Nebraska and Kansas, so that the Bureau of Reclamation plan of development could make the best and most complete use of the waters of the Republican River. The Republican River Compact was approved in 1941. The objective of maximum use of water supply was also followed in the other river basins. This necessitated that a plan of operation be established which would accomplish this objective.

With the basin type of operation as a goal to be attained, the water supply studies were handled in a manner to make the maximum use of sectional gains. Requirements not met by sectional gains were then met by reservoir releases. It was recognized early that the maximum use of water, within economic limitations, in a large river basin required that canal and reservoir water rights be established which would permit a complete use of the water supply. As far as it possible to obtain them, canal and reservoir priorities are being established in downstream order. The use of water in the basin development is further based on the concept that the Federal Government will control the stored water in the reservoirs, built or to be built by the Government, to the extent that such storage water can be administered to supplement natural flow so that all areas proposed for development will share the available water supply. The terminology in the repayment contracts of the various districts is worded to accomplish this objective.

It is expected under actual operating conditions that natural flow priorities will be enforced in the various states. Some canal priorities have been established prior to the Bureau developments by private interests which were in conflict with the desire of having the priorities in downstream order; however, if the reservoirs are used to supplement natural flow with storage water, these older

priorities should not conflict with the Bureau development. The greatest use of storage water will be realized if storage is held as far upstream as possible and transferred downstream only as required to satisfy irrigation and other needs and to alleviate floods.

During the early stages of development of Federal construction in the Republican and Smoky Hill River Basins, the plan of operation will not be difficult because the acreage irrigated will first be small and growth will take place at a gradual rate. It is expected that under normal conditions it would take approximately 6 years to place 80 percent of the lands in a canal system under irrigation after construction was completed. It is also expected that the construction program will take place over a considerable period of time. With complete development, it is expected that the operation will be quite complicated as the present plan now contemplates approximately 20 reservoirs required for irrigation uses with a total irrigated acres of approximately 295,000 acres.

Development of the Operating Plan

The construction of reservoirs in the Republican and Smoky Hill River Basins has exceeded the rate of construction of canal systems. Since the storage supply available has exceeded the canal requirements, the need for a precise annual operating plan has not been critical up to the present time insofar as the water supply is concerned. However, even commencing with the planning stage, efforts have been directed toward meeting requirements for an operations plan. As mentioned above, canal priorities have been established in downstream order to the extent that it was possible to do so. Efforts were made also to establish rights to store water in the various reservoirs in downstream order. The will of the people has, however, influenced the order of construction of the large reservoirs in Nebraska to the extent that Swanson Lake, Parks, and Red Willow Reservoir will have priorities junior to Harlan County Reservoir insofar as the right to store water is concerned. Nebraska laws, however, require storage use filings to be made also. In Nebraska, it is the intention of the Bureau of Reclamation to prepare these storage use filings in such a manner that all of the reservoirs will be recognized as one pool of water with the storage use filings given the same priority date. Thus, the basin-type of operation can be accomplished even though the rights to store water in the various reservoirs may not be in the ideal priority order.

Early in the planning stage, river gaging stations were established to meet planning requirements which will also serve for operational purposes. Early efforts were also made to obtain operating agreements between the Corps of Engineers and the Bureau of Reclamation regarding the reservoirs. Forecasting requirements of flood conditions were also taken care of by agreements with the Corps of Engineers and the Weather Bureau. A network of precipitation

stations was established to meet this requirement. The needs for an operating organization have also been recognized, and in addition to the requirement for irrigation superintendents, ditchriders, and reservoir superintendents, an Hydrology and Reservoir Operations Branch under the Operations Division has been established in the Kansas River Projects office to prepare and carry out an annual operating plan. The Hydrology and Reservoir Operations Branch is responsible for ordering releases on a day to day basis from the irrigation storage pools of the various reservoirs.

Forecasting Requirements

Routine seasonal forecasts of water supply and irrigation requirements for each irrigation season are expected to be made at the beginning of each calendar year. These forecasts will take into account the carryover storage from the previous year, expected reservoir inflow and the various water requirements. It is anticipated that meetings will be held between the various interested agencies to determine the seasonal requirements for each of the reservoirs. These meetings will include the boards of directors of the irrigation districts. Such a meeting was held for the Harlan County Reservoir to plan its operations prior to the initial storage. However, in this case, the directors of the Bostwick Irrigation District were not included since it was not expected that the water supply would be critical for the 1953 Irrigation Season.

Special flood warning services have been required of the Weather Bureau. The Corps of Engineers and the Bureau of Reclamation are paying the Weather Bureau to operate a flood warning network (See Exhibit 1). The map indicates the channeling of flood reports to the various offices of the Bureau of Reclamation, Corps of Engineers and the Weather Bureau. In all cases, the flood reports from upstream drainage areas are made available to Bureau of Reclamation or Corps of Engineers offices which are located downstream or which have other reasons for being interested in such reports.

The Weather Bureau has also been requested to give the Bureau of Reclamation forecasts of flood runoff which may cause flows at flood stages at various points. The requirements for the flood warning network vary from time to time depending upon the construction program. As new reservoirs are added, new flood warning stations will be added to give protection during construction. After construction is completed, the density of the flood warning stations above these reservoirs will be reduced to that necessary to meet operation requirements. Many of the hydrologic installations are already installed and in operation. Most of the stream gaging stations required for operation of the system are also installed. The stream gaging stations are installed and operated by the Geological Survey. At the present time, the Corps of Engineers and the Bureau of Reclamation are each paying approximately half of the hydrologic

network costs. It is anticipated that, in time, the operation costs of these stream gaging stations will be borne entirely by the states and by the Geological Survey. It is also hoped that the Weather Bureau will entirely absorb the costs of the precipitation stations in the flood warning networks. During the flood season and the irrigation season, routine daily reports are exchanged between the Corps and the Bureau of Reclamation by means of a radio network. A cut in funds caused considerable reduction in the number of flood-warning network stations to be operated during Fiscal Year 1954.

Radio Network

An A. M. system and a F. M. system are to be used in the radio network of communication between the various operating offices and with field personnel. The A. M. system (5,287.5 and 3,207.5 kilocycles) will be installed at McCook and Superior, Nebraska, and at Harlan County Dam, Bonny Dam, Kirwin Dam, Webster Dam, and Cedar Bluff Dam. These stations are all installed with the exception of the Kirwin and Webster stations. The F. M. system (40,700 kilocycles) will include installations at McCook and Superior, Nebraska, and at Trenton Dam, Enders Dam, Medicine Creek Dam, Superior-Courtland Diversion Dam, Cambridge Diversion Dam, Lovewell Dam, and Scandia Diversion Dam. These stations are all installed with the exception of Lovewell Dam and Scandia Diversion Dam. The ditchriders in the Frenchman-Cambridge and Bostwick Divisions are now equipped with mobile F. M. stations, in order to communicate with each other and with their division offices. This network is shown in Exhibit 2.

Origin and Channeling of Operational Orders

Arrangements have been made with the Corps of Engineers to provide for a daily exchange of routine information regarding reservoir and streamflow data. During flood conditions, the exchange of data will be as often as necessary, and may be on an hourly basis with the Corps of Engineers and with the Weather Bureau. Routine information exchange between the Corps and the Bureau of Reclamation by telephone or radio will be confirmed by written reports. Each work-day morning the offices of the Irrigation Superintendents will assemble data pertaining to canal use requirements on a daily basis for the division. This information, which will include current streamflow data, canal requirements, and reservoir storage, will be relayed to the Hydrology Operations Personnel of the Kansas River Projects office each morning at 8 a.m. or shortly thereafter. The existing reservoir and stream conditions will be considered by the Hydrology office in planning releases from the various reservoirs to meet irrigation requirements. The Hydrology Operations Personnel will, in their routine daily exchange of information, request irrigation releases to be made from reservoirs operated by the Corps of Engineers.

Cooperation with the Corps of Engineers

For each Bureau-operated reservoir, the overall operating agreement between the Corps of Engineers and the Bureau of Reclamation consists of two parts. One is the "Field Working Agreement" and the other is the "Flood Control Regulations." The "Field Working Agreement" contains the more specific details regarding operating procedures agreed to by the Corps of Engineers and by the Bureau of Reclamation. The "Flood Control Regulations" are brief regulations of a more or less standard form which have been prescribed by the Secretary of Defense and published in the Federal Register. These agreements are developed jointly by the field offices of the Bureau of Reclamation and of the Corps of Engineers and must be approved at the Washington level. According to the operating agreements, the Bureau of Reclamation is responsible for the operation of the irrigation pool. The Corps of Engineers directs the regulation of water when it is in the flood control pool. The agency operating the reservoir is responsible for operation of the surcharge pool and for operation of the reservoir to meet the requirements of other cooperating organizations. The operating agreement for Harry Strunk Lake (Medicine Creek Dam) has received final approval. The operating agreements for Enders, Bonny, Swanson Lake and Cedar Bluff Reservoirs are in draft form awaiting final revision by the Corps of Engineers.

The operating agreement for Harlan County Reservoir is the only agreement negotiated between the Bureau and the Corps regarding reservoirs operated by the Corps of Engineers in the Republican and Smoky Hill River Basins. The operation agreement for Harlan County Reservoir is in draft form awaiting final approval by the Corps of Engineers. The operating agreement consists of "Field Working Agreement" and a "Statement of Operational Objectives." The "Statement of Operational Objectives" is an overall plan for operating the Harlan County Reservoir to provide a maximum benefit for irrigation, flood control, public health, and fish and wildlife preservation. These operational objectives were prepared cooperatively by the various interested agencies. The "Field Working Agreement" provides that the Corps of Engineers, through their District Engineer will operate the reservoir to supply water requirements for the irrigation projects as prescribed by the Bureau of Reclamation through their Projects Manager. Insofar as may be practicable, and existing laws and regulations will permit, the reservoir will be operated to fulfill other objectives, such as those planned by the Public Health Service, Fish and Wildlife Service, National Park Service, and the various state agencies. General storage and release schedules will be worked out by the Corps in cooperation with the Bureau of Reclamation, and other interested agencies, in meetings to be held annually or more frequently if necessary.

Operating Organization

Until such time as portions of the irrigation systems are taken over by the irrigation district, as provided under the terms of the repayment contracts, the canals will be operated under the general supervision of the Superintendent of Operations who is responsible to the Projects Manager. At present, most of the irrigation is confined to the Republican River Basin in the Bostwick and Frenchman-Cambridge Divisions. There are three branch Irrigation Superintendents and an Hydraulic Engineer in charge of the Hydrology and Reservoir Operations Branch, who are directly responsible to the Superintendent of Operations. The Irrigation Superintendent of the Bostwick Water Systems Branch has offices at Superior, Nebraska, and is responsible for operating and maintaining the diversion dams and canals in the Bostwick Division. The Irrigation Superintendent of the Upper Republican and Frenchman-Cambridge Water Systems Branch has his office at McCook, Nebraska, and is responsible for operating reservoirs, dams, and canals in the Upper Republican and Frenchman-Cambridge Division. The Acting Irrigation Superintendent of the Smoky Hill and Solomon Water Systems Branch is temporarily stationed at Superior, Nebraska, and supervises operation of Cedar Bluff Dam and Reservoir. He will also be in charge of operating the Kirwin and Webster Dams and Reservoirs which are now under construction. Personnel in the Reservoir Operations Section of the Hydrology and Reservoir Operations Branch have been given the responsibility of working with the details of daily operation water requirements, and have been assigned the responsibility of working out agreements with cooperating agencies.

CHAPTER IV

SUMMARY OF OPERATIONS PRIOR TO 1953

Irrigation under Government constructed canals and reservoirs has been limited so far to lands in the Republican River Basin. Historical records of inflow for the various reservoirs, see Exhibits 3 through 8, indicate that at all of the reservoirs, except Enders and Cedar Bluff, three out of the past five years have been periods of below average inflow. The year 1951 was one of the wettest years on record and the year 1952 was exceptionally dry.

Prior to 1952, a policy was followed which provided for filling the irrigation pools at all reservoirs as soon as possible. During the Spring of 1952, releases were made at Bonny and Enders Reservoirs to prevent filling. It was desirable at Bonny to prevent spills because construction work below Bonny Dam required that a minimum release be made from the reservoir to the river during 1952. It was also desirable that the water level in Enders Reservoir be held at a lower level while corrective steps were taken to alleviate seepage problems below the dam and that spills through the ungated spillway be avoided. Water was dumped from Cedar Bluff Reservoir in order that the dam could be completed and repairs to the riprap on the upstream face of the dam could be made. The riprap had been damaged during a winter windstorm. During the 1951 flood in Kansas, the irrigation pool and part of the flood control pool were filled before the dam was completed in order to alleviate flood conditions downstream.

During the period 1949-52, no shortages of irrigation water for Bureau operated projects were experienced. Table 2 lists the acreage served and the acre-feet delivered prior to 1954.

Records of reservoir storage at the beginning of each calendar year are shown in Tables 3 and 4. Operational hydrographs are shown in Exhibit 9. The tables and hydrographs are prepared on a calendar year basis because in most cases the irrigation season extendeds past September 30, the end of a water year. The use of the calendar year for plotting and summarization purposes of irrigation data permits a complete irrigation season to be included.

The present irrigation development, compared to the ultimate plan of development, is relatively small, therefore, the existing reservoirs have so far been more important in providing flood control than they have been in providing supplemental water for irrigation projects.

CHAPTER V

SUMMARY OF 1953 OPERATIONS

The year 1953 was one of the driest on record. Inspection of the historical records plotted on graphs, Exhibits 3 through 8, indicates that 1953 was the driest, or almost the driest, year of inflow at all reservoirs except Bonny and Enders Reservoirs.

Irrigation under Bureau operated projects was limited to areas in the Republican River Basin. During the year, no shortages of irrigation water were experienced. Table 2 shows the total annual diversions by the various canals. Exhibit 10 shows the monthly diversions by each canal.

Reservoir operational hydrographs are shown on Exhibit 9, and a tabulation of water utilization at the various reservoirs is shown in Table 5. Reservoir storage during 1953 is shown in Table 4.

A total of about 10,900 acres was irrigated under Bureau operated projects during 1953, and approximately 1,500 acres of lands not under Bureau operated projects received supplemental water.

