NEBRASKA
Floods and Droughts

Nebraska's land surface slopes gently from the west near the Rocky Mountains to the east at the Missouri River. The geographic location, combined with moisture-laden winds from the south (fig. 1) and cold, dry winds from the north, can create weather extremes that range from intense thunderstorms to little rainfall. These extremes are responsible for floods and prolonged droughts. Since 1900, several floods have affected the State; the most notable was in southwestern Nebraska in 1935. Ninety-four deaths were attributed to that flood, which had a peak discharge that, at some streamflow-gaging stations, was 3 times that expected to recur once in every 100 years. An anomaly of that flood is that it occurred during the drought of 1930–42. Since 1929, Nebraska has had three extended droughts: 1930–42, 1952–57, and 1963–77. Drought conditions also developed in 1988, particularly in eastern and southern Nebraska, and continued into 1989 in most parts of the State.

The effects of flooding on the population of Nebraska have been immediate and dramatic—people have been killed, families have been evacuated, and highways and bridges have been washed away. The effects of droughts, however, have been more subtle. Many farmers lost their livelihood and left the State during the drought of 1930–42. In subsequent droughts, fewer farmers were adversely affected because they compensated for the lack of precipitation by drilling wells and irrigating crops with ground water. The increased ground-water withdrawals, however, have caused new concerns about the potential risk to the quantity and quality of ground-water supplies during a future drought and the possible decrease in base flow of many streams caused by ground-water withdrawals.

The State and many municipalities use flood-plain-management programs to control development in flood-prone areas and, thereby, to lessen the damage that can result from flooding. With regard to imminent flooding, the National Weather Service (NWS) coordinates a statewide network of more than 300 precipitation and river-stage observers who telephone readings to the NWS. In addition, the U.S. Geological Survey operates about 30 telemetry-equipped streamflow-gaging stations that can provide almost immediate river-stage data. For evaluation of drought conditions, the State has implemented a task force called the Drought Assessment and Response System. Annually, beginning in April and at other times as conditions warrant, the Moisture Situation Committee of the task force meets to assess the statewide moisture conditions. Depending on the findings of the committee, other State agencies may invoke various programs to alleviate the effects of a drought.

GENERAL CLIMATOLOGY

Nebraska's climate is classified as subhumid continental and is characterized by little annual rainfall, little humidity, hot summers, cold winters, and large variations in temperature and precipitation from year to year. Frequent changes in weather from day to day are typical.

The principal movement of air across the State is controlled by the jetstream and the formation and rotation of high- and low-pressure systems. During the warmer months, the prevailing winds are southerly; during the colder months, they are northerly and northwesterly (Lawson and others, 1977, p. 72–73). The principal source of precipitation in Nebraska is the Gulf of Mexico (fig. 1). Air from the west generally is dry because most of the moisture from the Pacific Ocean is removed during passage of airmasses over the Rocky Mountains.

In addition to the oceans, important moisture sources include local and upwind land surfaces, as well as lakes and reservoirs, from which moisture evaporates into the atmosphere. Typically, as a moisture-laden ocean airmass moves inland, it is modified to include some water that has been recycled one or more times through the land-vegetation-air interface.

Throughout the year, precipitation occurs along frontal systems when warm airmasses from the south meet cold airmasses from the north. In the summer, particularly July and August, convective thunderstorms produce rain and sometimes hail. On the basis of precipitation records for 1951–80, the average annual precipitation in Nebraska was about 35 inches in the southeastern part of the State, about 23 inches in the central part, and about 14 inches in the western part (National Oceanic and Atmospheric Administration, 1986, p. 3-11).

