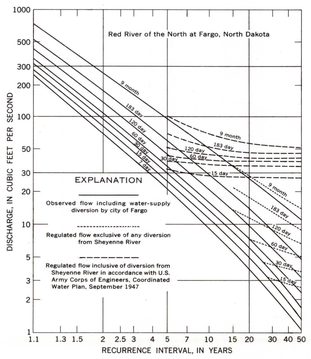
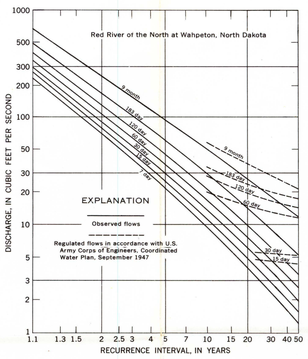
PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS, SOILS AND MINERALS

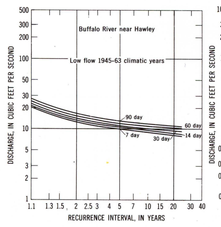
SURFACE WATER

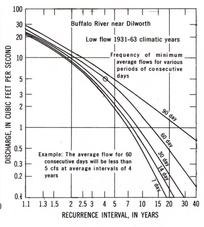


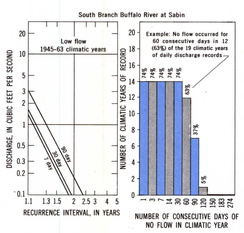


UNREGULATED LOW FLOW OF THE RED RIVER OF THE NORTH IS INADEQUATE AT TIMES FOR RIPARIAN WATER USES AND QUALITY CONTROL

The dependability of the low flow of the Red River of the North is increased by the release of water stored in Orwell Reservoir on the Otter Tail River in the headwaters of the Red River of the North. It is planned that during years of normal wetness at least 40 cfs will be released from Orwell Dam for the period June through September for water supply and pollution abatement in the Fargo, N. Dak.—Moorhead, Minn. area. During critical periods outflow may be reduced to 5 cfs (U.S. Army Corps of Engineers, 1963). The proposed diversion from the Sheyenne River into the Red River of the North has not been implemented.

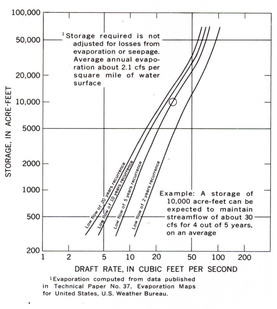




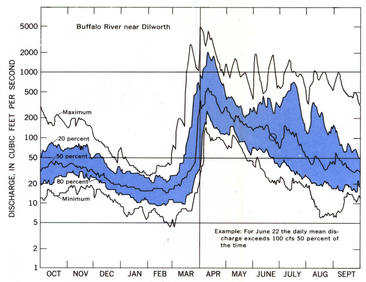


THE DURATION AND OCCURRENCE OF LOW FLOW CAN BE DETERMINED FOR BUFFALO RIVER AND SOUTH BRANCH BUFFALO RIVER, BY USE OF THE GRAPHS

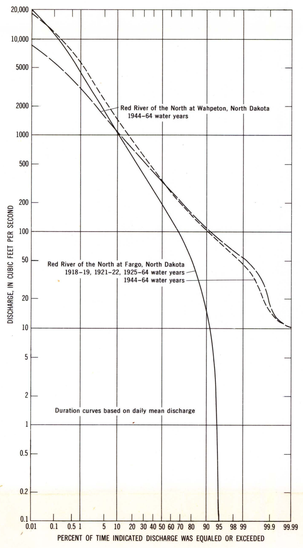
Low flow is largely from ground-water sources, and frequency curves for other sites would differ from those shown because of variations in surficial geology. The low flow of the Buffalo River near Hawley is sustained by discharge from lakes and many springs along the western base of the morainal area. The effect of the low flow during the drought of the 1930's and the days of no flow which occurred in 1936 is shown by the frequency curves for the Buffalo River near Dilworth. Freezeup and buildup of ice in the upper reaches of the tributaries cause long periods of no flow most winters on the South Branch Buffalo River.