Upper Republican Division

Bonny Reservoir supplied water only to the Hale Ditch during the 1953 Irrigation Season. A total of 3,870 acre-feet of water was delivered to irrigate about 700 acres under the Hale Ditch. Included in the delivery was 170 acre-feet of storage water which was sold under Warren Act Contracts. The reservoir started the year with 25,550 acre-feet of storage and ended the year with 37,485 acre-feet. Practically all of the inflow was stored except for deliveries to the Hale Ditch and reservoir seepage. A flow of approximately 6 second-feet occurred continuously below the reservoir due to seepage past the dam. The only releases to the river through the outlet works were made during November when maximum releases of about 100 second-feet were made during a short period for the purpose of rating the outflow gaging station.

In August, a flash flood occurred above Bonny Reservoir resulting in the highest peak flow of record except for that of the 1935 Flood. On August 19, the peak flow of the Republican River near Idalia, Colorado, was approximately 12,000 second-feet and that on Landsman Creek was 5,500 second-feet. It was this flash flood that kept the Bonny inflow figure from being one of the lowest on record. The inflow in 1953 was 25,000 acre-feet. The average for 25 years of records is 33,000 acre-feet.

Frenchman-Cambridge Division

Closure was made at Swanson Lake (Trenton Dam) on May 4, 1953, however, storage in the irrigation pool did not commence until November 15, 1953. All inflow was stored except for releases for stockwater downstream. Continuous releases for stockwater were commenced in December 1953. At the end of the year, the total storage in Swanson Lake was 9,695 acre-feet. The inflow at Swanson Lake during the year was the lowest on record. It amounted to only 54,400 acre-feet compared with a 32-year average of 139,500 acre-feet.

Enders Reservoir commenced the 1953 Calendar Year with 31,340 acre-feet of storage and ended the year with 33,990 acre-feet. During the period of January 1 to the beginning of the irrigation season, releases of 40 to 80 second-feet were made in order to maintain the water level at about elevation 3106.0 or lower. This policy was followed in order to reduce seepage past the dam until relief drains being constructed near the toe of the dam could be completed. Storage water amounting to 621 acre-feet was sold under Warren Act Contracts to pump irrigators below the dam and to the Meeker and Riverside Canals. After the irrigation season, all of the inflow was stored except for approximately 9 second-feet of seepage flowing past the dam. Records of inflow at the gaging station on Frenchman Creek near Imperial, Nebraska, indicated that the inflow into Enders Reservoir during Calendar Year 1953 was 51,800 acre-feet compared with a 29-year average of 49,600 acre-feet. Diversions by the Meeker Canal amounted to 10,306 acre-feet to irrigate 2,940 acres.

On January 1, 1953, the storage in Harry Strunk Lake amounted to 39,490 acre-feet. At the end of the year, the storage was 32,470 acre-feet. Considerable drawdown in the reservoir was experienced because of irrigation requirements of the Cambridge Canal. The irrigation pool was full on January 1. During the period January through May, releases ranging from 60 to 90 second-feet were made in order to keep the water from spilling over the spillway notch. After October 1, all water was stored except for that required for stock water or irrigation rights downstream. The Cambridge Canal diverted 16,338 acre-feet to serve 4,000 acres. Only about 29 miles of the main canal of a planned 49 miles of canal were completed in time for use during 1953. Also, the laterals on the first 29 miles of main canal were used for the first time. In 1950, the first 12.8 miles of Cambridge Main Canal were used for farm deliveries but not laterals were used. In 1951 and 1952, about 19 miles of main canal were used. The inflow during 1953 amounted to 39,200 acre-feet. The average for 29 years of records is 56,200 acre-feet.

During the 1953 Irrigation Season, some difficulty was encountered in bypassing flows for irrigation rights senior to that of the Cambridge Canal. These senior rights on the Republican River between Cambridge Diversion Dam and Harlan County Reservoir are owned

by three different pump irrigators and total 4.23 second-feet. However, only one irrigator, with a senior right of 1 second-foot, demanded that enough of the natural flow be bypassed to supply him with his water right. On two different occasions, Nebraska State Officials ordered the Bureau of Reclamation to bypass most of the natural flow, which sometimes amounted to 40 second-feet, in order to deliver 1 second-foot to an irrigator near Orleans, Nebraska, about 45 miles below Cambridge Diversion Dam. During the first release ordered by the state, it took a continous release, starting August 29, for a period of 9 days before the water reached the irrigator. However, it would have taken longer if considerable runoff had not occurred as a result of a storm between Cambridge and Orleans. On October 19, another release of approximately 30 second-feet of natural flow was ordered by the Nebraska State Officials to provide 1 second-foot of natural flow to the senior irrigator near Orleans. The dry condition of the river caused considerable transportation losses of water and it took 24 days for the water to reach the irrigator.

Since pump irrigators use their water rights at intermittent periods, and bypassing water continuously to keep the river from drying up does not appear practical, consideration is being given to using wasteways on the Cambridge Canal to deliver water into the Republican River at points near the irrigators with senior rights so that they can obtain the water with less transportation losses. It can be expected, in the future, that all these irrigators may demand the water to which they are entitled under senior rights.

Bostwick Division

Storage water from Harlan County Reservoir was used to supply irrigation units in the Bostwick Division. On January 1, 1953, the reservoir had a storage content of 12,430 acre-feet; however, it was not until the last of February before the release was reduced to about 30 second-feet and most of the inflow was stored. Water was released to serve the Franklin South Side Pump Canal, the Superior Canal, and the first 3 miles of the Courtland Canal in Nebraska. Also, during the summer months, sufficient water was released to bypass 40 second-feet of water past the Superior-Courtland Diversion Dam for purposes of stream-pollution abatement. There were periods during which considerable transportation losses (sometimes amounting to 70 second-feet) occurred in the 60 mile reach between Harlan County Dam and Superior-Courtland Diversion Dam. At the end of the year, the content of the reservoir was 122,300 acre-feet.

During May, one of the largest floods on record occurred on Prairie Dog Creek. The 1953 reservoir inflow of 232,800 acre-feet, which included the Prairie Dog Creek Flood, was the driest on record and was considerably below the 25-year average of 507,300 acre-feet.

The Franklin South Side Pump Canal was used for the first time in 1953. The diversions amounted to 2,293 acre-feet to serve 953 acres. The entire length of 5 miles of canal was placed in operation.

In 1953, about 10,170 acre-feet were diverted to irrigate 2,839 acres under the Superior Canal and Laterals. The entire length of 30 miles of main canal was used and all of the laterals were used. The full length of main canal was first used in 1951 but no laterals were used. In 1952, laterals on the first 12 miles of the canal were placed in operation.

Remedial construction work to reduce seepage losses on the Courtland Canal in Nebraska made it impossible to use much of the canal for irrigation deliveries; however, 3.6 miles of the canal were used to divert about 1,470 acre-feet to irrigate 167 acres. No laterals were used in 1953. The first 14 miles of the main canal and laterals taking off of the first 4.7 miles of the main canal were used in 1952, but excessive canal losses occurred and made it necessary to line portions of the canal with compacted earth backfill.

Inspection of the 1953 records of releases from Harlan County Reservoir indicated that of the 81,200 acre-feet released, 24,168 acre-feet were storage releases. Of the storage water released, approximately 7,434 acre-feet were diverted by canals, and the remainder was for stream pollution abatement or was lost in delivery.

After full irrigation development, releases of storage water for pollution abatement cannot be made. Therefore, the various towns and cities downstream which depend on releases from Harlan County Reservoir for dilution of untreated sewage should be urged to provide adequate treatment facilities prior to full development.

Smoky Hill Division

Kanopolis Reservoir, operated by the Corps of Engineers, served only flood control purposes in 1953 because the irrigation system planned to be supplied by the reservoir has not been constructed. During most of the year, the reservoir content was maintained at approximately 50,000 acre-feet.

Cedar Bluff Reservoir started the calendar year with a content of 120,590 acre-feet and ended the year with a content of 109,970 acre-feet. No irrigation system has been constructed under Cedar Bluff Reservoir, therefore, the primary benefit of the reservoir is flood control. The 1953 inflow into the reservoir, 11,700 acre-feet, was considerably below the 35-year average of 63,200 acre-feet. The only release for irrigation was to an irrigation demonstration farm about 6 miles below Cedar Bluff Dam. Approximately 134 acre-feet were pumped from the Smoky Hill River to irrigate 76 acres on this farm.

During the period October 21 - November 9, releases of stored water from Cedar Bluff Reservoir were made in order to dilute water in the Smoky Hill River at the pump intake for the municipal water supply of the City of Russell, Kansas. This pump is located about 70 miles below Cedar Bluff Dam. There was sufficient flow in the river to meet the water right of 2.2 second-feet of natural flow claimed by the City of Russell; however, chloride concentrations in the water made it unfit for human consumption unless it was considerably diluted. The Kansas State Health Officials advised that the salt concentrations of the flow of about 2 second-feet at the pump were so high that a flow of 20 second-feet was required to dilute the water enough to make it potable for human consumption. A contract in preliminary draft form was signed by officials of the City of Russell. Under the terms of this contract, the City of Russell used 224 acre-feet of stored water. Releases were discontinued on November 9 due to precipitation in the area of Big Creek. The normal source of water supply for the city is from Big Creek. The pump on the Smoky Hill River was only a supplemental source of supply.

After May 1, 1954, the City of Russell will pump from the Smoky Hill River below Cedar Bluff Reservoir, at a point near Pfeifer, Kansas. A new pumping station will divert flow through a pipeline directly north to Big Creek. The City of Russell has a water right of 11 second-feet for this point of diversion.

CHAPTER VI

ANNUAL OPERATING PLAN FOR 1954

The plan of operation for 1954 will be similar to the Operation of 1953 and will not bear much resemblance to the basin type of operation which will be required with complete development in the Republican and Smoky Hill River Basins. The irrigation of land will be limited primarily to the Republican River Basin except for the operation of development and research farms on the Cedar Bluff, Kanopolis and Webster Projects because no canals have yet been constructed in other river basins.

Exhibit No. 11 is a profile diagram of the storage and stream flow for the Republican and Smoky Hill River Basins. In addition to irrigation, the reservoirs will serve the usual flood control, recreational, fishery, and sewage dilution benefits.

Water Supply

The water supply outlook for 1954 is excellent for all requirements due to the fact that the construction of reservoir dams has taken place at a more rapid pace than the construction of canal systems. Consequently, sufficient storage water is available to more than meet the maximum requirements during this season. Due to this factor, the necessity for estimating the water supplies in any exact manner has not yet been a factor in the Kansas River Basin. An approach has, however, been made to set up a method of estimating the flow on the basis of frequency analysis of historical flows. The water supply studies in the Republican River Basin have been based upon the period 1929 to 1947 and figures of flow, either estimated or actual, are available for all of the critical points. For some of the other tributaries of the Kansas River, longer records have been used as a basis of water supply. Where records were short, they were extended to the desired period of study by correlation procedures. Commencing with these discharge tables from the water supply studies, individual tables of discharge have been built up for each gaging station to include the entire record of flow for each station. These tables are thus being used for determining the probability of flow at each gaging station. The tables also provide a basis for comparing the yearly flow with the computed normal for each station.

It appears that any estimation of stream flows in the Republican Basin will be dependent primarily upon the frequency analysis reinforced by a preseason inventory of the soil moisture conditions due to the fact that the water supply is primarily dependent upon rainfall. Most of the streams do have a small base flow from ground water, but only in the cases of Medicine Creek and Frenchman Creek is the ground water supply a major portion of the water supply. Snow melt is not an important item in the Kansas River Basin since the tributaries do not drain mountain areas. After the projects have been in operation for several years, return flows will become an important item, but up to the present time, return flows have not yet been developed from Bureau constructed projects.

The frequency method of analysis was used to estimate reservoir inflow for dry, normal and wet conditions. Frequency curves were drawn and shown as Exhibits 12 through 14. The discharge occurances for 10, 50 and 90 percent of the time were used to represent wet, normal and dry conditions, respectively. The basic data used for the frequency analysis were as follows:

Bonny Reservoir. Twenty-five years, of which 14 years are direct measurement and 11 are built up by correlations.
January 1929 - August 1937, is based on the built-up records at Hale adjusted to the dam site. These records are built up on a correlation of South Fork Republican River at Hale versus Republican River at Max.
September 1937 - March 1940, is based on the Hale station records filled out by correlation with South Fork Republican near Benkleman.
April 1940 - September 1947, is based on Hale records adjusted to the dam site.
October 1947 - March 1950, is based on South Fork Republican River at Colorado-Kansas line, adjusted to the dam site.
April 1950 - December 1953, is the sum of records of South Fork Republican River near Idalia and Landsman Creek near Hale.

Swanson Lake. Thirty-one years, of which 30 are direct measurement and 1 is built up by correlation.
January 1922 - December 1922 and January 1924 - November 1946, are based on records of Republican River at Culbertson adjusted to the dam site. During this period, records for Culbertson for April and October 1929, and January through September 1930, were estimated by correlation with Republican River at Max.
December 1946 - July 1950. Records at Trenton were used.
August 1950 - December 1953. Records at Stratton were used.

Enders Reservoir. Thirty years, 20 of which are measured records and 10 are built up by correlation.
January 1924 - December 1930. Records at Imperial were used.
January 1931 - November 1940, inflow considered to be 69 percent of the flow at the Hamlet station of Frenchman Creek.
December 1940 - December 1953, records at Imperial were used.

Harry Strunk Lake. Twenty-nine years, 23 years based on measurement and 6 years based on correlation.
January 1925 - September 1931, January 1937 - September 1943, and October 1944 - July 1949, base on Medicine Creek records at Cambridge, adjusted to Harry Strunk Lake.
October 1931 - December 1936, based on correlation between Medicine Creek at Cambridge and Frenchman Creek at Culbertson.
October 1943 - September 1944, based on correlation between Cambridge and Red Willow Creek near Red Willow.
August 1949 - December 1953, is the sum of records of Medicine Creek and Mitchell Creek above Harry Strunk Lake.

Harlan County Reservoir. Twenty-five years, all based on measurement.
January 1929 - September 1947, is based on Bloomington records adjusted to the reservoir location.
October 1947 - December 1953, is considered to be the sum of records of Republican River at Orleans, Sappa Creek near Stamford, and Prairie Dog Creek near Woodruff.

