PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS, SOILS, AND MINERALS

SURFACE WATER

EXPLANATION

Number above line indicates approximate drainage area in square miles; number below line is percentage of drainage area in lakes

Gaging station

Area in which major floods occurred during the spring of 1950

The Red Lake River flooded ½ to ¾ mile in width in most other reaches in 1950. This flood exceeded in discharge any other flood of record. The Clearwater and major tributaries although having the 1941 flood exceeded the 1950 flood stage because of ice jams. The highest flood known on the Red River of the North since 1861 occurred in 1897

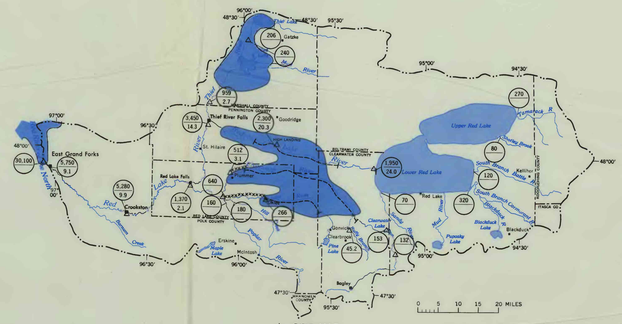
Enlargement of stream channel

Snagging and clearing stream channel

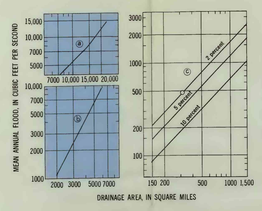
The channel modification designed to provide for floods of a greater frequency, was completed after the 1950 flood

Crookston and East Grand Forks, Minn.-Grand Forks, N. Dak. protected from floods by levees and floodwalls

Watershed boundary

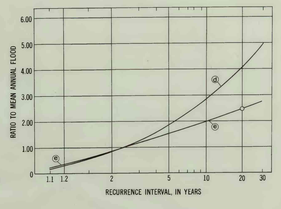


A.—SITE MAP



B.—RELATION CURVES OF MEAN ANNUAL FLOOD TO DRAINAGE AREA

(A) Main stem Red River of the North
(B) Main stem Red Lake River
(C) Red Lake River watershed, except (B) and (S) with percentage of drainage area in lakes as a factor



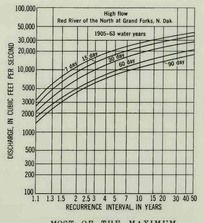
C.—FLOOD-FREQUENCY CURVES

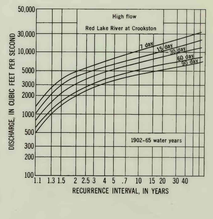
(A) Main stem Red River of the North
(B) Red Lake River watershed, except (S)

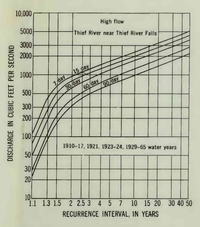
Example: The recurrence interval of a flood of a selected magnitude, or the magnitude of a flood at a specified recurrence interval can be determined by use of drainage area (Map A, for selected sites) relation curves (B) and Flood-frequency curves (C). Follow steps 1-3 to find the recurrence interval of a flood of 1,200 cfs on the Clearwater River at a site having a drainage area of 110 square miles, of which 2 percent is lakes:

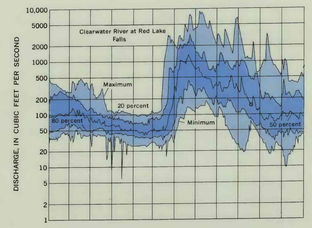
1. Enter diagram (B); curve (c) with a drainage area of 310 sq mi—the 2 percent curve shows the mean annual flood 480 cfs.
2. Compute the ratio of the 1,200 cfs flood to the mean annual flood (480 cfs) $\frac{1200}{480} = 2.50$.
3. Enter diagram (C); with a ratio to mean annual flood of 2.50—the frequency curve (a) shows that the 1,200 cfs flood will occur on an average once every 20 years.