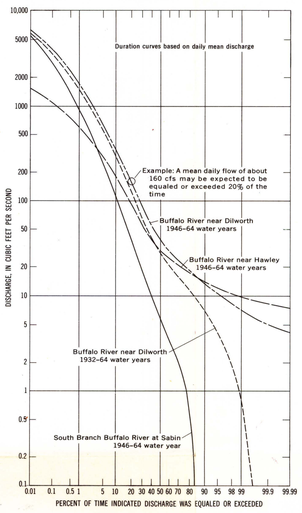


THE APPROXIMATE STORAGE REQUIRED TO MAINTAIN SPECIFIED STREAMFLOW FOR LOW FLOWS OF VARIOUS RECURRENCE INTERVALS IS SHOWN BY THE CURVES.—*Low streamflow can be increased by release of water stored during periods of high flow. The curves are computed from streamflow records of Buffalo River near Dilworth. These curves do not cover a drought of the severity of that of the 1930's.*



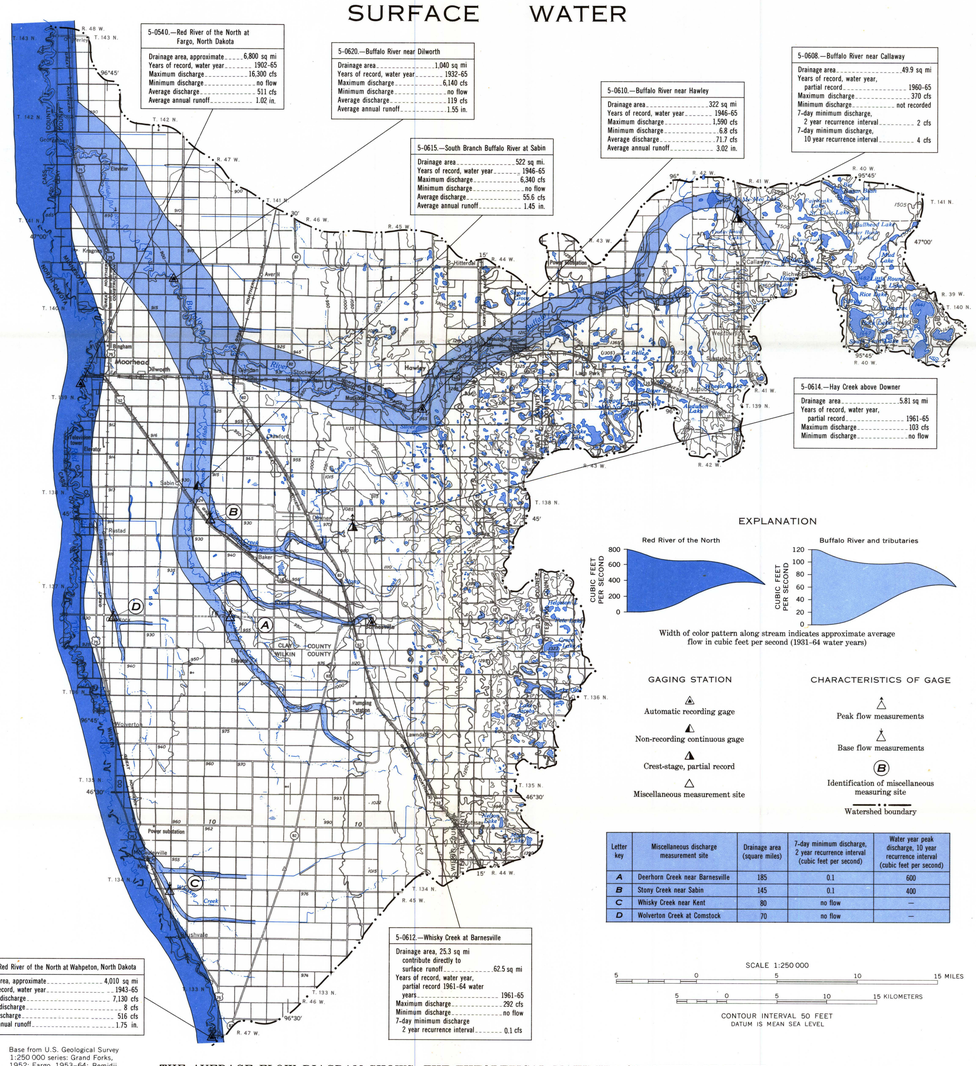
THE VARIATION OF DAILY MEAN DISCHARGE FOR EACH DAY AND THE SEASONAL VARIATION OF DAILY MEAN DISCHARGE FOR A 19 YEAR PERIOD IS SHOWN BY THE DAILY DURATION HYDROGRAPH.—*The most uniform daily mean discharge on the Buffalo River below the South Branch Buffalo River occurs in the winter.*