Cedar Bluff Reservoir. Thirty-five years, of which 12 are records and 23 are based upon correlations with records at other stations.
January 1919 - December 1941, based on Smoky Hill River near Ellis extended by correlation with Ellsworth station and adjusted to the dam site. (Ellsworth correlated with Mentor for July 1925 - July 1928.)
January 1942 - January 1950, based on records at Ellis adjusted to dam site.
February 1950 - April 1951, are records at Ransom station.
May, June, July 1951, are from USGS Water Supply Paper #1139, measurements at Ransom station.
August 1951 - December 1953, are records at Arnold station.

Estimated Water Requirements

Irrigation Requirements

Use of river water for irrigation purposes during 1954 will be confined to the Republican River Basin except for the development farm which is irrigated by pump diversion from the stream below the Cedar Bluff Reservoir. It is expected that 17,410 acres will be irrigated in the Republican River Basin under Bureau operated canals. In addition, it is expected that 1,200 acres of lands under private canals and stream pumps may be irrigated with supplemental storage water. The acreage irrigated under the Culbertson Canal which diverts from Frenchman River is not included in this acreage since it is a private canal and it is not expected that it will purchase storage

water under Warren Act Contracts. The offer of storage water has been made to this canal but the owners purchased no storage water in past years. Approximately 9,450 acres are irrigated under this project. This is the only private canal of any size which will not take storage water.

The irrigation requirements for 1954 have been estimated for dry, normal and wet conditions. The diversion requirement tables as used in the Bostwick Division and Frenchman-Cambridge Division Definite Plan Reports were used as the basis for determining the diversion rates for the various conditions. The diversion rates thus obtained were then corrected for canal loss rates obtained from actual experience and for water required for seasoning the canal, and then these adjusted diversion rates were applied to the acreage expected to be irrigated. It is expected that the Bureau operated canals plus Hale Ditch will divert 68,000 acre-feet under dry conditions, 50,000 acre-feet under normal conditions and 32,000 acre-feet under wet conditions.

Fishery Requirements

Bonny, Enders, Medicine Creek and Cedar Bluff Reservoirs have had water in the irrigation pools for several years and adequate storage has been provided for fishery needs in the reservoirs. The interests responsible for fishing and recreation at the various reservoirs are kept informed of any major changes in the storage of water in order that the maximum benefits may be obtained for these two purposes. Below the reservoirs the benefits for fish are incidental to releases made for stock or other purposes.

The dead storage pool at Swanson Lake was filled during June of 1953. Water was first stored in the irrigation pool commencing November 15, 1953. The Nebraska Fish and Game Commission has already stocked the reservoir with fish. Harlan County first commenced to store water in November 1952. The tentative 1954 operation schedule for Harlan County Reservoir states that the minimum disposal pool level for fish and wildlife preservation will be at elevation 1930.

Public Health Requirements

The "Statement of Operational Objectives for Harlan County Reservoir" agreed upon by the various cooperating states and agencies sets desired minimum flows to be maintained because of public health requirements at various points downstream from Harlan County Dam. The recommended minimum flows in second feet are as follows:

	Dec. to Feb.	Mar.	Apr.	May	June to Sept.	Oct.	Nov.
Franklin, Nebraska	2	2	3	5	8	4	2
Red Cloud, Nebraska	4	5	8	12	20	9	6
Superior, Nebraska	8	10	16	24	40	18	12
Scandia, Kansas	6	8	12	18	30	14	9
Concordia, Kansas	9	12	19	28	47	21	14
Clay Center, Kansas	7	8	13	20	33	15	10
Junction City, Kansas	8	10	16	24	40	18	20

During 1953, releases were made from Harlan County Reservoir to provide minimum flows recommended for stream pollution abatement. There were times when much of the release for this purpose was storage water which had been filed upon for irrigation purposes. Although irrigation requirements may not demand all of the water filed upon for that purpose during the early stages of development, it is to be expected that, when ultimate development requires the water for irrigation purposes, there will be conflicts between the two uses.

Flood Control Requirements

The Corps of Engineers is responsible for flood control operations in the Republican River Basin and Smoky Hill River Basin. They have indicated that storage allocated to flood control will be operated to control the flow in the streams below to effect the maximum practicable reduction in flood damages on the streams below the dams and on the Kansas and Missouri Rivers. Normally, storage will be kept at or below the bottom of the flood control pools in all reservoirs, except during the impoundment and release of flood inflows.

Operating Limitations

During 1954, there will be no operating limitations at any of the reservoirs at which irrigation water will be stored except that the maximum storage for this purpose will be limited to the top of the various irrigation pools. During 1953, Enders Reservoir was operated so that the maximum water level would not exceed the approximate elevation 3106.0 because of seepage conditions below the dam. This is not expected to be a problem in 1954.

Reservoir Operating Criteria

The adopted policy provides that all appropriate facilities be operated for maximum flood control, fish and wildlife, recreation, and pollution abatement after irrigation requirements are satisfied. A minimum release of 3 second-feet will be made at all times for livestock water downstream except when seepage below a reservoir is sufficient to meet this requirement. The operating criteria in 1954 for the various reservoirs will be as follows:

Bonny Reservoir. Store all available inflow that can be stored in the irrigation pool. Stored water may be released under terms of Warren Act Contracts to irrigators under the Hale Ditch. During winter months, spills must be passed through the gated spillway because of the danger of the water freezing in the Hale Ditch pipe which is exposed to weather conditions. Water backs into this pipe when releases are made through the outlet works. During that part of the year when there is no danger of water freezing in the Hale Ditch pipe, spills will be passed through the outlet works, or the gated spillway, in accordance with the terms of the reservoir operating agreement with the Corps of Engineers.

Swanson Lake. All available water will be stored in the irrigation pool. Under normal conditions, Swanson Lake will not spill in 1954, but it may the latter part of 1955. Releases will be made to serve new lands under the Bartley Canal and to provide storage water under Warren Act Contracts to lands under the Meeker Canal.

Enders Reservoir. All available inflow will be stored in the irrigation pool. Storage water may be released under terms of Warren Act Contracts to the Riverside Canal or to private pump irrigators on Frenchman Creek. When the irrigation pool is filled, normal inflow will be passed through the outlet works in order to avoid spilling water over the spillway.

Harry Strunk Lake. Store all available inflow and supply water to the Cambridge Canal. Also water may be sold under Warren Act Contracts to private pump irrigators downstream. When the irrigation pool is filled, normal inflow will be passed through the outlet works in order to avoid spills over the spillway.

Harlan County Reservoir. All inflow not required for releases will be stored. Under normal conditions, the irrigation pool will not fill during the 1954 Calendar Year. Water will be supplied to the Franklin Canal, Franklin South Side Pump Canal, Superior Canal, and Courtland Canal. Also releases for public health requirements will be made as described under the topic "Public Health Requirements," previously discussed in this report.

Cedar Bluff Reservoir. Store all available inflow and release water for the irrigation demonstration farm about 6 miles downstream. Stored water may be delivered under terms of Warren Act Contracts to private irrigators.

Kanopolis Reservoir. The reservoir will not be operated for irrigation in 1954.

1954 Operation Plan by Divisions

It is planned that 17,410 acres of land in Nebraska will be irrigated under canals operated by the Bureau of Reclamation in 1954. During a dry year, it is estimated that as much as 800 acres of land with private irrigation rights would receive supplemental storage water in Nebraska. About 700 acres of land in Colorado will be irrigated by the privately operated Hale Ditch which may use supplemental storage water, and only approximately 80 acres of land at a demonstration farm below Cedar Bluff Dam will be served in Kansas, unless private irrigators purchase water under Warren Act Contracts. A listing of the approximate acreages to be served next year and the estimated irrigation requirements for canal or pump diversions during a dry, normal, or wet year are shown in Table 6. Also, summary tables estimating reservoir operation if 1954 is a dry, median or wet year are shown in Tables 7 through 9.

Upper Republican Division

On January 1, 1954, Bonny Reservoir had a total content of 37,480 acre-feet of which 36,060 acre-feet were active storage. It is expected that the irrigation pool will be full before the beginning of the 1954 Irrigation Season. Water claimed under natural flow rights will be delivered to the Hale Ditch. Also, storage water may be sold to Hale Ditch under Warren Act Contracts. No Bureau of Reclamation projects will be served during 1954. It is anticipated that if 1954 inflow is equal to that of a median year, the reservoir content at the end of the calendar year will be 41,300 acre-feet.

Frenchman-Cambridge Division

Swanson Lake started the 1954 Calendar Year with a total content of 9,560 acre-feet, of which 5,460 acre-feet were active storage. It is expected that by July 1954, it will be possible to use the first 10.5 miles of the main Bartley Canal and Laterals to irrigate 1,200 acres of the Red Willow Unit. Inflows into Swanson

Lake which are claimed under natural flow rights by the Meeker Canal will be bypassed downstream. Also, lands under the Meeker Canal may receive supplemental storage from Swanson Lake under Warren Act Contracts. If the 1954 inflow is equal to that of a median year, the content of Swanson Lake at the end of the year will be 68,400 acre-feet.

On January 1, 1954, the total content of Enders Reservoir was 33,990 acre-feet, of which 25,520 acre-feet were active storage. Under normal conditions, the irrigation pool will be filled before the beginning of the 1954 Irrigation Season. No canals operated by the Bureau of Reclamation will be served from Enders Reservoir during 1954; however, supplemental storage water may be sold under Warren Act Contracts to private irrigators. If the inflow into Enders Reservoir during 1954 is equal to that of a median year, the content at the end of the year will be approximately 40,600 acre-feet.

It is necessary that the Bureau of Reclamation work very closely with the Nebraska Water Commissioners in order to protect downstream water users with senior water rights and to protect storage releases which are made from Enders Reservoir. Each year the State of Nebraska hires a Water Commissioner to administer the natural flow waters of the Frenchman River. The Commissioner is also requested to protect storage releases which are made from Enders Reservoir. The senior water right on Frenchman Creek is for the Culbertson Canal located 32 miles downstream from Enders Reservoir which has a water right for 215 second-feet; however, the maximum that can be diverted under existing conditions is approximately 130 second-feet. The next senior water right is the Meeker Canal which is located 55 miles downstream from the Culbertson Canal. The Culbertson Canal is owned by private irrigators and the Meeker Canal is owned and operated by the Bureau of Reclamation. Since the Culbertson Canal is entitled to all the natural flow which passes that point up to the capacity of the canal, considerable planning and care must be exercised in routing the storage water from Enders Reservoir so that it will reach the purchasers of storage water such as Riverside Canal which is one of the farthest downstream users of storage water from Enders Reservoir. The Riverside Canal, which is located approximately 10 miles below the Culbertson Canal headgate, has a junior water right which is frequently closed down for the benefit of the Meeker Canal. As a result, the water users under the Riverside Canal purchase storage water. The Riverside and Meeker Canals are in the Frenchman-Cambridge Irrigation District. However, the Bureau of Reclamation has not taken over operation of the Riverside Canal.

Harry Strunk Lake started the 1954 Calendar Year with a total content of 32,320 acre-feet of which 26,950 acre-feet were active storage. The irrigation pool will be filled before the beginning of the 1954 Irrigation Season. It will be used in 1954 to serve 6,400 acres under 39 miles of the Cambridge Main Canal and Laterals. Supplemental storage water may be sold under Warren Act Contracts.

During very dry periods, the entire inflow of 30-40 second-feet into Harry Strunk Lake could be ordered by Nebraska State Officials to be passed downstream to deliver 1-4 second-feet of natural flow claimed under water rights senior to that of the Cambridge Canal. The fact that one of the senior rights is about 45 miles below Cambridge Diversion Dam sometimes causes excessive transportation losses to occur. Much of these excessive losses could be avoided by using the Cambridge Canal instead of the Republican River to transport the water which could be wasted from the canal into the river at points just above the location of the senior pump irrigation rights. It is assumed that this plan of operation will be followed during 1954. If the 1954 inflow is equal to that of a median year, the content of Harry Strunk Lake at the end of the year will be about 39,200 acre-feet.

Bostwick Division

Releases from Harlan County for public health requirements downstream will be made according to schedules previously discussed in this report. The reservoir will be used in 1954 to irrigate about 6,810 acres of land in Nebraska. The miles of each canal to be used and approximate acreages to be served during 1954 are listed as follows:

Canal	Miles of Canal	Acres Irrigated
Franklin	21	1,035
Franklin South Side Pump	5	1,347
Superior	30	3,513
Courtland (Nebraska)	14	915
	70	6,810

On January 1, 1954, the total content of Harlan County Reservoir was 122,300 acre-feet, of which 25,100 acre-feet were active storage. If the inflow into Harlan County Reservoir is equal to that of a median year, the content on January 1, 1955, is estimated to be 254,700 acre-feet.

Smoky Hill Division

The total storage in Cedar Bluff Reservoir at the beginning of the 1954 Calendar Year was 109,970 acre-feet of which 101,710 acre-feet were active storage. No Bureau operated canals will be served. However, about 80 acres of land in an irrigation demonstration farm will receive water from the reservoir. Supplemental storage water may be delivered to pump sites downstream for private irrigators (under Warren Act Contracts) and for the City of Russell, Kansas. If the 1954 inflow is equal to that of a median year, the content of Cedar Bluff Reservoir at the end of the year will be approximately 123,500 acre-feet.

CHAPTER VII

SUMMARY

Tables 2 and 6 compare past irrigation requirements with the estimates for the 1954 Irrigation Season. In 1953, a total of 10,899 acres were irrigated under the projects operated by the Bureau of Reclamation. It is expected that 17,410 acres will be irrigated in 1954.

At the beginning of 1954, there was a total reservoir storage of 345,620 acre-feet of which 220,800 acre-feet were active storage. The total irrigation requirements for 1954 are estimated to be approximately 68,000; 50,000; and 32,000 acre-feet respectively for dry, normal, and wet years. No shortages of irrigation water are expected in 1954. The water supply outlook is excellent for projects in the Republican and Smoky Hill River Basins.

Table 1. RESERVOIR DATA - REPUBLICAN RIVER BASIN AND SMOKY HILL RIVER BASIN

Reservoir	Storage in Acre-feet					Limitation on Active Storage
	Dead 1/	Inactive 2/	Irrigation	Flood Control	Total	
Bonny	1,420	1,420	39,920	128,820	170,160	Lowest outlet elevation
Swanson Lake	4,100	4,100	116,060	133,790	253,950	Lowest outlet elevation
Enders	8,470	8,470	36,010	30,040	74,520	Lowest outlet elevation
Harry Strunk Lake	5,370	5,370	33,860	51,690	90,920	Lowest outlet elevation
Harlan County 3/	1,300	97,200	252,920	499,880	850,000	Outlet to Franklin Canal
Cedar Bluff	8,260	8,260	176,830	191,860	376,950	Lowest outlet elevation
Kanopolis 3/	3,320	53,000	0 4/	397,000	450,000	Lowest outlet elevation
Total	32,240	177,820	655,600	1,433,080	2,266,500	

1/ Dead storage is that below elevation of lowest outlet.
2/ Inactive storage is that below the normal minimum operating level and includes dead storage.
3/ Constructed and operated by Corps of Engineers.
4/ Irrigation storage may later be provided in parts of inactive and flood control pools.