The magnitude of a flood at a specified recurrence interval at this same site can also be found by reversing the procedure. Relation and frequency curves from Prior and Hess (1961).

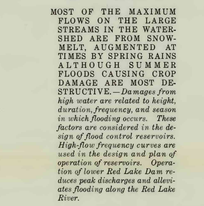


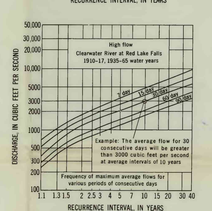


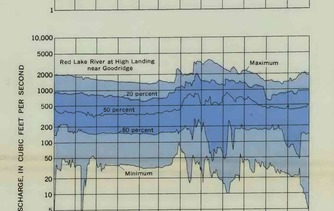


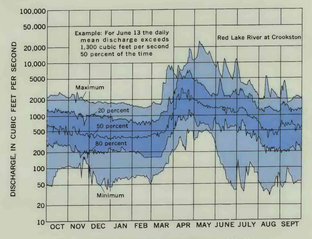


MOST OF THE MAXIMUM FLOWS ON THE LARGE STREAMS IN THE WATERSHED ARE FROM SNOWMELT, AUGMENTED AT TIMES BY SPRING RAINS ALTHOUGH SUMMER FLOODS CAUSING CROP DAMAGE ARE MOST DESTRUCTIVE.—*Damages from high water are related to height, duration, frequency, and season in which flooding occurs. These factors are considered in the design of flood control reservoirs. High-flow frequency curves are used in the design and plan of operation of reservoirs. Operation of lower Red Lake Dam reduces peak discharges and alleviates flooding along the Red Lake River.*









DAILY DURATION HYDROGRAPHS, 1943-61
WATER YEARS

THE VARIATION OF DAILY MEAN DISCHARGE FOR EACH DAY AND THE SEASONAL VARIATION OF DAILY MEAN DISCHARGE FOR CLEARWATER RIVER AT RED LAKE FALLS IS REPRESENTATIVE OF NATURAL STREAMFLOW IN THE WATERSHED.—*Regulation by storage in Upper and Lower Red Lakes affects the natural runoff pattern of Red Lake River by reducing the seasonal variations in daily mean discharge for Red Lake River at High Landing. Red Lake River at Crookston is influenced by both regulated and natural streamflow. The smallest range in daily mean discharge of unregulated streams in the watershed occurs in late winter just prior to spring breakup. The lowest flows occur during the winter and the highest during the spring and early summer.*

MAJOR FLOODS ON LARGE DRAINAGE AREAS ARE FROM SNOWMELT AND SPRING RAINS BUT FLOODS ON SMALL DRAINAGE AREAS RESULT FROM HEAVY LOCAL SUMMER THUNDERSTORM RAINFALL.