FLOW DURATION CURVES OF THE MAJOR STREAMS IN THE BUFFALO RIVER WATERSHED CAN BE USED TO DETERMINE STREAMFLOW AND BASIN CHARACTERISTICS

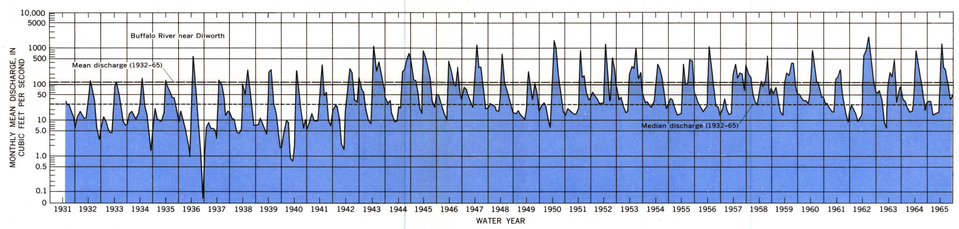
The duration curves for the 1944–64 water years for the Red River of the North at Wahpeton and at Fargo are flattened because of regulation of high and low flows by Lake Traverse (operated since 1941), Orwell Reservoir (operated since 1953) and power plants on the Otter Tail River. Sources of base flow were severely depleted during the extreme drought of the 1930's as shown by the steep slope of the downward curves at discharges less than the 90 percent flow for Red River of the North at Fargo (1918–19, 1921–22, 1925–64 water years) and Buffalo River near Dilworth (1932–64 water years). The upper Buffalo River has greater sustained flow from lakes and morainal deposits than the South Branch Buffalo River as shown by the flatter duration curves for Buffalo River near Hawley and near Dilworth for 1946–64 water years. In contrast, the steep slope of the curve for South Branch Buffalo River at Sabin for the same period reflects less storage than in the upper Buffalo River basin, although the sharp downward slope at the lower end is the result of freezeup and buildup of ice in the upper part of the tributaries of the South Branch Buffalo River.



Letter key	Miscellaneous discharge measurement site	Drainage area (square miles)	7-day minimum discharge, 2 year recurrence interval (cubic feet per second)	Water year peak discharge, 10 year recurrence interval (cubic feet per second)
A	Deerhorn Creek near Barnesville	185	0.1	600
B	Stony Creek near Sabin	145	0.1	400
C	Whisky Creek near Kent	80	no flow	—
D	Wolverton Creek at Comstock	70	no flow	—

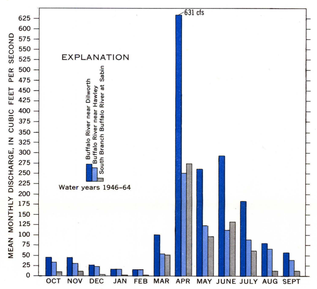
THE AVERAGE FLOW DIAGRAM SHOWS THE THEORETICAL MAXIMUM QUANTITY OF WATER IN THE STREAM THAT COULD BE DEVELOPED FOR A WATER SUPPLY

Evaporation and seepage losses and lack of suitable reservoir sites prevent utilization of the maximum quantity available. Although during periods of high flow some water is stored in lakes, swamps, and potholes, and low flow is maintained by many seeps and springs along the western base of the morainal area, the natural streamflow remains variable and storage reservoirs are necessary to provide for a dependable surface-water supply. The average discharge per square mile from the South Branch Buffalo River is about one half of that for the Buffalo River above the South Branch.

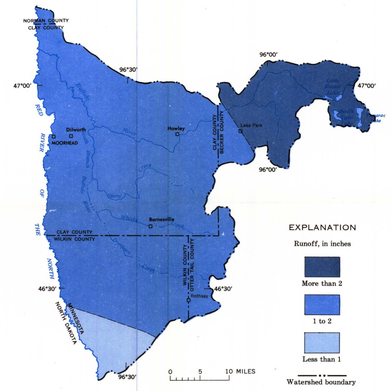


MONTHLY AND SEASONAL VARIATIONS IN DISCHARGE OCCUR IN STREAMS OF THE WATERSHED AS SHOWN BY THE HYDROGRAPH FOR BUFFALO RIVER NEAR DILWORTH