Table 2. CANAL DIVERSIONS AND ACRES IRRIGATED PRIOR TO 1954.

Canals	1949		1950		1951		1952		1953	
	A.F.	Acres	A.F.	Acres	A.F.	Acres	A.F.	Acres	A.F.	Acres
Oper. by U.S.B.R.										
Meeker	5,290	2,661	7,660	2,616	7,390	2,930	9,622	2,930	10,306	2,940
Bartley	0	0	0	0	0	0	0	0	0	0
Cambridge	0	0	5,997	78	8,900	1,450	6,513	2,292	16,338	4,000
Franklin	0	0	0	0	0	0	0	0	0	0
Franklin S.S. Pump	0	0	0	0	0	0	0	0	2,293	953
Superior	0	0	0	0	1,940	301	6,280	1,488	10,169	2,839
Courtland	0	0	0	0	0	0	7,340	431	1,468	167
Total	5,290	2,661	13,657	2,694	18,230	4,681	29,755	7,141	40,574	10,899
Non-Bureau										
Hale Ditch	0	0	0	0	2,821	700	3,463	700	3,870	700
Pvt. Irrigators 1/	0	0	0	0	0	0	84	330	469	730
C. Bluff D. Farm	0	0	0	0	0	0	45	33	134	76
Total	0	0	0	0	2,821	700	3,592	1,063	4,473	1,506

1/ Received supplemental storage water.

Table 3. RESERVOIR STORAGE PRIOR TO 1953

Reservoir	Date of Closure	Reservoir Content in A.F. at beginning of Calendar Year 1950	1951	1952
Bonny	July 6, 1950	0	6,960	29,800
Swanson Lake	May 4, 1953	0	0	0
Enders	October 23, 1950	0	8,527	42,630
Harry Strunk Lake	August 8, 1949	9,230	38,770	38,580
Harlan County	July 22, 1951	0	0	1,770
Cedar Bluff	November 13, 1950	0	3,801	181,340
Total		9,230	58,058	294,120

Table 4. RESERVOIR STORAGE DURING 1953

Reservoir	Storage in A.F. on Jan. 1, 1953		Storage in A.F. on Jan. 1, 1954		Discharge in 1000 A.F. During Calendar Year 1953	
	Total	Active	Total	Active	Inflow	Outflow
Bonny	25,500	24,130	37,480	36,060	25.4	8.6
Swanson Lake	0	0	9,560	5,460	17.2 1/	4.6 1/
Enders	31,340	22,870	33,990	25,520	51.8	43.2
Harry Strunk Lake	39,490	34,120	32,320	26,950	39.2	41.5
Harlan County	12,430	0	122,300	25,100	232.8	81.2
Cedar Bluff	120,590	112,330	109,970	101,710	14.9	4.2
Total	229,350	193,450	345,620	220,800	381.3	183.3

1/ Records started on date of closure, May 4, 1953.

Note: Kanopolis Reservoir not listed because no storage was provided for irrigation.

Table 5. UTILIZATION OF WATER IN RESERVOIRS - 1953

Reservoir	Acre-feet						
	Inflow	Total Outflow	Total Storage Releases 1/	Storage Div. for Irrigation 2/	Change in Res. Storage	Reservoir Losses 2/ Net Evap. 3/	Reservoir Losses 2/ Bank Storage
Bonny	25,400	8,600	1,570	170	+12,095	6,665	-1,800
Swanson Lake	17,200	4,600	0	0	+ 9,515	2,420	680
Enders	51,800	43,200	2,588	621	+ 2,575	4,138	1,887
Harry Strunk Lake	39,200	41,500	12,067	6,684	- 7,240	4,047	893
Harlan County	232,800	81,200	24,164	7,170	+109,852	14,230	27,318
Cedar Bluff	14,900	4,200	2,908	134 4/	-10,620	16,200	3,320
Total	381,300	183,300	43,297	14,779	116,177	47,700	32,298

1/ Releases in excess of reservoir inflow computed on daily basis.

2/ Values approximate.

3/ Total evaporation minus precipitation during summer months. Winter evaporation included in bank storage loss. Values approximate.

4/ Does not include 224 acre-feet delivered to Russell municipal water supply pump.

Table 6. ESTIMATED IRRIGATION REQUIREMENTS FOR 1954

Canals	Acres to be Irrig.	Canal Diversions in Acre-feet		
		Dry Year	Median Year	Wet Year
Oper. by U.S.B.R.				
Meeker	3,000	10,320	9,630	7,060
Bartley	1,200	3,600 1/	3,600 1/	3,600 1/
Cambridge	6,400	22,490	14,970	8,380
Franklin	1,035	5,790	4,960	4,450
Franklin S.S. Pump	1,347	4,440	3,220	1,880
Superior	3,513	12,350	8,310	3,860
Courtland (Nebr.)	915	8,780	5,240	2,330
Total	17,410	67,770	49,930	31,560
Non-Bureau				
Hale Ditch	700	3,930	3,450	2,040
Pvt. Irrig. 2/	800 (Max.)	510	110	80
C. Bluff Demonst. Farm	80	160	80	40
Total	1,580	4,600	3,640	2,160

1/ Minimum requirements for seasoning canal.
2/ Supplemental storage water.

Table 7. ESTIMATED SUMMARY OF RESERVOIR OPERATIONS IF 1954 IS A DRY YEAR

Reservoir	Values in 1,000 A.F. Depleted Inflow	Evap. Loss	Bank Storage Loss	Reservoir Releases 1/	Spills	Reservoir Content Jan. 1, 1954	Reservoir Content Jan. 1, 1955
Bonny	19.0	9.7	0	11.0	2.2	37.5	33.4
Swanson Lake	60.2	11.4	12.0	13.0	0	9.5	33.3
Enders	41.5	7.4	3.6	28.8	0	33.8	35.5
Harry Strunk Lake	39.0	7.1	2.4	22.7	9.3	32.2	29.7
Harlan County	131.8	39.5	18.0	53.2	0	122.3	143.4
Cedar Bluff	15.0	22.8	3.6	7.4	0	110.0	91.2
Total	306.5	97.9	39.6	136.1	11.5	345.3	366.5

1/ Includes all releases except spills.

Note: A dry year is determined, on the basis of probability curves, to be a year in which the inflow value will be less only 10 percent of the time.

Table 8. ESTIMATED SUMMARY OF RESERVOIR OPERATIONS IF 1954 IS A MEDIAN YEAR

Reservoir	Values in 1,000 A.F. Depleted Inflow	Evap. Loss	Bank Storage Loss	Reservoir Releases 1/	Spills	Reservoir Content Jan. 1, 1954	Reservoir Content Jan. 1, 1955
Bonny	28.0	6.6	0	10.8	6.8	37.5	41.3
Swanson Lake	101.8	9.5	24.0	9.4	0	9.5	68.4
Enders	50.0	4.9	3.6	31.8	2.9	33.8	40.6
Harry Strunk Lake	49.0	4.8	2.4	11.7	23.1	32.2	39.2
Harlan County	234.0	30.3	36.0	35.3	0	122.3	254.7
Cedar Bluff	40.5	15.2	6.0	5.8	0	110.0	123.5
Total	503.3	71.3	72.0	104.8	32.8	345.3	567.7

1/ Includes all releases except spills.

Note: A median year is determined, on the basis of probability curves, to be a year in which the inflow value will be exceeded 50 percent of the time.

Table 9. ESTIMATED SUMMARY OF RESERVOIR OPERATIONS IF 1954 IS A WET YEAR

Reservoir	Values in 1,000 A.F. Depleted Inflow	Evap. Loss	Bank Storage Loss	Reservoir Releases 1/	Spills	Reservoir Content Jan. 1, 1954	Reservoir Content Jan. 1, 1955
Bonny	40.0	4.5	0	9.3	22.4	37.5	41.3
Swanson Lake	182.4	6.6	36.0	4.8	24.3	9.5	120.2
Enders	55.5	4.8	3.6	23.8	12.6	33.8	44.5
Harry Strunk Lake	88.0	3.4	2.4	3.6	71.6	32.2	39.2
Harlan County	605.0	13.2	96.0	17.7	250.3	122.3	350.1
Cedar Bluff	117.0	14.3	24.0	2.6	2.8	110.0	183.3
Total	1,087.9	46.8	162.0	61.8	384.0	345.3	778.6

1/ Includes all releases except spills.

Note: A wet year is determined, on the basis of probability curves, to be a year in which the inflow value would be exceeded only 10 percent of the time.