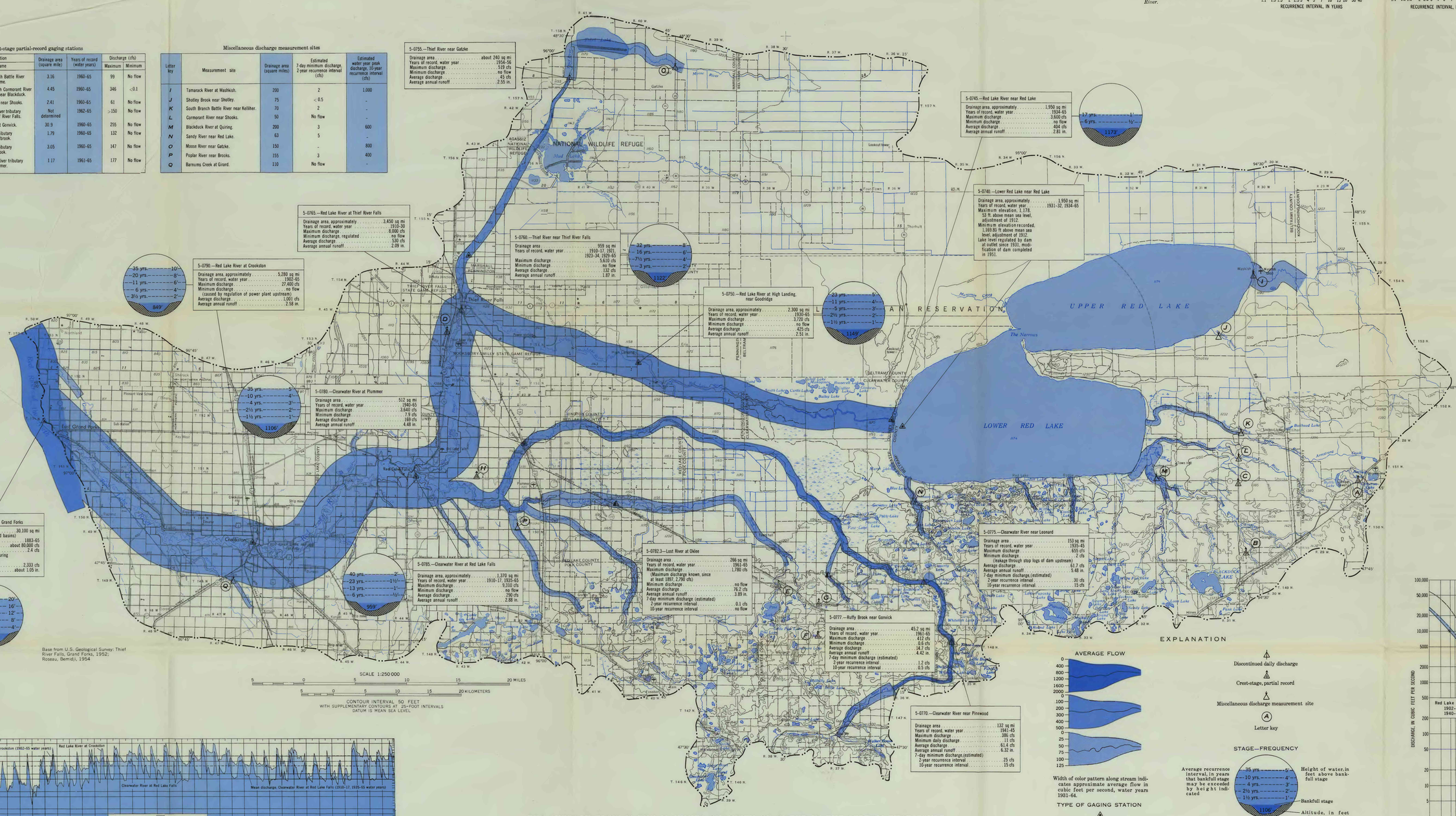
Flood discharge of a specific recurrence interval for a site in the watershed is related to the mean annual flood, the drainage area, and the percentage of the drainage area in lakes. Flood peaks are proportionately smaller on drainage areas that have a large percentage of the area in lakes. Separate relationships of mean annual flood to drainage area are used for (1) The Red River of the North (2) Red Lake River and (3) tributaries of the Red Lake River and minor streams. The frequency relation for Red River of the North is different than that for other streams in the watershed. Upper and Lower Red Lakes are used as flood control reservoirs and the relation and frequency curves for Red Lake River are unreliable between Lower Red Lake and High Landing.