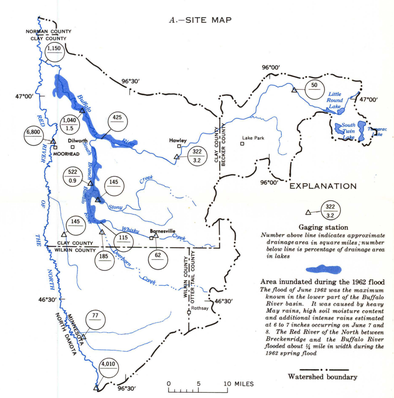
Generally, the highest streamflow is in the spring followed by a recession through the late summer, fall, and winter months. The highest mean annual runoff recorded was in the 1962 water year, and the lowest in the 1934 water year; although the only period of no flow recorded on the Buffalo River near Dilworth occurred during the summer of 1936. Monthly and seasonal variation in discharge of the Red River of the North is similar to that of the Buffalo River near Dilworth, except that the extremes are modified by regulation of reservoirs. The low discharge during the drought years of the 1930's for the Buffalo River near Dilworth is typical of all streams in the watershed.

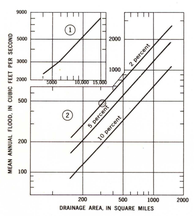


THE DISCHARGE ON THE LOWER REACH OF THE BUFFALO RIVER IS THE COMBINED FLOW FROM THE UPPER BUFFALO RIVER AND THE SOUTH BRANCH BUFFALO RIVER.—*During the spring and early summer the South Branch Buffalo River is the large contributor of surface runoff. During the late summer, fall, and winter when the streamflow is largely from ground-water sources the major contribution comes from the main stem as is shown by the records from the gage near Hawley. The regimes of the main stem and the South Branch are different and each stream has an influence on the discharge of the lower reach of the Buffalo River as recorded at the gage near Dilworth. The streamflow on the South Branch Buffalo River at Sabin is representative of that from the Glacial Lake Agassiz plain and the streamflow on the Buffalo River near Hawley is more representative of that from the morainal area.*



RUNOFF IN THE HEADWATERS OF THE BUFFALO RIVER IN THE NORTHEASTERN PART OF THE MORAINAL AREA IS OVER TWICE THE RUNOFF IN THE SOUTHWESTERN PART OF THE GLACIAL LAKE AGASSIZ PLAIN.—*Precipitation is somewhat similar in distribution in the watershed, increasing from west to east (See precipitation map, sheet 1). Flat land surface and small capacity of natural channels result in flooding and slow runoff in the lake plain. Much of the lake plain is drained by ditches. The streams generally have well defined channels in the morainal area.*





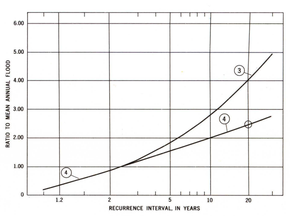
B.—RELATION CURVES OF MEAN ANNUAL FLOOD TO DRAINAGE AREA

(1) Main stem Red River of the North
(2) Buffalo River watershed, except (1), with percentage of drainage area in lakes as a factor

Example: Find the recurrence interval of a flood of 1,200 cfs on the Buffalo River at a site having a drainage area of 310 sq mi, of which 2 percent is lakes.

1. The 2 percent curve (2) in graph (B) shows that for a drainage area of 310 sq mi the mean annual flood is 480 cfs.
2. The ratio of the 1,200 cfs flood to the mean annual flood of 480 cfs is 1,200/480 or 2.50.
3. Entering graph (C) with a ratio of 2.50, the frequency curve (4) 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. Frequency and relation curves from Prior and Hess (1961).

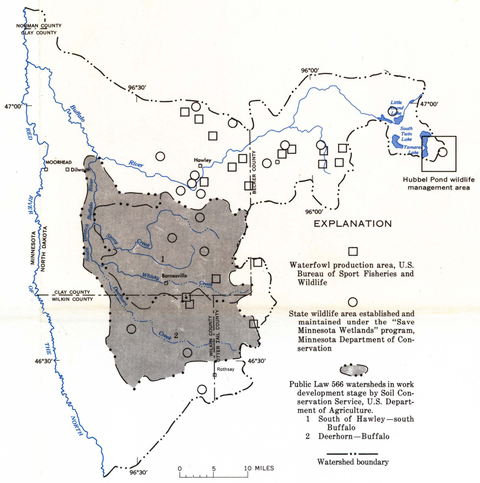


C.—FLOOD-FREQUENCY CURVES

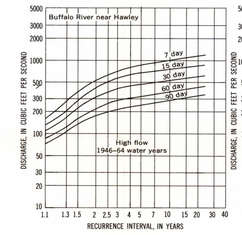
(3) Main stem Red River of the North
(4) Buffalo River watershed, except (3)