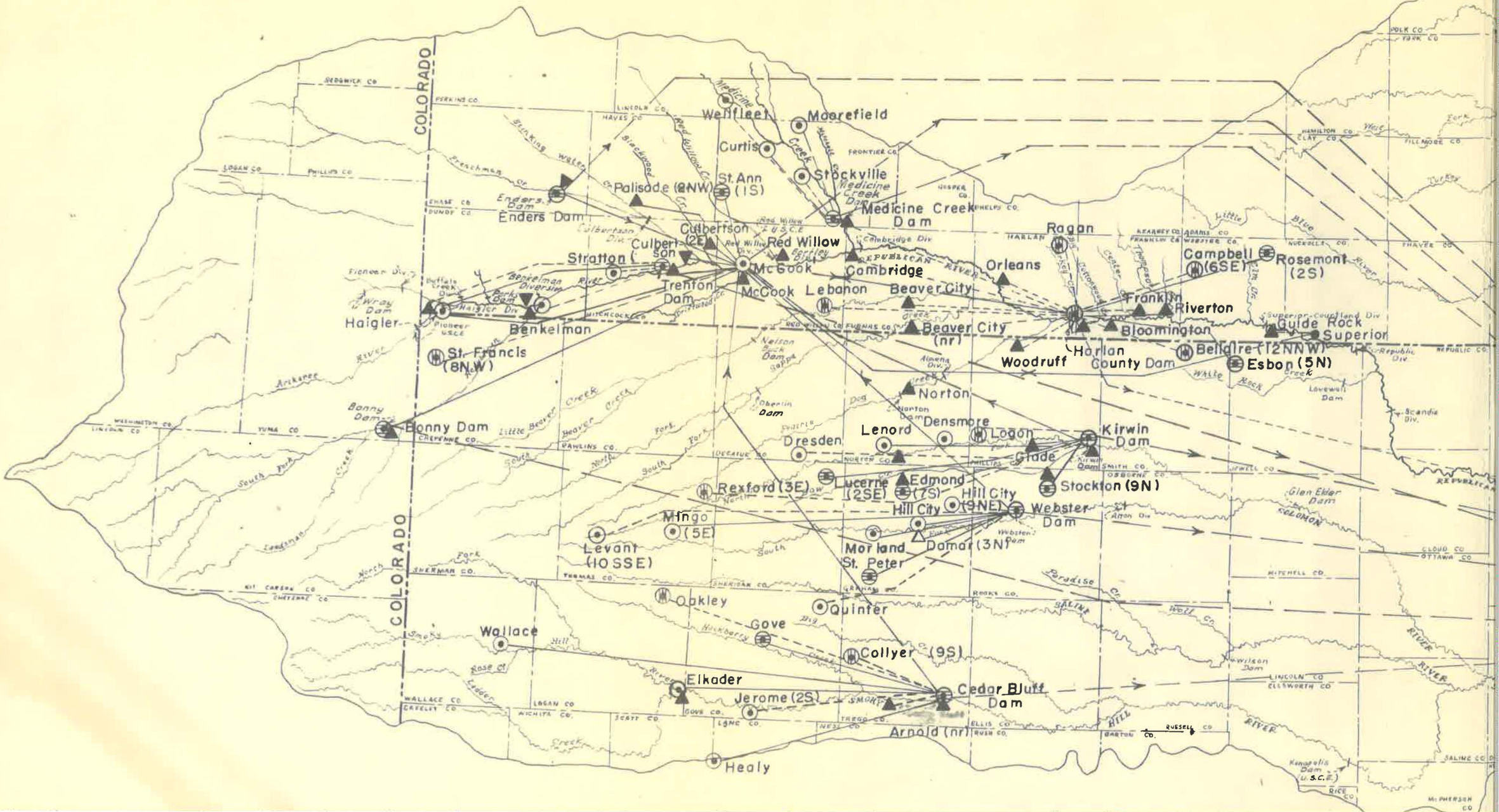
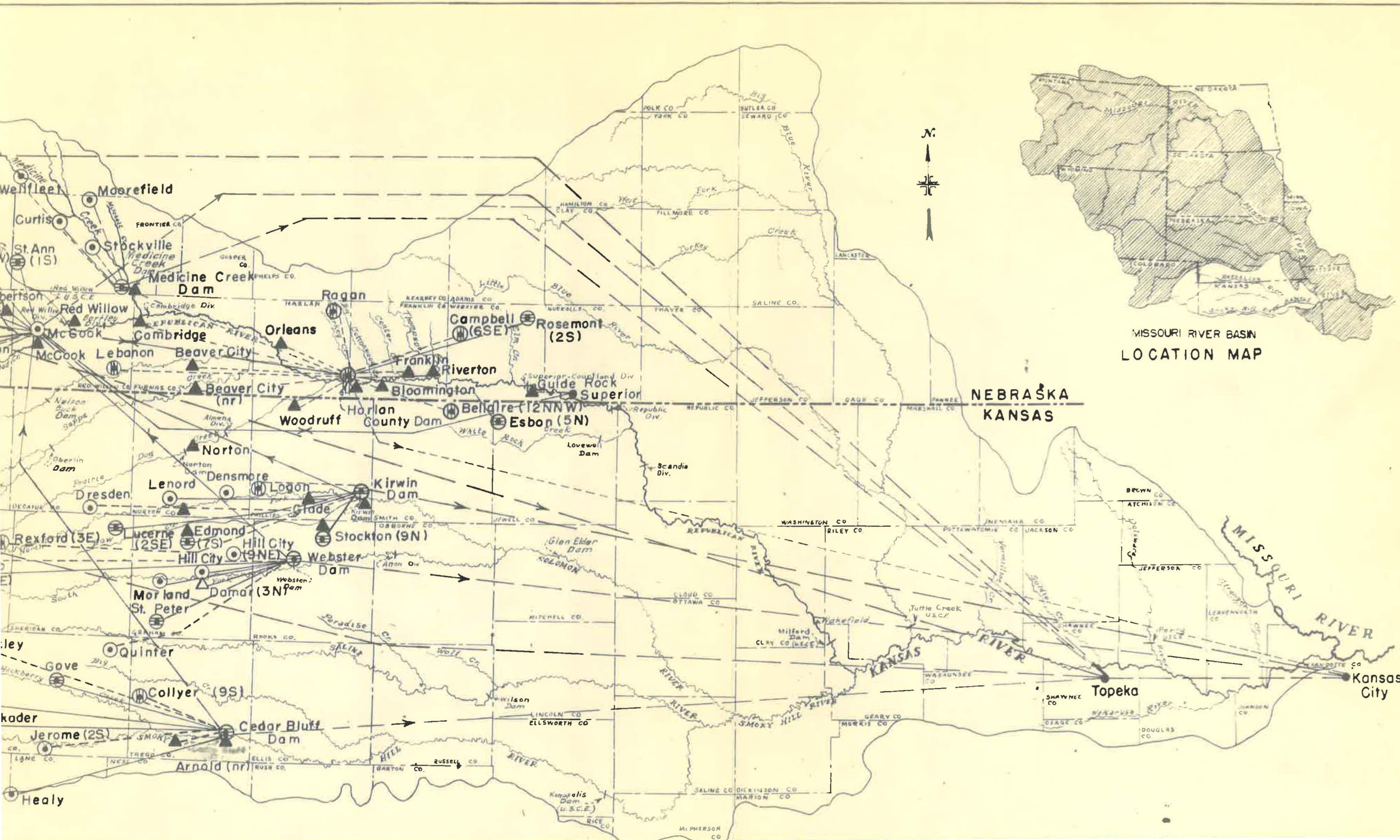
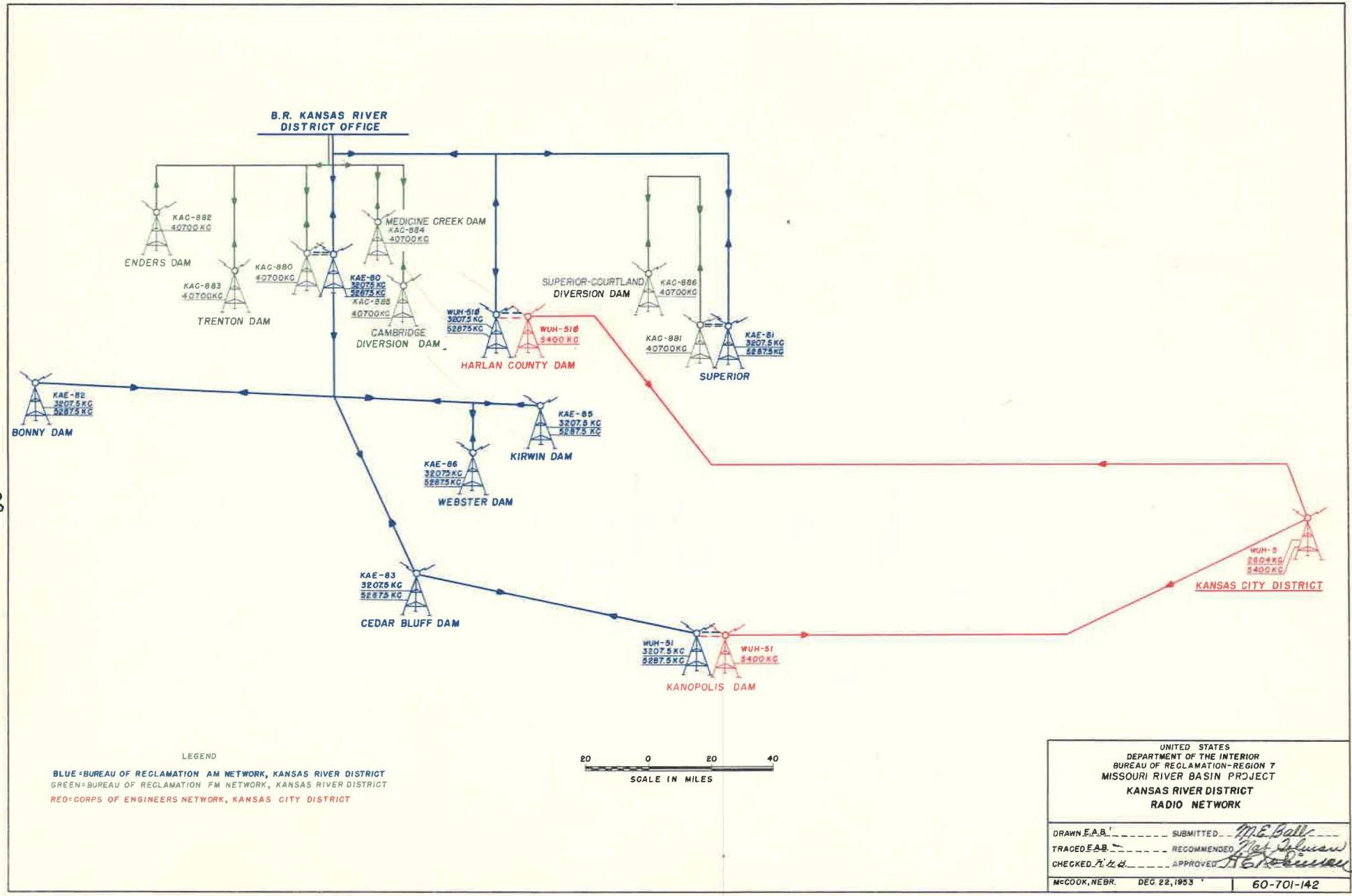

COLORADO
COLORADO
Wellfleet
Moorefield
Curtis
Stockville
St. Ann (1S)
Palisade (2NW)
Enders Dam
Medicine Creek Dam
Culbertson (2E)
Culbertson
Red Willow
McCook
Stratton
Trenton Dam
McCook Lebanon
Cambridge
Beaver City
Ragan
Orleans
Campbell (6SE)
Rosemont (2S)
Franklin
Riverton
Guide Rock
Superior
Haigler
Benkelman
Wray Dam
St. Francis (8NW)
Harlan County Dam
Bloomington
Bellaire (12NNW)
Esbon (5N)
Woodruff
Norton
Bonny Dam
Lenord
Densmore
Logan
Kirwin Dam
Dresden
Glade
Rexford (3E)
Lucerne (2SE)
Edmond (7S)
Hill City (9NE)
Webster Dam
Stockton (9N)
Mingo (5E)
Levant (10SSE)
Morland
St. Peter
Damar (3N)
Oakley
Quinter
Gove
Wallace
Collyer (9S)
Elkader
Jerome (2S)
Cedar Bluff Dam
Arnold (nr)
Healy
Glen Elder Dam
Kanopolis Dam (U.S.C.E.)

Exhibit 1


Wellfleet
Moorefield
Curtis
Stockville
St. Ann (1S)
Medicine Creek Dam
Red Willow
McCook
Cambridge
Lebanon
Beaver City
Beaver City (nr)
Ragan
Orleans
Campbell (6SE)
Rosemont (2S)
Franklin
Riverton
Bloomington
Guide Rock
Superior
Harlan County Dam
Bellaire (12NNW)
Esbon (5N)
Woodruff
Norton
Densmore
Lenord
Logan
Kirwin Dam
Dresden
Glade
Rexford (3E)
Lucerne (2SE)
Edmond (7S)
Hill City (9NE)
Webster Dam
Stockton (9N)
Damar (3N)
Morland
St. Peter
Quinter
Gove
Collyer (9S)
Jerome (2S)
Cedar Bluff Dam
Arnold (nr)
Healy
Lovewell Dam
Scandia Div.
Glen Elder Dam
Milford Dam
Tuttle Creek U.S.C.E.
Wakefield
Topeka
Kansas City
Wilson Dam
Kanopolis Dam (U.S.C.E.)
NEBRASKA
KANSAS
MISSOURI RIVER
KANSAS RIVER
REPUBLICAN RIVER
SOLOMON RIVER
SMOKY HILL RIVER
BIG BLUE RIVER
LITTLE BLUE RIVER
N.

MISSOURI RIVER BASIN
LOCATION MAP



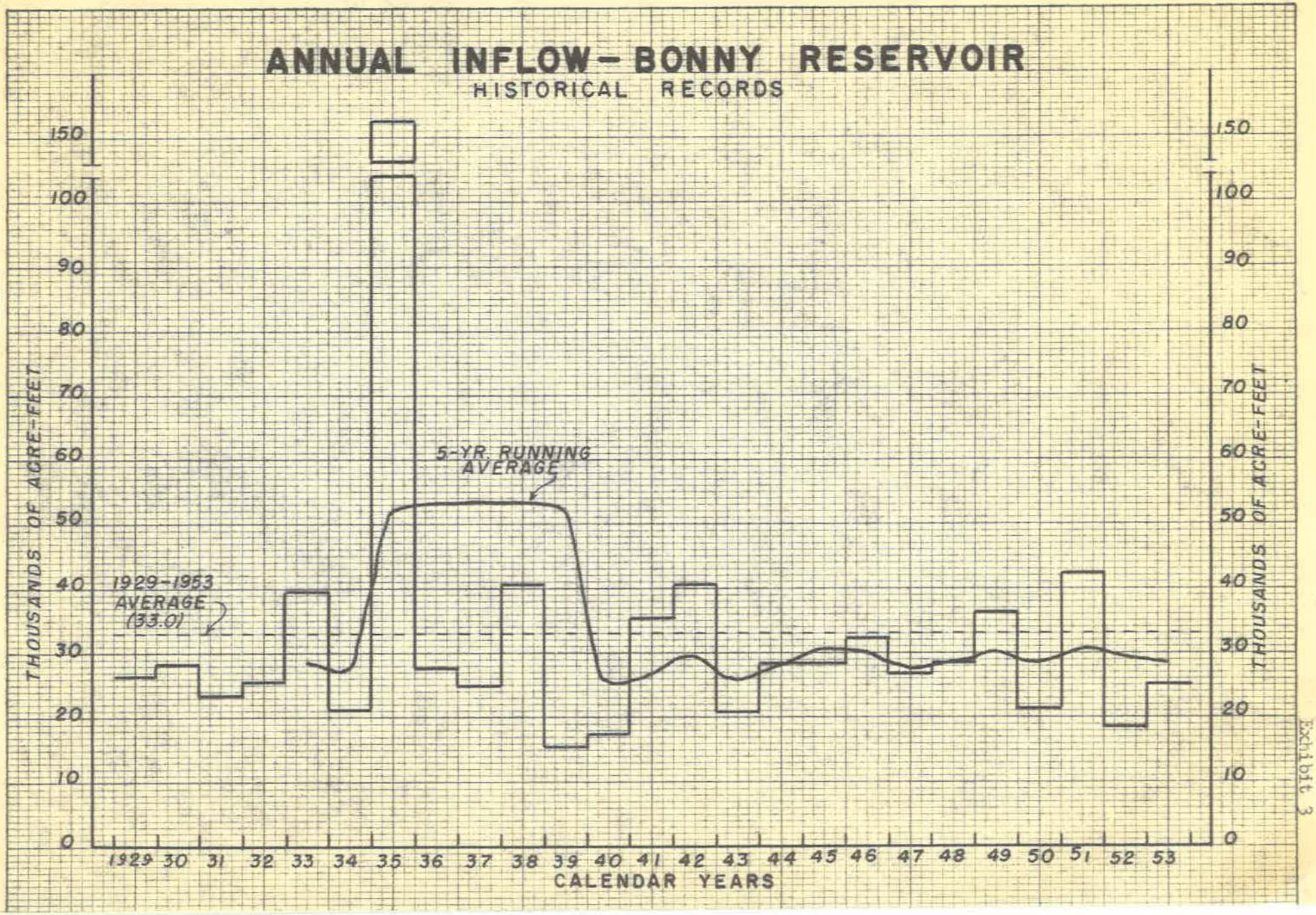
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION-REGION 7
MISSOURI RIVER BASIN PROJECT
KANSAS RIVER DISTRICT
RADIO NETWORK

DRAWN E.A.B. SUBMITTED M.E. Ball
TRACED E.A.B. RECOMMENDED Mat Johnson
CHECKED A.L.S. APPROVED A.E. Johnson