Most floods in Nebraska result from intense thunderstorms during the summer. The areal extent of these floods is limited to the region of thunderstorm activity and to the stream reaches downstream from the storm. Occasionally, some

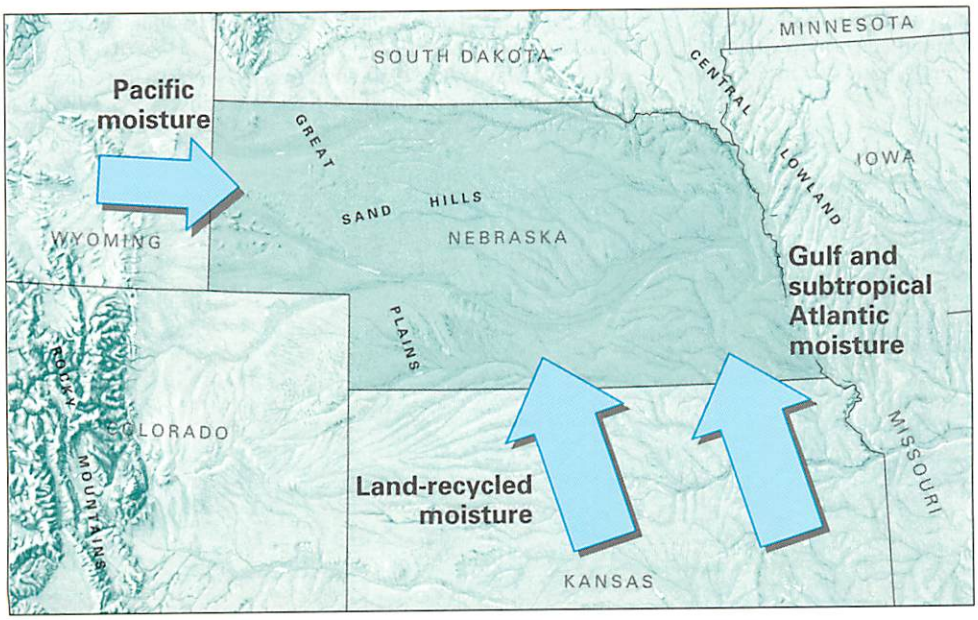


Figure 1. Principal sources and patterns of delivery of moisture into Nebraska. Size of arrow implies relative contribution of moisture from source shown. (Sources: Data from Douglas R. Clark and Andrea Lage, Wisconsin Geological and Natural History Survey.)

streams flood upstream from ice jams during spring breakup. Floods that result from high water levels due to ice jams may not be detected in a review of the peak-discharge record because the accompanying discharge may be relatively small.

Before dams were built, the flood plains along the North Platte, South Platte, and Platte Rivers (fig. 2) were inundated regularly in the spring as a result of snowmelt runoff from the Rocky Mountains in Colorado and Wyoming. Since dams have been built, flooding along these rivers has not been as frequent. Nonetheless, in the past 25 years, floods occurred in 1965, 1971, 1973, and 1983 that were the result of excessive runoff that originated outside of Nebraska.

Climatic records indicate that drought in Nebraska is a recurring phenomenon. For example, an analysis of the annual growth rings of trees indicates that during the past 750 years, the region has had 21 droughts. The average length of each drought was about 13 years, and the average period between droughts was about 24 years. The longest drought identified by this analysis lasted about 38 years and the shortest about 5 years (Lawson and others, 1977, p. 53).

MAJOR FLOODS AND DROUGHTS

The major floods and droughts discussed herein are those that have significant areal extent and significant recurrence intervals—greater than 25 years for floods and greater than 10 years for droughts. Major floods and droughts in Nebraska since 1905 are listed chronologically in table 1; rivers and cities are shown in figure 2.

Floods and droughts are evaluated on the basis of streamflow data, which are collected, stored, and reported by water year (a water year is the 12-month period from October 1 through September 30 and is identified by the calendar year in which it ends). The streamflow record evaluated started in the 1920's when gaging stations began to be systematically operated statewide. Although a few gaging stations were installed in Nebraska in the late 1800's and early 1900's, they generally were placed on regulated streams or on streams that since have become regulated. Nine gaging stations were selected from the statewide network—six to depict floods (fig. 3) and six to depict droughts (fig. 4); three of these gaging stations were used to show both floods and droughts. The selection was based on areal distribution, basin size, hydrologic setting, and degree of streamflow regulation. Many streams in Nebraska are affected by regulation, diversion, or nearby ground-water pumping; those streams are not good indicators of climatological conditions.