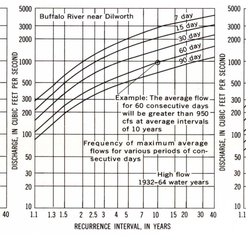
THE RECURRENCE INTERVAL OF A FLOOD OF SELECTED MAGNITUDE, OR THE MAGNITUDE OF A FLOOD AT A SPECIFIED RECURRENCE INTERVAL CAN BE DETERMINED BY USE OF DRAINAGE AREA (MAP *A*, FOR SELECTED SITES), RELATION CURVES (*B*), AND FLOOD-FREQUENCY CURVES (*C*)

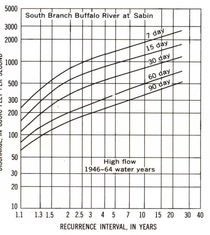
The magnitude of floods is affected by the area of lakes in the drainage basin; flood peaks are proportionately smaller on drainage areas that have a large percentage of lakes. Although most of the major floods on large drainage areas are from snowmelt and spring rains, the maximum flood of record in the lower part of the Buffalo River basin occurred in June (map A). Floods on small drainage areas result from heavy local thunderstorm rainfall. Flood peaks on tributaries with headwaters in the morainal area are reduced by storage in lakes, swamps, potholes, and noncontributing closed basins.



WATERSHED MANAGEMENT INCLUDES IMPROVED LAND TREATMENT PRACTICES, DRAINAGE-WAY MODIFICATION, AND ESTABLISHMENT OF WETLAND WILDLIFE AREAS.—*The Soil Conservation Service watershed development is designed to reduce erosion, sediment damage, and flooding and to make better use of the land and water resources. The 18 state wetland wildlife management areas and 18 federal waterfowl production areas shown on the map are managed for maximum wildlife production and public hunting. The lakes and potholes in the wildlife areas provide nesting, loafing and feeding areas for waterfowl and surrounding drier marsh areas provide habitat for pheasants, small game and some deer.*

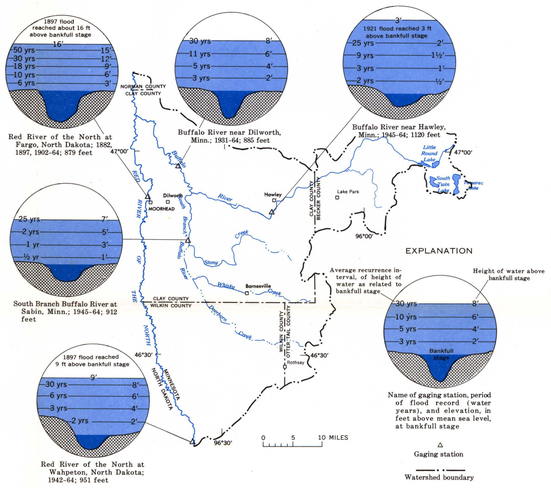






MOST OF THE MAXIMUM FLOWS ON THE BUFFALO RIVER AND SOUTH BRANCH BUFFALO RIVER ARE FROM SNOWMELT, AUGMENTED AT TIMES BY SPRING RAINS, ALTHOUGH THE LESS FREQUENT SUMMER FLOODS CAUSING CROP DAMAGE ARE THE MOST DESTRUCTIVE

Damages from high water are related to the height, duration, frequency, and season in which flooding occurs. These factors are considered in the design of flood control reservoirs, and the high flow frequency curves are useful in solving problems of reservoir design and operation.



HEIGHT AND FREQUENCY OF FLOODING AT GAGING SITES CAN BE RELATED TO LOCATIONS IN THE VICINITY OF THE GAGE BY USE OF TOPOGRAPHIC MAPS TO DETERMINE CHANNEL SHAPE

Height of water above bankfull stage for a given recurrence interval has been much less at the Buffalo River near Hawley gage which is in the morainal area than at the gages in the lake plain. The stage of the Red River of the North at Wahpeton and Fargo is partly controlled by operation of the outlet dams at Orwell Reservoir and Lake Traverse.

WATER RESOURCES OF THE BUFFALO RIVER WATERSHED, WEST-CENTRAL MINNESOTA

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

1969

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