McCOOK, NEBR. DEC 22, 1953 | 60-701-142

GPO 831615

Exhibit 2



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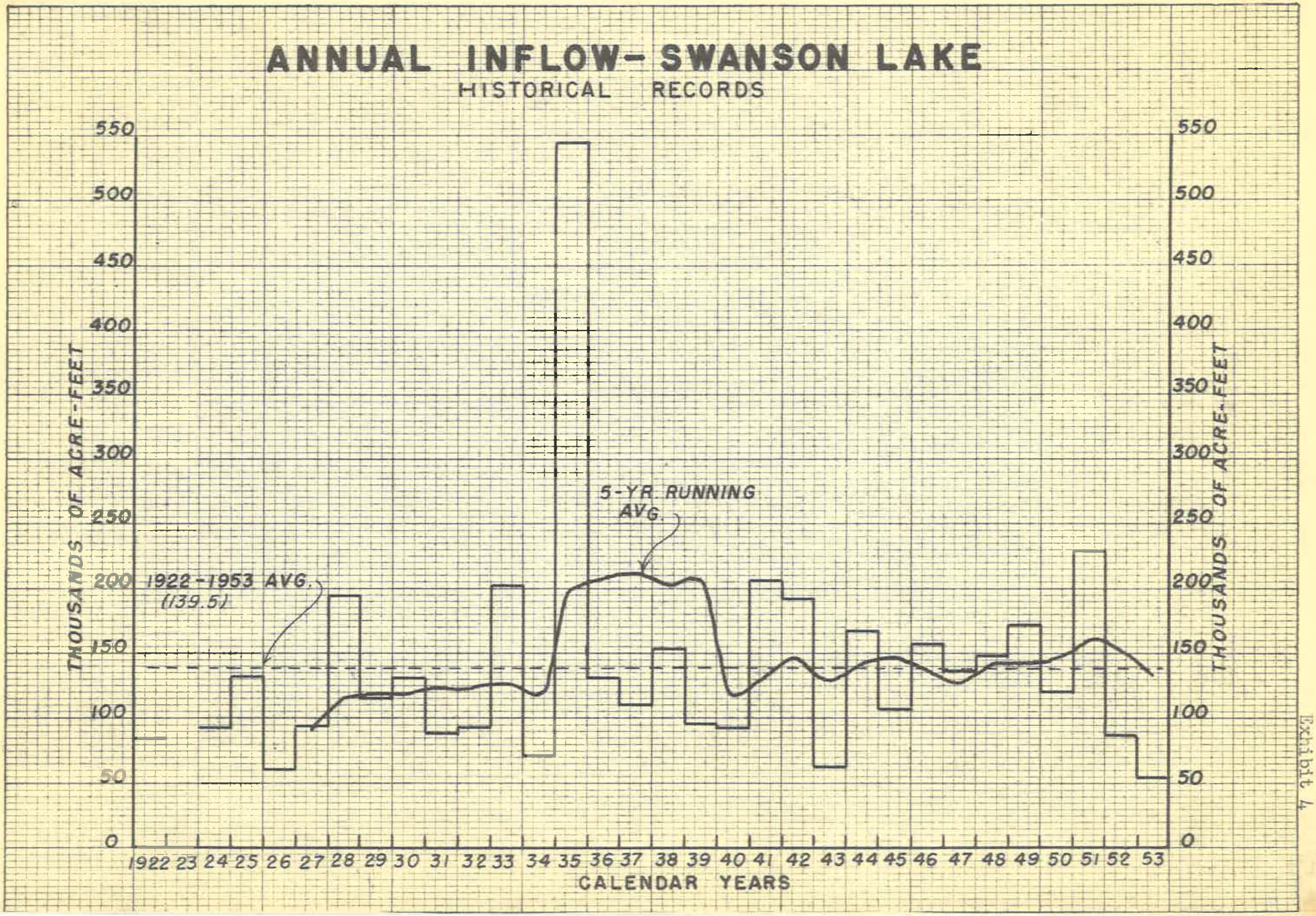

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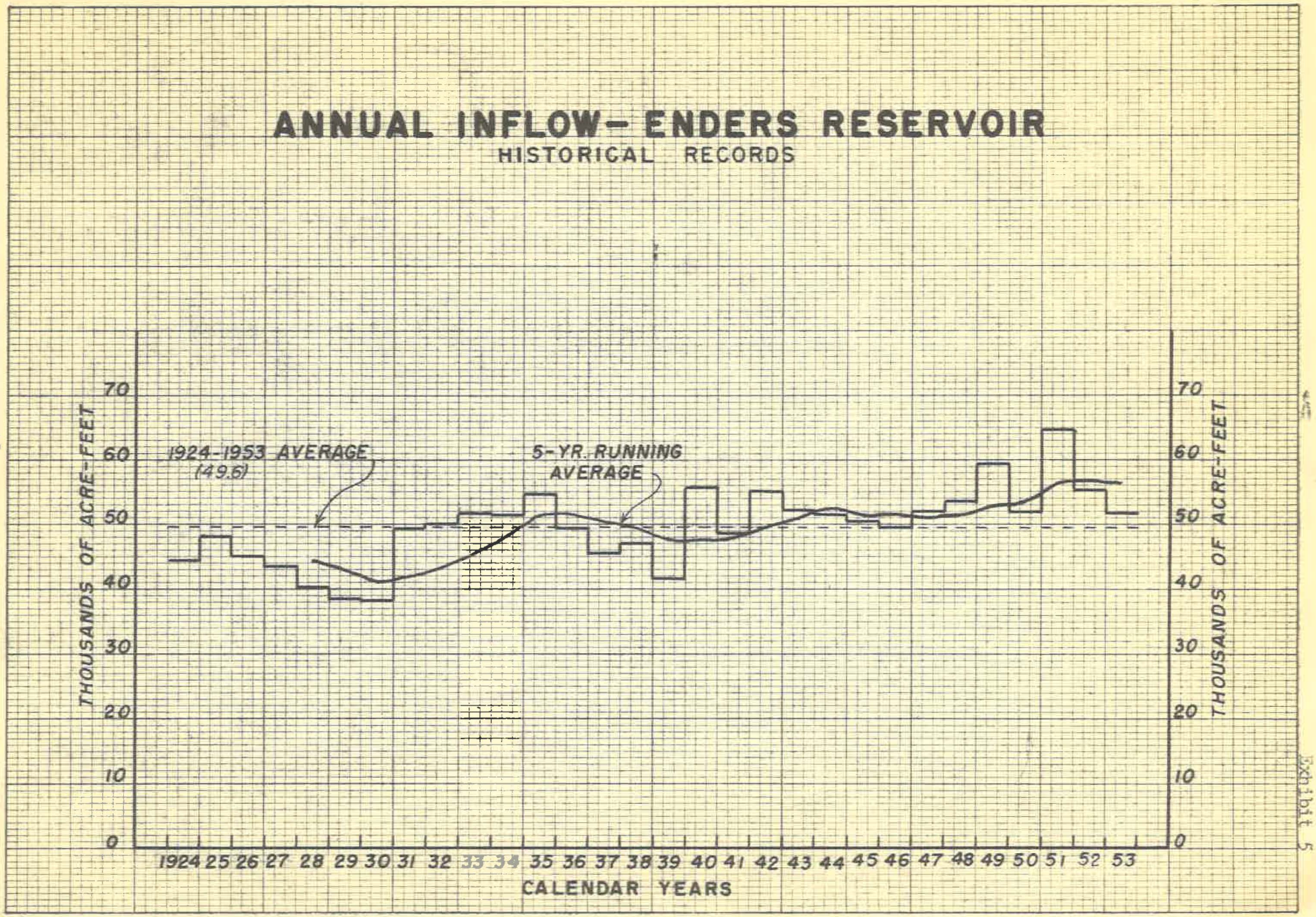
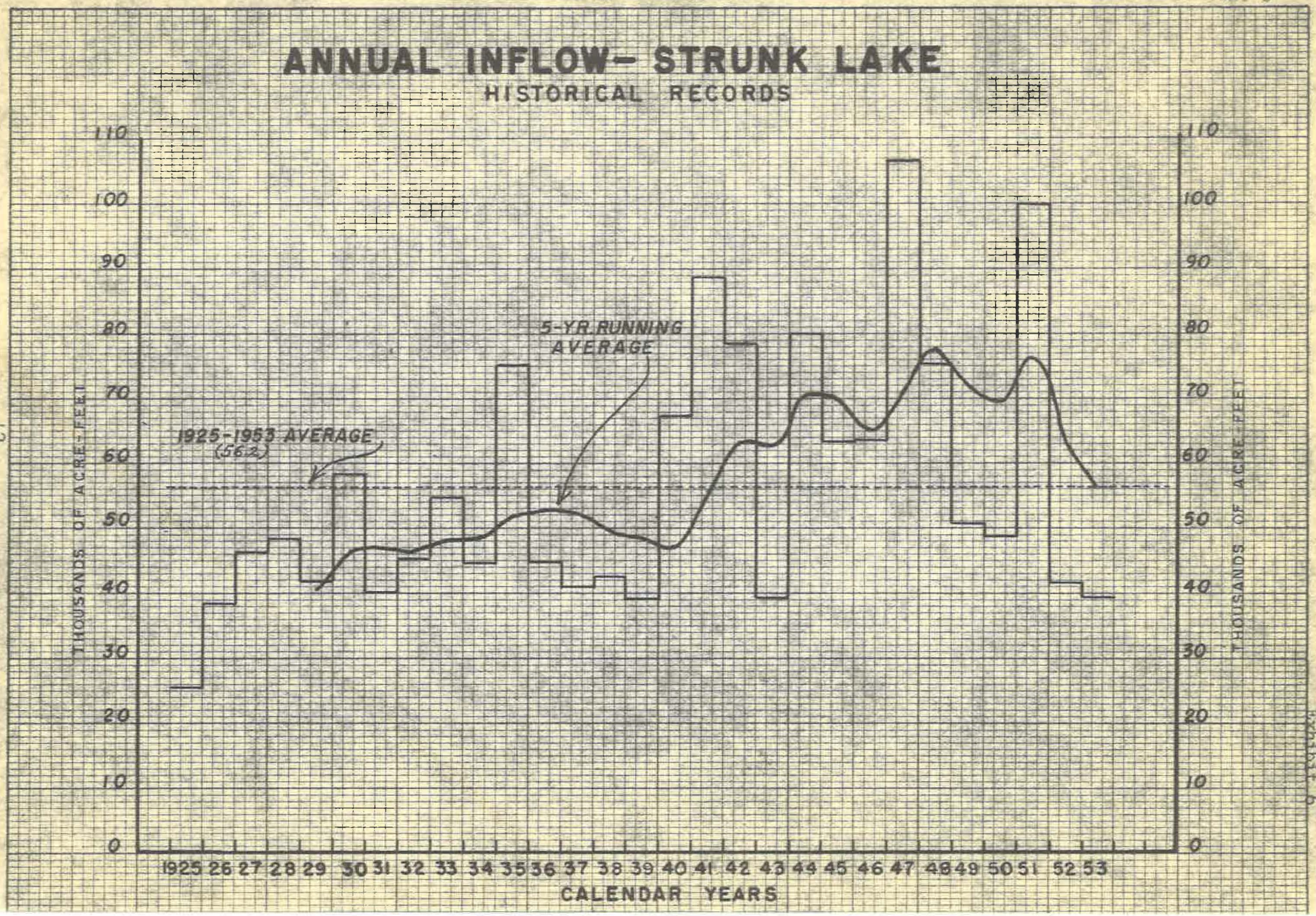
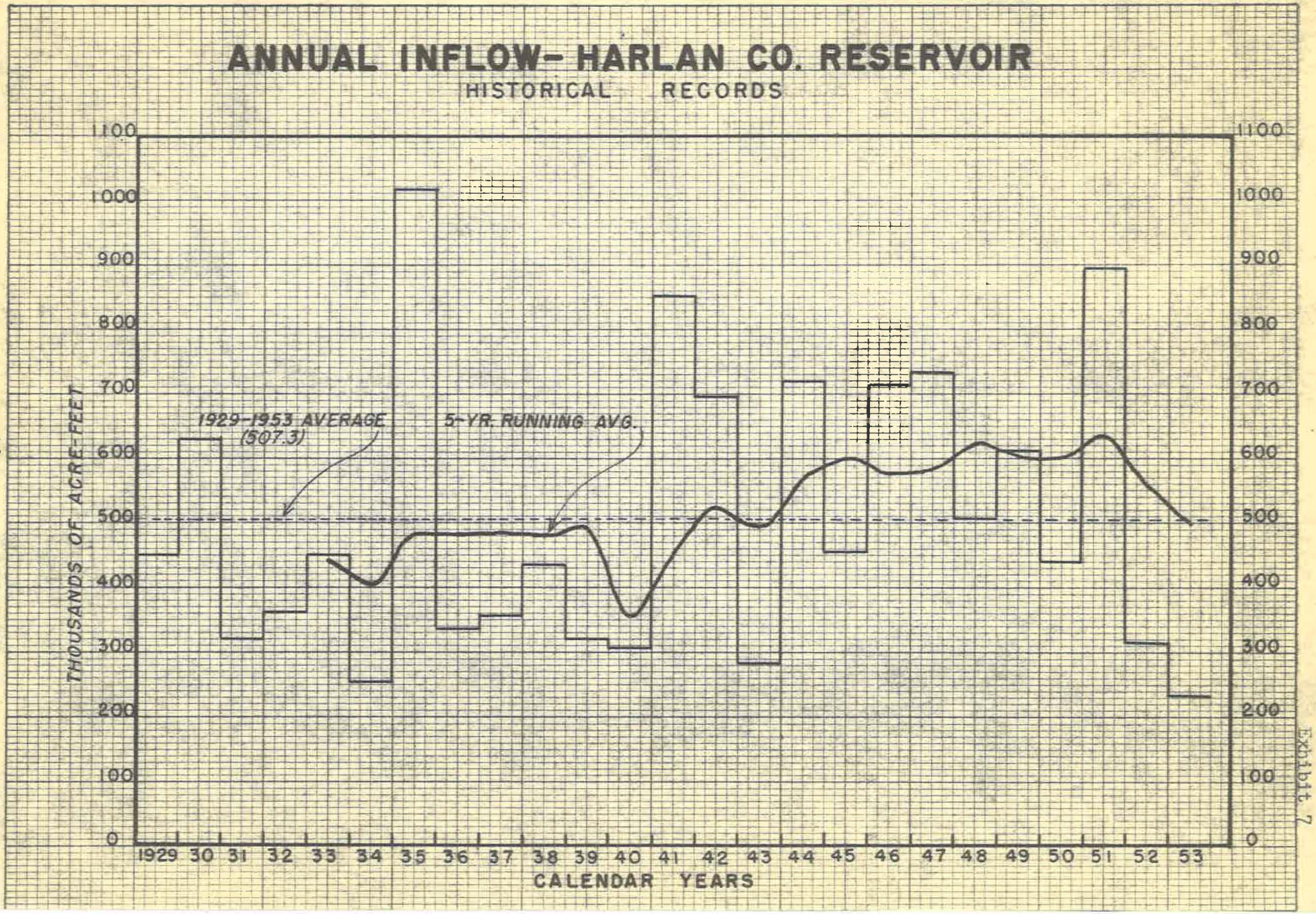