Crest-stage partial-record gaging stations

Letter key	Gaging station Number	Gaging station Name	Drainage area (square mile)	Years of record (water year)	Discharge (cfs) Maximum	Discharge (cfs) Minimum
A	5-0736	South Branch Battle River at Northome.	3.16	1960-65	99	No flow
B	5-0737.5	South Branch Cormorant River tributary near Blackduck.	4.45	1960-65	346	<0.1
C	5-0738	Perry Creek near Shooks.	2.41	1960-65	61	No flow
D	5-0766	Red Lake River tributary near Thief River Falls.	Not determined	1962-65	>150	No flow
E	5-0781	Lost River at Gonvick.	30.9	1960-65	255	No flow
F	5-0781.8	Lost River tributary near Clearbrook.	1.79	1960-65	132	No flow
G	5-0782	Lost River tributary at Clearbrook.	3.05	1960-65	147	No flow
H	5-0784	Clearwater River tributary near Plummer.	1.17	1961-65	177	No flow

Miscellaneous discharge measurement sites

Letter key	Measurement site	Drainage area (square miles)	Estimated 7-day minimum discharge, 2-year recurrence interval (cfs)	Estimated water year peak discharge, 10-year recurrence interval (cfs)
I	Tamarack River at Washkish.	200	2	1,000
J	Shotley Brook near Shotley.	75	<0.5	-
K	South Branch Battle River near Kelliher.	70	2	-
L	Cormorant River near Shooks.	50	No flow	-
M	Blackduck River at Quining.	200	3	600
N	Sandy River near Red Lake.	63	5	-
O	Moose River near Gatzke.	150	-	800
P	Poplar River near Brooks.	155	3	400
Q	Bemidus Creek at Grand.	110	No flow	-



EXPLANATION

AVERAGE FLOW

Width of color pattern along stream indicates approximate average flow in cubic feet per second, water years 1931-64.

TYPE OF GAGING STATION

Continuous automatic recording

Continuous non-recording

Discontinued daily discharge

Crest-stage, partial record

Miscellaneous discharge measurement site

Letter key

STAGE-FREQUENCY

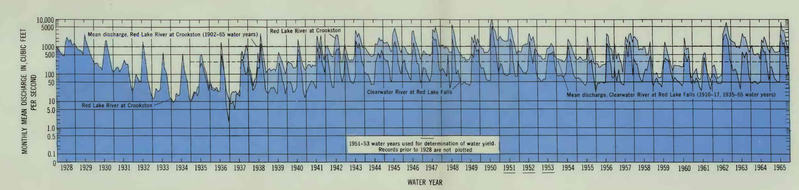
Average recurrence interval, in years that bankfull stage may be exceeded by height indicated

Height of water, in feet above bankfull stage

Bankfull stage

Altitude, in feet above mean sea level, of bankfull stage

Watershed boundary

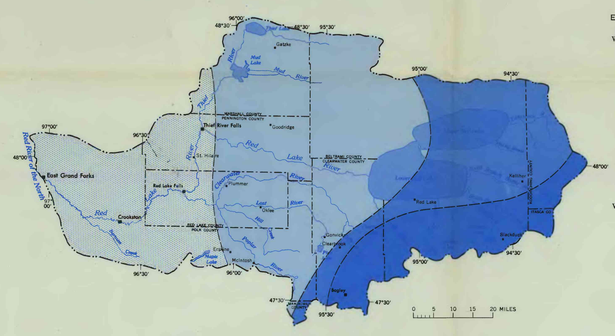


SIMILAR MONTHLY AND SEASONAL VARIATIONS IN DISCHARGE OCCUR ON THE RED LAKE AND CLEARWATER RIVERS AND THEIR TRIBUTARIES

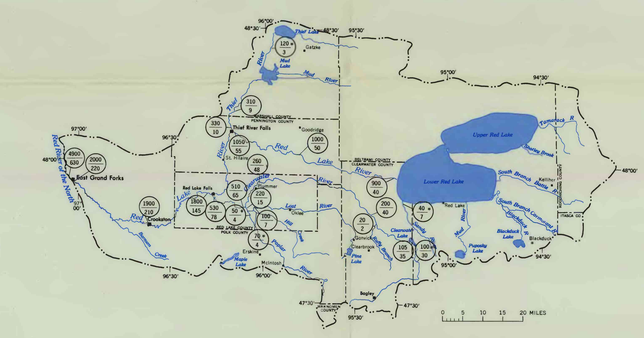
Generally the highest streamflow is in the spring, followed by a recession through the late summer, fall, and winter months. Storage and later release of spring runoff in Upper and Lower Red Lakes reduces the monthly and seasonal variation on the Red Lake River. Although the monthly and seasonal variations in discharge of the Red River of the North are similar to the discharge of the Red Lake River the extremes are further modified by additional reservoirs on upstream tributaries in Minnesota and North Dakota. The low streamflow of the Red Lake and Clearwater Rivers that occurred during the severe drought years of the 1930's is typical of all streams in the watershed.