FLOODS

The areal extent of major floods and the magnitude of annual peak discharges at the selected gaging stations are shown in figure 3. The maps denote floods having calculated recurrence intervals between 25 and 50 years and greater than 50 years. The magnitudes of the discharges that have recurrence intervals of 10 years and 100 years are identified on the graphs.

One of the most notable floods in the history of the State occurred in 1935 on the Republican River in southwestern Nebraska. Rainfall of 18–24 inches occurred May 30–31 over the South Fork Republican River and Arikaree River (headwater of Republican River) basins in the tristate corner of Colorado, Kansas, and Nebraska (Follansbee and Spiegel, 1937, p. 21). The result was severe flooding during May 31–June 2 all along the Republican River in Nebraska; the flooded area ranged in width from 3/4 to 1 1/2 miles. Towns close to the river, including Parks, Benkelman, Culbertson, and Cambridge, were flooded. Cambridge, the most affected, had nearly three-fourths of its homes flooded. Ninety-four people were killed, 341 miles of highway were damaged, and 307 bridges were damaged or destroyed (Follansbee and Spiegel, 1937, p. 43). On May 31, 1935, the peak discharge of the Republican River at Benkelman (fig. 3, site 5) was 50,000 ft^3/s (cubic feet per second), which was nearly 3 times the discharge having a 100-year recurrence interval. The discharge for the Republican River at Cambridge, just downstream from Medicine Creek, was estimated to be 280,000 ft^3/s. The depths of overflow in this area ranged from 7 to 10 feet (Follansbee and Spiegel, 1937, p. 38).

During June 1947, flooding was severe along Medicine Creek and the downstream reaches of the Republican River in southwestern Nebraska, along the Elkhorn River in northeastern Nebraska, and along the lower Loup River in central Nebraska. More than 5 inches of rain fell in 24 hours during June 21–22 in the upper Medicine Creek basin. Flooding in Cambridge caused 13 deaths and extensive property damage (U.S. Weather Bureau, 1947, p. 1). More than 6 inches of rain in central Nebraska on June 22 caused floods along the North, Middle, and South Loup Rivers. The Loup River subsequently flooded the low-lying areas of Columbus. The estimated peak discharge of 27,000 ft^3/s of Mud Creek near Sweetwater (fig. 3, site 3) was more than twice the discharge having a 100-year recurrence interval. Parts of the Elkhorn River basin in northeastern Nebraska also were flooded.

From May to July 1950, southeastern Nebraska had four major floods that together claimed 24 lives and caused $65 million in