Exhibit 5

ANNUAL INFLOW- STRUNK LAKE

HISTORICAL RECORDS





ANNUAL INFLOW – CEDAR BLUFF RESERVOIR

HISTORICAL RECORDS

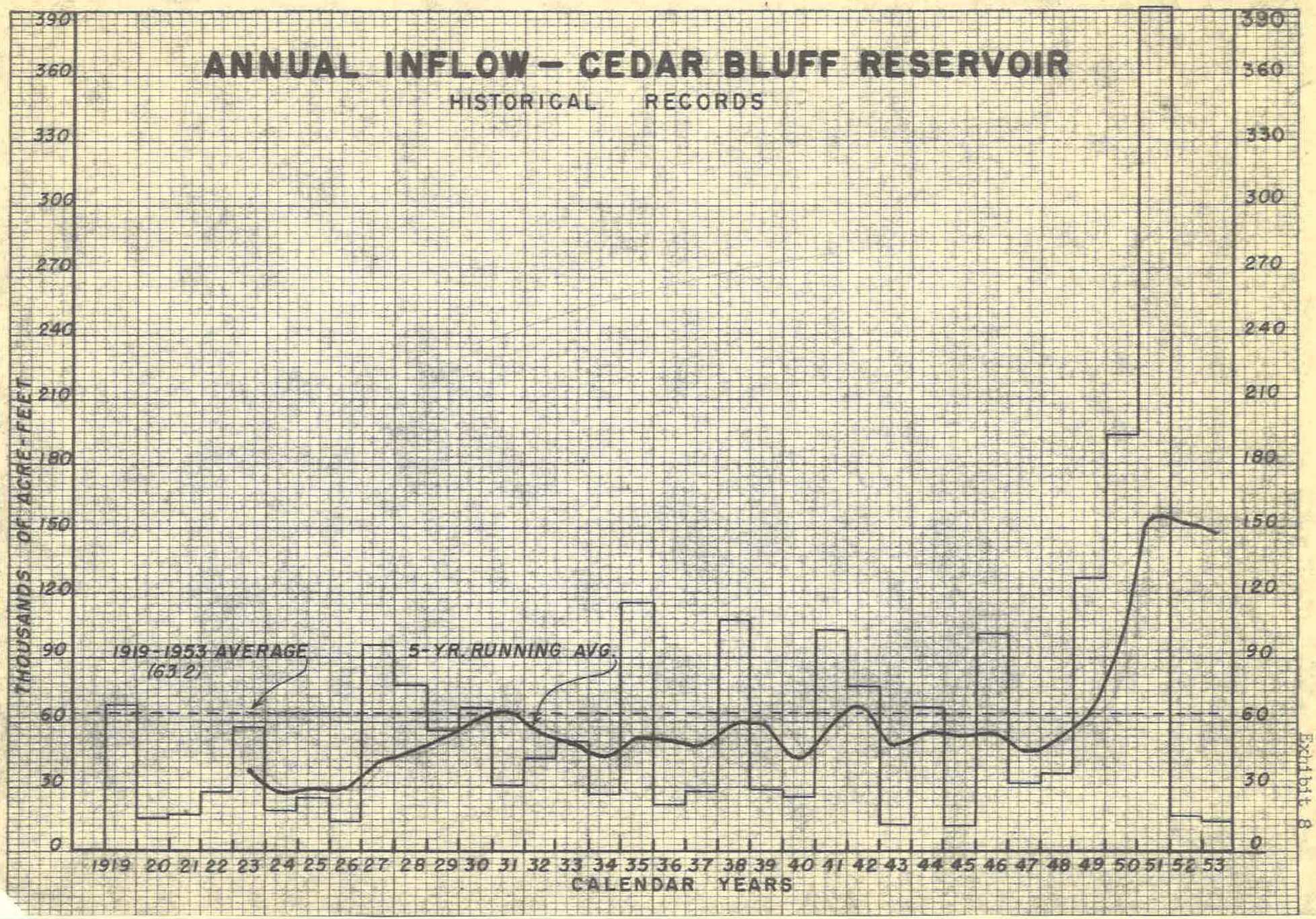


Exhibit 8

Exhibit 9

RESERVOIR OPERATIONS—KANSAS RIVER BASIN

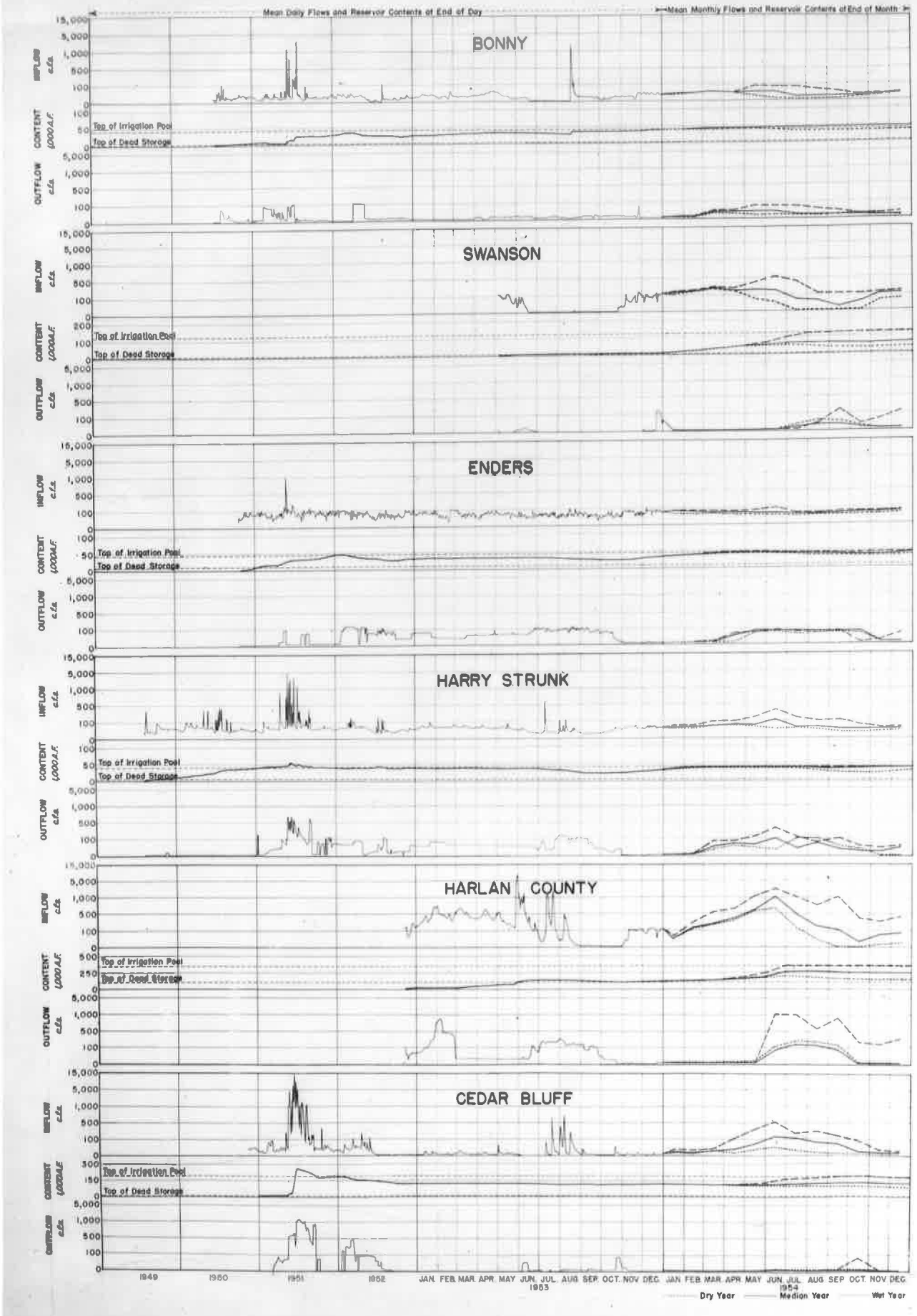
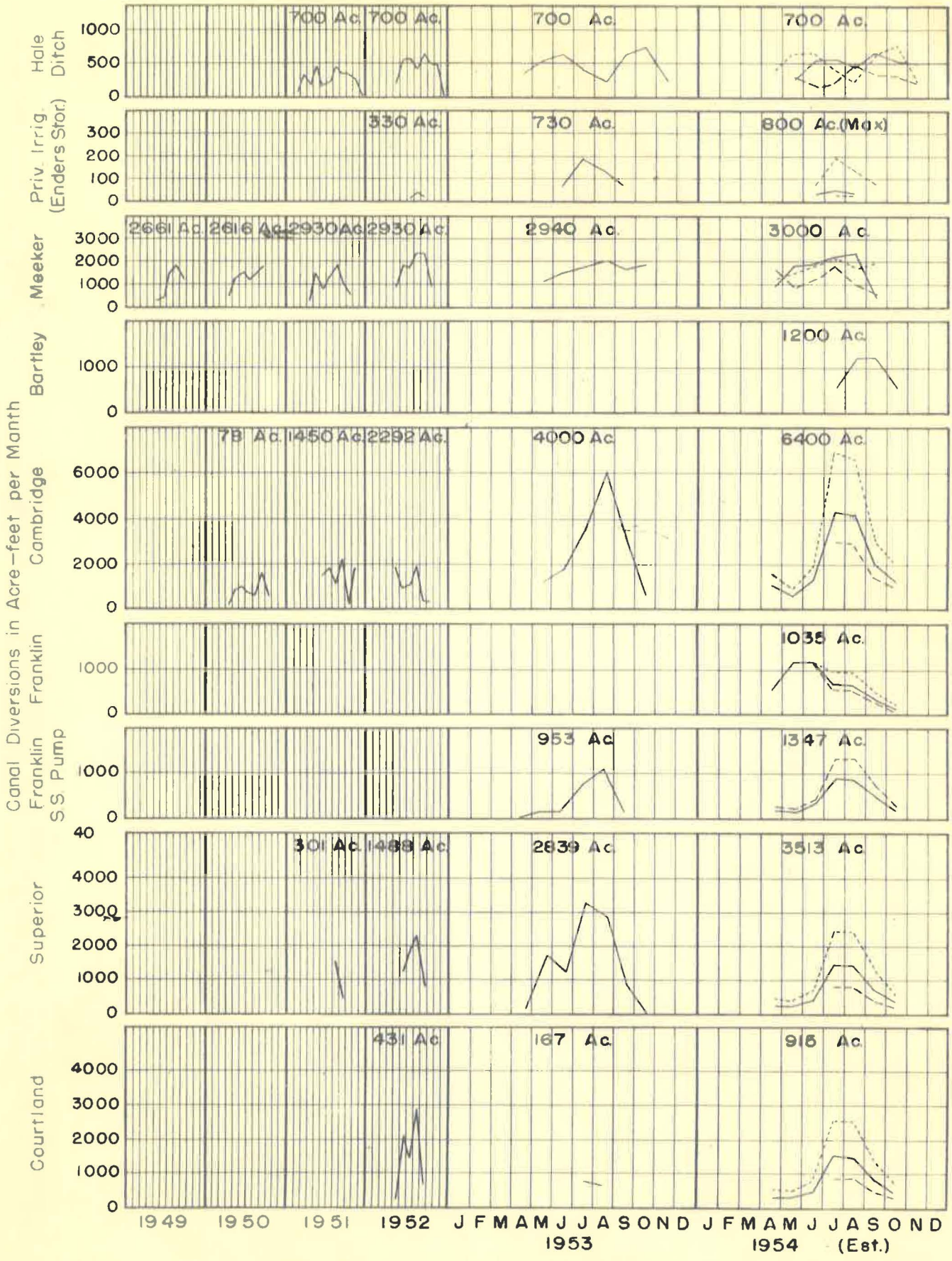


Exhibit 10

CANAL DIVERSIONS -- ACRES IRRIGATED



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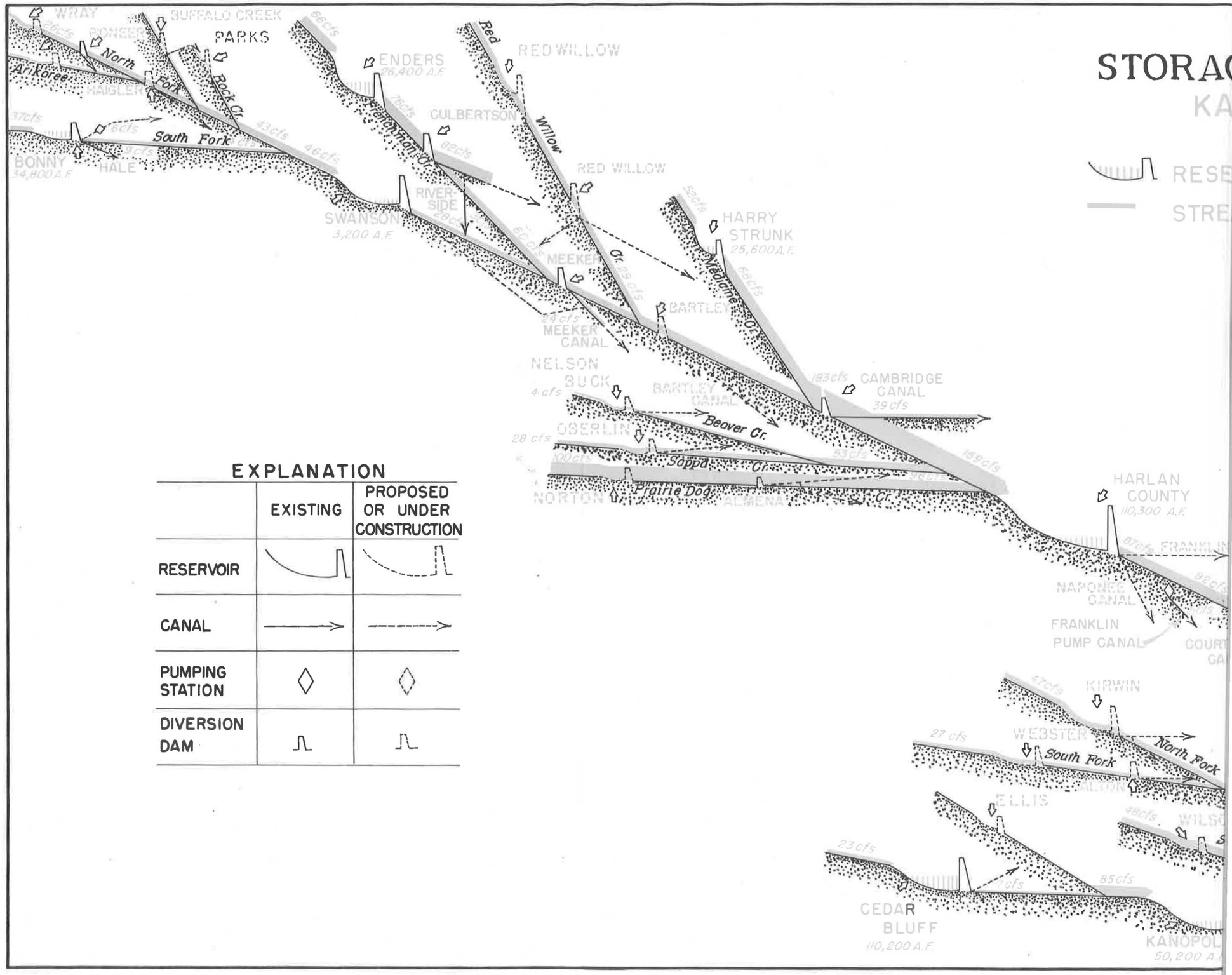