THE AVERAGE FLOW IS THE MAXIMUM QUANTITY OF WATER IN THE STREAM THAT COULD, THEORETICALLY, BE DEVELOPED FOR A WATER SUPPLY.

Evaporation, seepage losses, and lack of suitable reservoir sites prevent utilization of the maximum quantity available. About half the average flow of the Red River of the North below East Grand Forks comes from the Red Lake River. High flow stored in Upper and Lower Red Lakes reduces flooding and augments low flow for water supply and pollution abatement in the Red Lake River and Red River of the North below East Grand Forks. The ground-water reservoirs and the lakes and swamps in the southeastern part of the morainal area are effective in reducing flood peaks and increasing low flow in the upper reaches of the Clearwater River. The management of the Agassiz pool within the Agassiz National Wildlife Refuge to control spring runoff minimizes flooding and sustains low flows into the Thief River below the refuge. The stage of Red Lake River near Red Lake is controlled by the operation of the dam but the effect on stage becomes progressively less downstream. The stage of the Red River of the North is partly controlled by the Red Lakes and by reservoirs on other upstream tributaries outside the watershed. Tops of levees in Crookston are about 12 feet higher than bankfull stage at the gaging station and height and frequency of flooding above bankfull stage refer to unleveed areas. The surface area of Upper and Lower Red Lakes is about 151 square miles at a lake surface altitude of 1173.4 feet above mean sea level.



RUNOFF IN THE HEADWATERS OF THE CLEARWATER RIVER AND THE SMALL STREAMS FLOWING INTO LOWER RED LAKE IS MORE THAN FOUR TIMES THE RUNOFF IN THE GLACIAL LAKE AGASSIZ PLAIN.—*Precipitation is similar in distribution in the watershed, increasing from west to east (see precipitation map, sheet 1). The low relief and slope of the land surface and the small capacity of natural channels result in slow runoff and flooding in the lake plain. This flooding is aggravated by relatively rapid runoff from streams with steeper gradients in the morainal area. Drainage in most parts of the lake plain has been accelerated by ditching and channel modification.*



THE GREATEST RANGE IN ANNUAL MEAN DISCHARGE IN THE WATERSHED OCCURS IN THE NORTHERN THIRD WHICH IS AN AREA OF FLAT TERRAIN, MANY BOGS, AND A FEW LARGE LAKES.—*The ratio of the low 10-year to the high 10-year annual mean discharge is largest in the Thief River; whereas the smallest ratio is in the Clearwater River, especially in the headwaters in the morainal where the stream flows through outwash sand and gravel. Moderate ratios occur in the Lost River and its major tributaries and in the lower reaches of the Red Lake River where the discharge is the integrated flow from most of the watershed.*

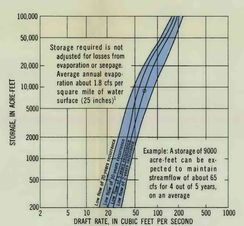
EXPLANATION

(12/2)

Numbers indicate 10-year annual mean discharge in cubic feet per second
Upper number is for 10 percent of the years annual mean discharge will be less than shown
Lower number is for 10 percent of the years annual mean discharge will be less than shown