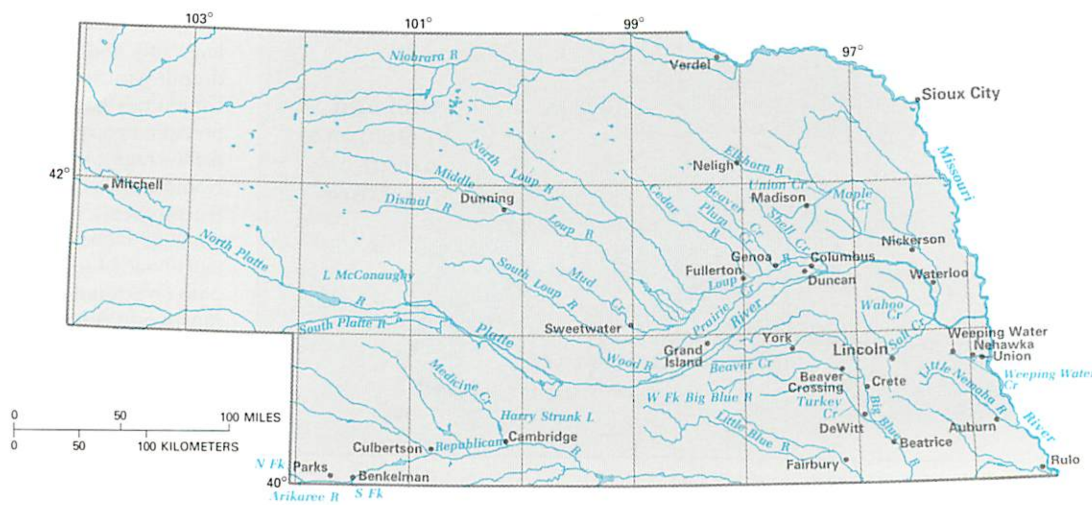


Figure 2. Selected geographic features, Nebraska.

damage. The flood of May 8–9 caused 23 deaths and inundated more than 60,000 acres of land (U.S. Geological Survey, 1953, p. 351). The flooding was most severe along the Little Nemaha River, Salt Creek, Weeping Water Creek, and several tributaries of the Big Blue River. Agricultural land in the river basin upstream from Lincoln was damaged considerably, and six people were killed as a result of flooding in the Salt Creek basin. In the Little Nemaha River basin, 14 people died and 8 towns were flooded (U.S. Geological Survey, 1953, p. 358). The peak discharge of the Little Nemaha River near Auburn (fig. 3, site 4) was 1.5 times the discharge having a 100-year recurrence interval. The villages of Nehawka, Union, and Weeping Water were flooded by Weeping Water Creek, and the village of DeWitt was flooded by Turkey Creek. There was one death at Union. Flooding was not as severe along the main-stem Big Blue River, but two people died when an automobile was swept from a highway.

The flood of June 2–3, 1950, on Beaver, Shell, and Union Creeks in east-central Nebraska was caused by thunderstorms the previous day. Much of the town of Madison was inundated by Union Creek.

The flood of July 8–10, 1950, was caused by thunderstorms over the headwaters of the West Fork Big Blue River. Floods developed on tributaries of the West Fork Big Blue River, particularly Beaver Creek (different from Beaver Creek in the Loup River basin; see fig. 2). A large area of York was flooded and most of Beaver Crossing was inundated (U.S. Geological Survey, 1953, p. 360). Flooding was not as extensive downstream from the confluence of the West Fork and the main stem of the Big Blue River, but low-lying areas of Crete were flooded, and serious damage extended downstream to Beatrice. This storm also caused flooding along Beaver Creek in the Loup River basin and resulted in one death.

The flood of July 18–19, 1950, was caused by storms that produced excessive runoff in the lower Loup River and Shell Creek basins. Beaver Creek flooded for the third time in 2 months. The peak discharge following the July 18 storm exceeded the two earlier peak discharges and had a 100-year recurrence interval.

From March 26 to April 3, 1960, several floods were caused by light to moderate rain on an extensive snow cover in eastern Nebraska. Maximum snow depth was 33 inches (the water equivalent of 1–5 inches of rain). Total rainfall during the period ranged from 0.5 to 2.5 inches (Brice and West, 1965, p. A6–A8). An eastward-moving warm front produced snowmelt and ice breakup in the headwaters of streams that caused serious jamming as the ice moved downstream. The flooding was most serious along the lower reaches of the Niobrara, Elkhorn, Platte, Republican, and Little Blue Rivers as tributary inflow from the melting snow moved downstream. Peak discharges at many gaging stations in eastern Nebraska had recurrence intervals of 7–25 years. Peak discharges at some gaging stations had recurrence intervals greater than 25 years, and at a few sites, such as Niobrara River near Verdel (fig. 3, site 1), the peak discharge had a recurrence interval of nearly 100 years. Flooding caused three deaths, and estimated damage in the State was about $7 million (Brice and West, 1965, p. A42–A43).