EXPLANATION

	EXISTING	PROPOSED OR UNDER CONSTRUCTION
RESERVOIR		
CANAL	——→	- - - →
PUMPING STATION	◇	◇
DIVERSION DAM	⎍	⎍

STORAGE AND STREAM FLOW

KANSAS RIVER SYSTEM

RESERVOIR STORAGE Oct. 31, 1953

STREAM AND CANAL FLOWS Months of Apr. 1, to Oct. 31, 1953

ENDERS 26,400 A.F.
GULBERTSON
Frenchman Cr.
RIVER SIDE
SWANSON 3,200 A.F.
Red
REDWILLOW
Willow
RED WILLOW
MEEKER
Cr.
MEEKER CANAL
HARRY STRUNK 25,600 A.F.
Medicine Cr.
BARTLEY
BARTLEY CANAL
NELSON
BUCK
OBERLIN
Beaver Cr.
Sappa Cr.
Prairie Dog
NORTON
ACME
CAMBRIDGE CANAL 39 cfs
HARLAN COUNTY 110,300 A.F.
FRANKLIN CANAL
SUPERIOR CANAL
NAPONEE CANAL
FRANKLIN PUMP CANAL
COURTLAND CANAL
KIRWIN
WEBSTER
South Fork
North Fork
White Rock Cr.
LOVEWELL
SCANDIA
GLEN ELDER
Republican River
ELLIS
WILSON
Saline
Solomon
River
Smoky Hill River
CEDAR BLUFF 110,200 A.F.
KANOPOLIS 50,200 A.F.
JUNCTION CITY

ATION

NG	PROPOSED OR UNDER CONSTRUCTION

GPO 831614

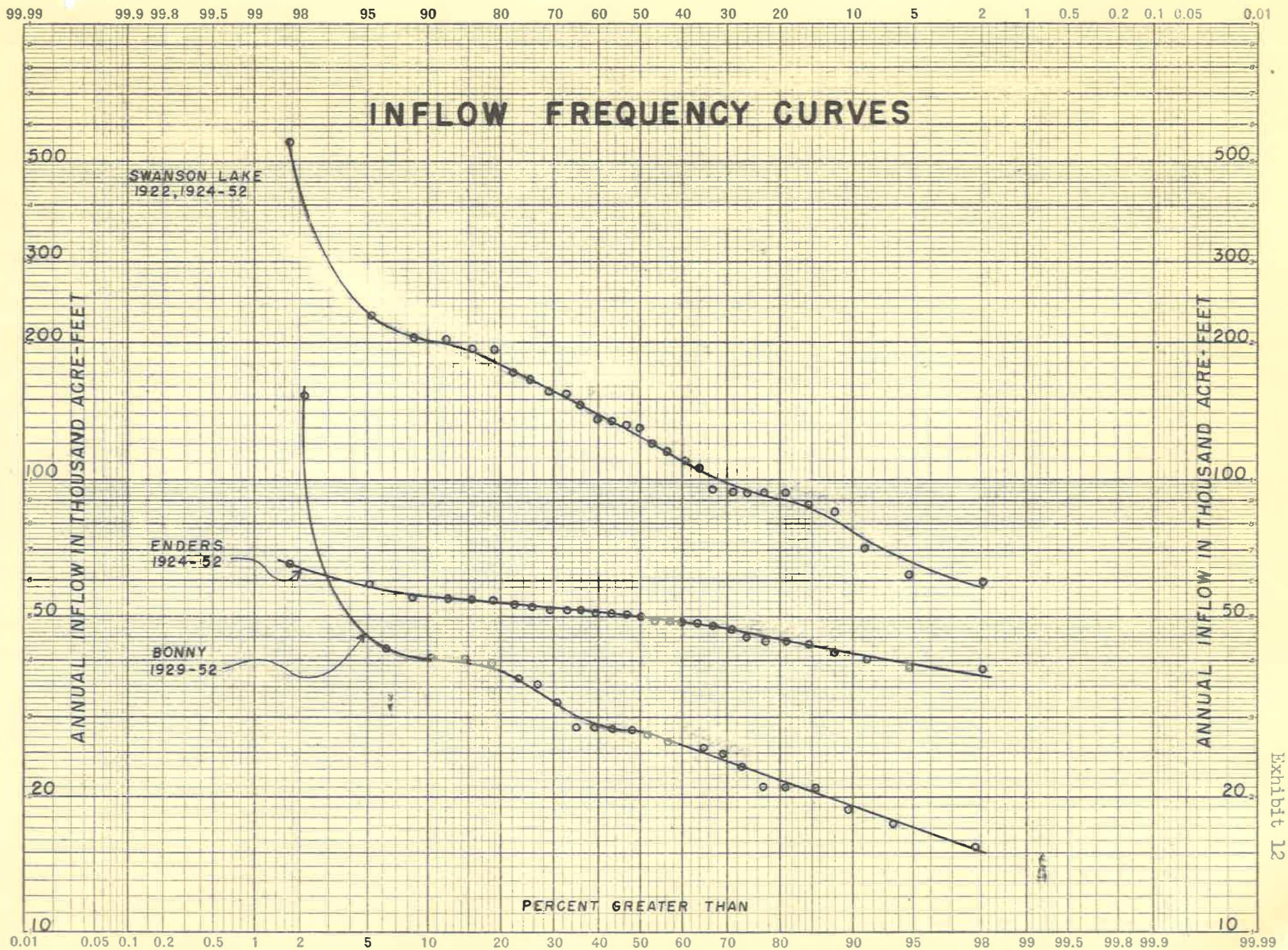
INFLOW FREQUENCY CURVES
SWANSON LAKE
1922, 1924-52
ENDERS
1924-52
BONNY
1929-52
ANNUAL INFLOW IN THOUSAND ACRE-FEET
PERCENT GREATER THAN
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
500
300
200
100
50
20
10

Exhibit 12

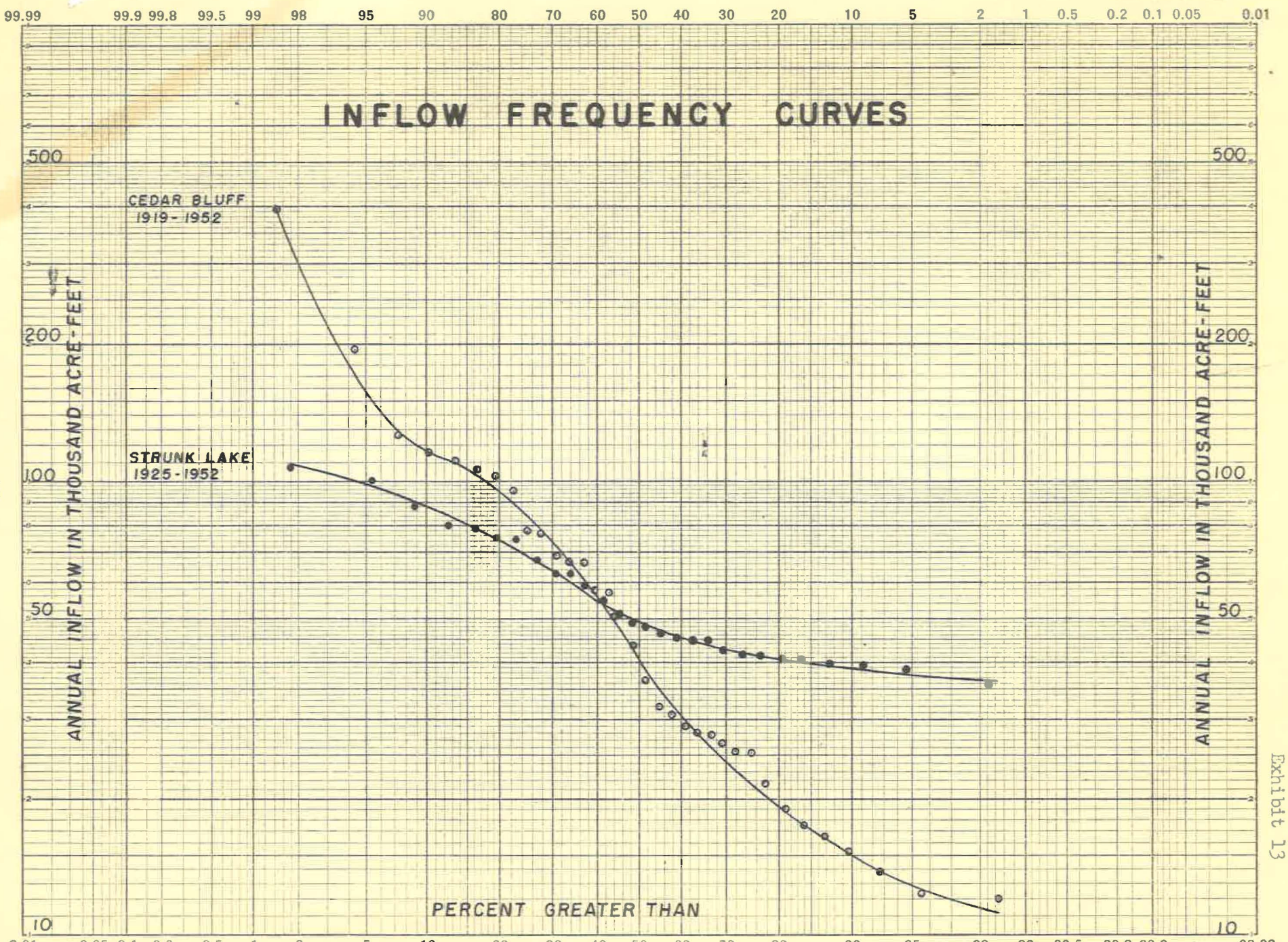
INFLOW FREQUENCY CURVES
CEDAR BLUFF
1919 - 1952
STRUNK LAKE
1925 - 1952
ANNUAL INFLOW IN THOUSAND ACRE-FEET
PERCENT GREATER THAN
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
500
200
100
50
10

Exhibit 13

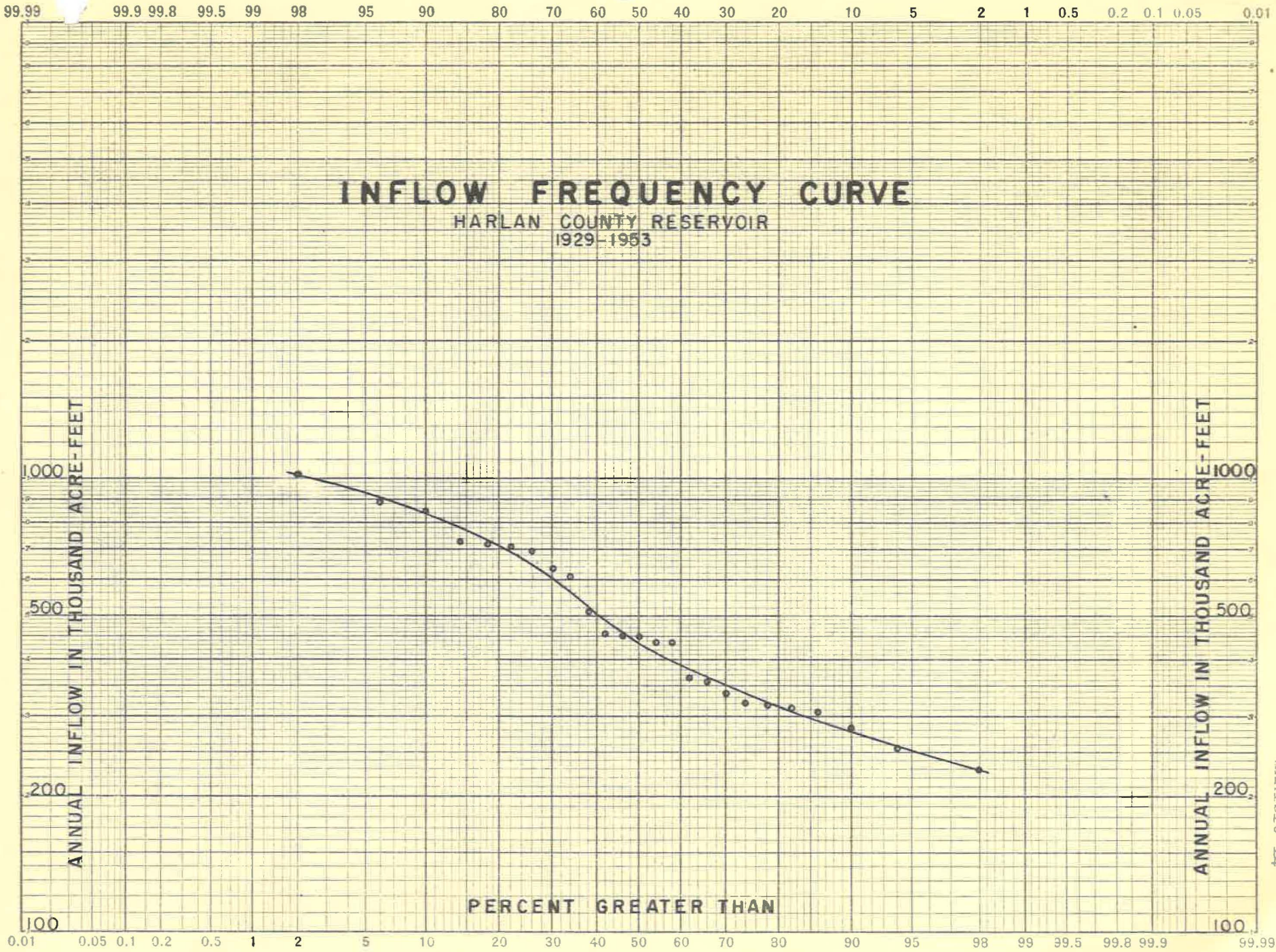
INFLOW FREQUENCY CURVE
HARLAN COUNTY RESERVOIR
1929-1953
ANNUAL INFLOW IN THOUSAND ACRE-FEET
PERCENT GREATER THAN
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
1000
500
200
100

Exhibit 14