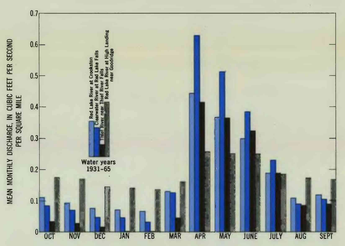
Estimated

Watershed boundary

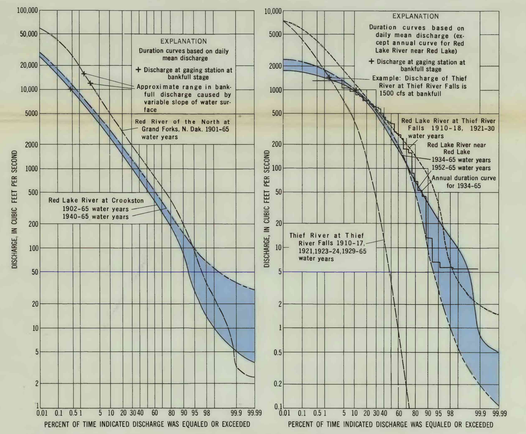


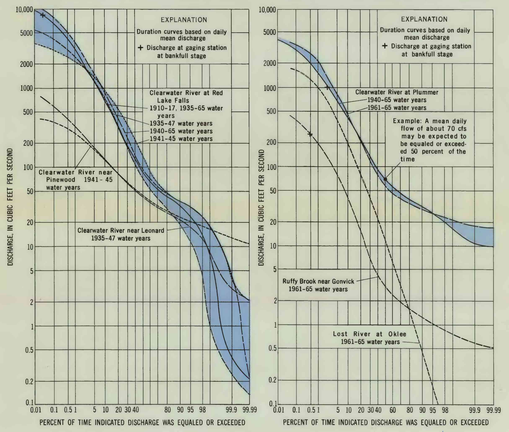
[1]Evaporation computed from data published in Technical Paper No. 37, Evaporation Maps for the United States, U.S. Weather Bureau.

SUSTAINED STREAMFLOW IN THE WATERSHED REQUIRES STORAGE OF HIGH FLOW THAT CAN BE RELEASED TO AUGMENT LOW FLOW.—*Although the draft-storage relationship curves are computed from the discharge records for Clearwater River they can be used to estimate similar relationships throughout the watershed except for the upper Red Lake River which is regulated by Lower Red Lake Dam. These curves do not cover a drought of the severity of that of the 1930's.*



STORAGE OF HIGH SPRING RUNOFF IN THE UPPER AND THE LOWER RED LAKES EFFECTIVELY REDUCES THE MEAN MONTHLY DISCHARGE OF RED LAKE RIVER DURING THE SPRING AND EARLY SUMMER.—*The stored water is later released to augment the low discharge in Red Lake River during the months of normally low runoff. Thief and Clearwater Rivers have greater monthly variation in runoff per square mile than the main stem of Red Lake River because they have less reservoir storage. Although the Thief River has periods of extremely low flows in the winter and occasional periods of no flow, the range in mean monthly discharge per square mile is less in the Thief River than in the Clearwater River. The average mean monthly discharge of the Red Lake River at Crookston shows the effect of flow from both regulated and unregulated streams.*





RIVERS THAT ARE LARGELY WITHIN THE GLACIAL LAKE AGASSIZ PLAIN ARE VARIABLE AND HAVE LOW BASE FLOW; TYPICAL ARE THE THIEF AND LOST RIVERS.—*In contrast the flow from lakes and morainal deposits sustains the base flow in the Clearwater River and its tributaries. Storage in the Upper and Lower Red Lakes has been controlled by an outlet dam since 1921 (modified in 1951 for greater control) although annual mean outflow into Red Lake River is not affected most years. Storage of ground water contributing to base flow throughout the watershed was severely depleted during the extreme drought of the 1930's. The pattern of streamflow of the Red River of the North at Grand Forks, North Dakota is similar to that of the Red Lake River at Crookston.*

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1970—W65321

WATER RESOURCES OF THE RED LAKE RIVER WATERSHED, NORTHWESTERN MINNESOTA

By
L. E. Bidwell, T. C. Winter, R. W. Maclay

1970