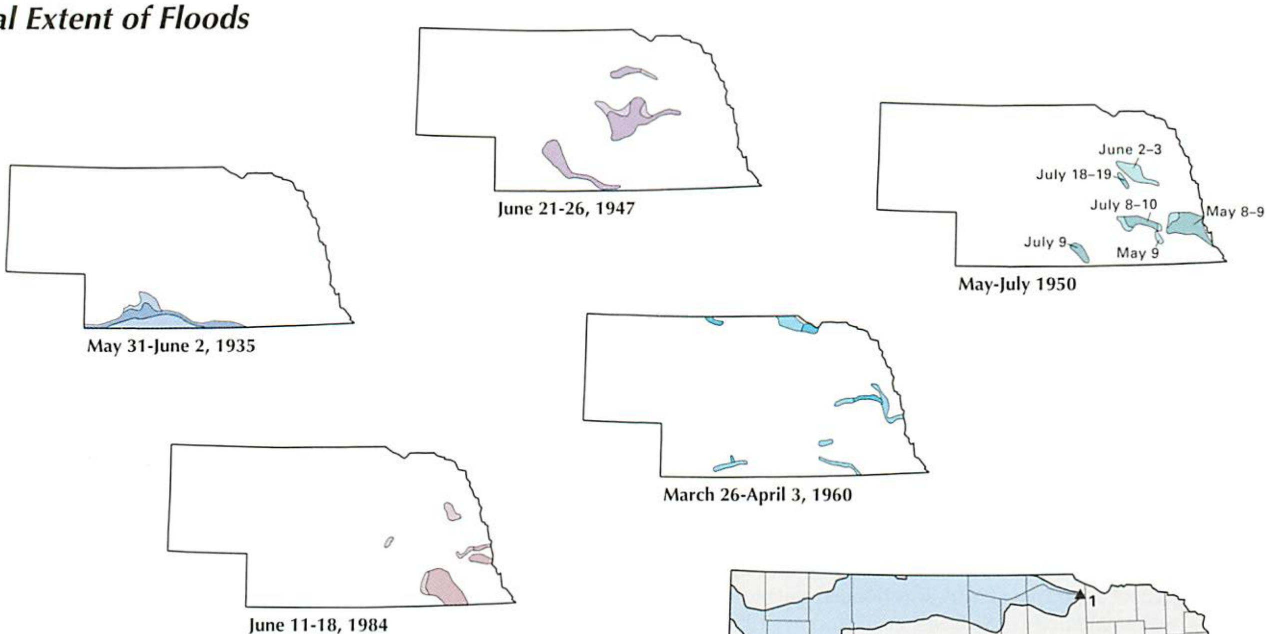
Thunderstorms during June 11–15, 1984, in eastern Nebraska produced substantial runoff because the ground was near saturation from greater than normal precipitation during April and May. Many streams in the Loup River, Elkhorn River, Platte River, Big Blue

Table 1. Chronology of major and other memorable floods and droughts in Nebraska, 1905–89

[Recurrence interval: The average interval of time within which streamflow will be greater than a particular value for floods or less than a particular value for droughts. Symbol: >, greater than. Sources: Recurrence intervals calculated from U.S. Geological Survey data; other information from U.S. Geological Survey, State and local reports, and newspapers]

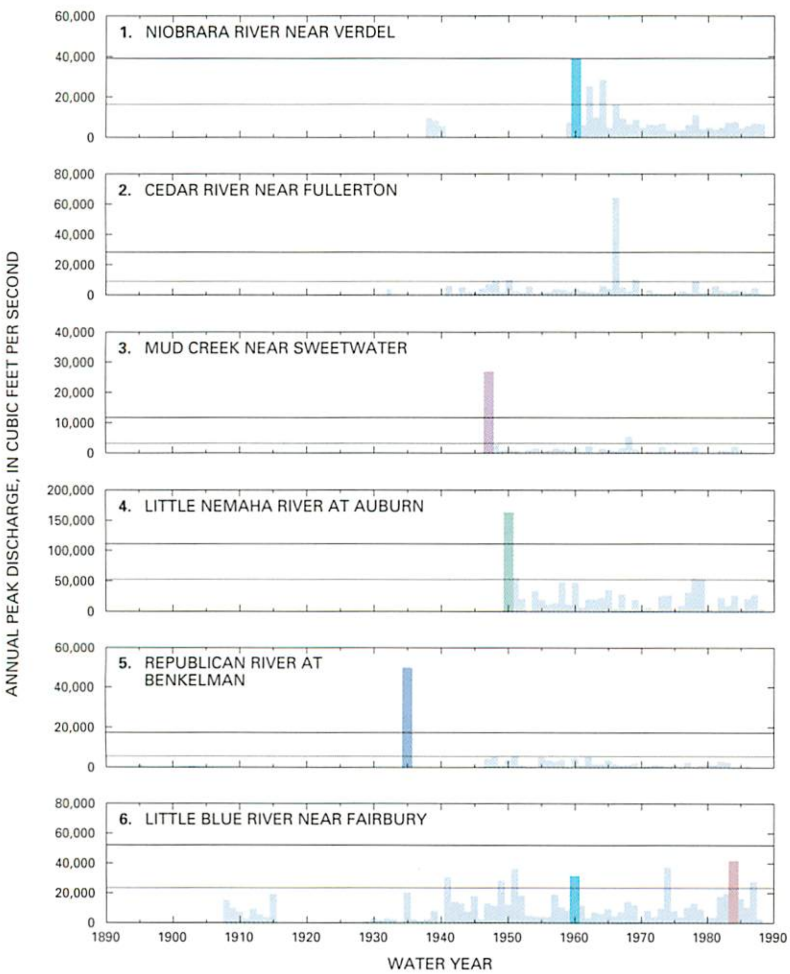
Flood or drought	Date	Area affected (fig. 2)	Recurrence interval (years)	Remarks
Flood	June 16-23, 1905	Platte River	Unknown	Snowmelt, before construction of upstream reservoirs. Maximum peak of record at Duncan.
Flood	June 3-4, 1909	North Platte River	Unknown	Snowmelt, before construction of upstream reservoirs. Maximum peak of record at Mitchell.
Drought	1930-42	Statewide	>25	Dust bowl conditions. Crop failures, dust storms, soil erosion, thousands of people left State.
Flood	May 31-June 2, 1935	Republican River basin	50 to >100	Locally intense rainfall. Deaths, 94; damage to towns and 307 bridges, $7.5 million.
Flood	June 3-6, 1935	South Platte and Platte Rivers	25 to 50	Locally intense thunderstorms in Colorado.
Flood	June 11-12, 1944	Maple Creek, lower Elkhorn River, lower Platte River.	>100	Locally intense thunderstorms. Damage to Nickerson. Maximum peak discharge of record for Elkhorn River at Waterloo and Maple Creek near Nickerson.
Flood	June 21-26, 1947	Medicine Creek, Elkhorn, Loup, and Republican Rivers.	25 to >100	Intense thunderstorms. Thirteen deaths in Republican River basin; property damage in Cambridge and Columbus.
Flood	May-July 1950	Eastern Nebraska	10 to >100	Series of locally intense thunderstorms. Deaths, 24; damage, $65 million.
Flood	Apr. 11-27, 1952	Missouri River main stem	Unknown	Snowmelt in upper basins; maximum peak discharges of record at all gaging stations on Missouri River. Damage, $31 million.
Drought	1952-57	Statewide	10 to >25	Began in Sand Hills in 1946.
Flood	Mar. 26-Apr. 3, 1960	Niobrara, Elkhorn, Platte, Republican, and Little Blue Rivers.	7 to >100	Snowmelt combined with rainfall and ice jams. Deaths, 3; damage, $7 million.
Flood	June 24-25, 1963	Salt Creek and tributaries, lower Platte River.	10 to >100	Intense thunderstorms. Peak discharge of record on Wahoo Creek.
Flood	June 21-22, 1965	South Platte River	25	Thunderstorms in Colorado.
Flood	Aug. 12-14, 1966	Loup River, Cedar River, Plum Creek, and Beaver Creek.	20 to >100	Locally intense thunderstorm; flood damage at Fullerton, Genoa, and Columbus.
Flood	June 14-16, 1967	Wood River, Prairie Creek, and Platte River.	25 to 50	Sustained period of rainfall; damage at Grand Island, $3 million.
Drought	1963-77	Statewide	10 to >25	Most extensive in western third of State. Greater than average streamflows in 1973.
Flood	June 2-4, 1971	North Platte River	25 to 100	Mountain snowmelt; intense rainfall downstream from reservoirs in Wyoming.
Flood	May 13-June 1, 1973	North Platte, South Platte, and Platte Rivers.	15 to 25	Mountain snowmelt augmented by rainfall in South Platte River basin.
Flood	June 19-30, 1983	North Platte, South Platte, and Platte Rivers.	15 to 50	Mountain snowmelt; greatest discharges in Platte River since construction of Lake McConaughy in 1941.
Flood	June 11-18, 1984	Eastern Nebraska	5 to >100	Series of thunderstorms. Deaths, 2; damage, $79 million.
Drought	1988-89	Statewide	Unknown	Severe in southeastern and south-central Nebraska in 1988.

Areal Extent of Floods



U.S. Geological Survey streamflow-gaging stations and corresponding drainage basins — Numbers refer to graphs

Peak Discharge



EXPLANATION

Areal extent of major flood

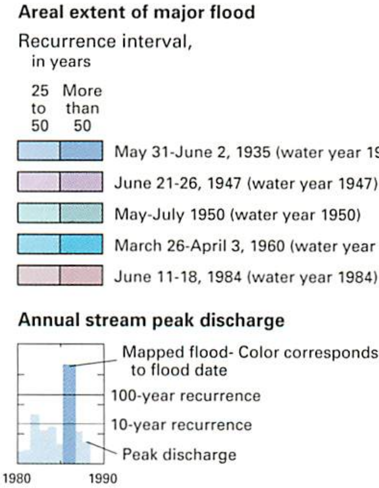


Figure 3. Areal extent of major floods with a recurrence interval of 25 years or more in Nebraska, and annual peak discharge for selected sites, water years 1895–1988. (Source: Data from U.S. Geological Survey files.)

River, Little Blue River, and Weeping Water Creek drainage basins flooded during June 11–18. The flooding was most severe along the Platte River downstream from the Elkhorn River and Salt Creek, along the downstream reaches of the Big Blue and Little Blue Rivers, and along Weeping Water Creek. These high flows also caused the most widespread flooding since April 1952 along the Missouri River from Sioux City, Iowa, to Rulo, Nebr. Two people drowned when their car was swept off the road by floodwaters along a tributary to Salt Creek (Engel and Benson, 1987, p. 7). Large quantities of top-soil were eroded, and roads, bridges, crops, and personal property were extensively damaged. Twenty-three counties in eastern Nebraska were declared Federal disaster areas (Engel and Benson, 1987, p. 23).

Niobrara River near Verdel, Nebr. Flood of March 27, 1960, washed out the right (south) section of bridge. (Photograph by J. A. Anderson, U.S. Geological Survey)

Other floods in Nebraska have not had the extent or severity of the ones discussed previously. Some of the floods listed in table 1 are noteworthy because of damage to towns. For example, flooding from Maple Creek caused considerable damage to Nickerson in 1944. Runoff from the 1966 storm in the Loup River basin produced the greatest flood on record at Cedar River near Fullerton (fig. 3, site 2) and in the downstream reaches of the Loup River. The communities of Fullerton, Genoa, and Columbus sustained considerable damage. The 1967 flood on the Wood River caused damage of about $3 million in Grand Island (Shaffer and Braun, 1970).

Droughts

The most severe droughts to occur in Nebraska since 1929 were those of the 1930's, the 1950's, and the 1970's. Annual departures from average discharge and cumulative departures from average monthly discharge at the 6 selected gaging stations and at 15 other gaging stations were analyzed to identify the geographic extent and the severity of major droughts. Annual departures are shown in figure 4. Periods of less than average discharge in the graphs indicate hydrologic drought. The areal extent and severity of the droughts are shown on the maps. Areas of drought having calculated recurrence intervals of 10–25 years and greater than 25 years are identified. During some droughts, annual discharges are occasionally greater than the average discharge. Whether these short-term reversals in annual departures mark the end of one drought and the beginning of another or merely a brief respite from a long-term drought is a subjective determination that must include consideration of, for example, the needs of fish and wildlife, municipal and industrial water supply, crop irrigation, and recreation.

The drought of 1930–42, which affected all parts of the State (fig. 4), culminated in the Dust Bowl of the Great Plains. During this period, Nebraska experienced numerous "dusters" and "black blizzards"—dust storms that at full intensity engulfed the area in virtual darkness at midday. The economic effect of this drought forced thousands of people to leave the State (Nicoll, 1967). The recurrence interval of this drought was greater than 25 years.

The drought of 1952–57, although generally shorter than that of 1930–42, produced the same detrimental effects and also was statewide (Nace and Pluhowski, 1965); however, the population was better prepared to cope with dry conditions in the 1950's than before. Record numbers of irrigation wells were installed in the State during 1953–57, as farmers sought to relieve the effects of the drought (fig. 5). In most of Nebraska, this drought began during 1952–53 and had a recurrence interval of about 10–25 years. The graph for the Dismal River at Dunning (fig. 4, site 1), however, indicates that in a large part of the Sand Hills of central Nebraska, the drought began as early as 1946. The recurrence interval in the Sand Hills was greater than 25 years.

The drought of 1963–77 affected most of Nebraska, but not all parts equally. Record numbers of irrigation wells were installed throughout the State. In 1976, the peak year for new-well registrations, more than 5,800 wells were drilled (fig. 5). As of January 1, 1987, more than 71,000 irrigation wells were registered in Nebraska. With irrigation, crop losses were not as devastating as during previous droughts; however, the increased use of ground water raised concerns about whether the quantity and quality of the State's ground-water supply would be at risk during a new drought. More than 80 percent of the public water supply in Nebraska is ground water (Steele, 1988, p. 5). Also, base flows in streams normally are maintained during drought by ground-water inflow; increased ground-water pumping could substantially decrease ground-water inflow to streams in some areas of the State.

Although annual departures from average discharge, as depicted for the selected stations in figure 4, were positive for several stations in 1973, the period 1963–77 was considered as one drought; recurrence intervals were calculated on the basis of one continuous drought period. A few gaging stations in the State indicated drought conditions beginning in 1963 and 1964, and some indicated that drought conditions continued until 1982, but the majority of station records indicated the drought period as 1968–77. During 1974–77, the drought was not generally as severe as during 1967–72.

Some gaging-station records indicate no break in drought conditions during the late 1960's and the 1970's. The record for Dismal River at Dunning (fig. 4, site 1) indicates that the annual discharge was continuously less than average from 1967 to 1976, although several months in 1973 and 1974 had average or greater than average discharges. The record for Medicine Creek above Harry Strunk Lake (fig. 4, site 5) indicates a continuous drought during 1970–78.

The drought of 1963–77 had a recurrence interval of greater than 25 years in southern Nebraska, in most of the Nebraska Panhandle, and in most of the tributaries to the Platte River in central and eastern Nebraska, such as Mud Creek, Cedar River, Beaver Creek, Shell Creek, and the lower Elkhorn River basin. The drought had a recurrence interval of 10–25 years in the remainder of the State, which is drained by the Platte River and streams that have drainage areas principally in the Sand Hills. The large ground-water contribution to the flow of these streams helped make the effects of the drought less severe.

Annual discharges recorded at gaging stations in eastern and southern Nebraska were less than average as a result of the 1988

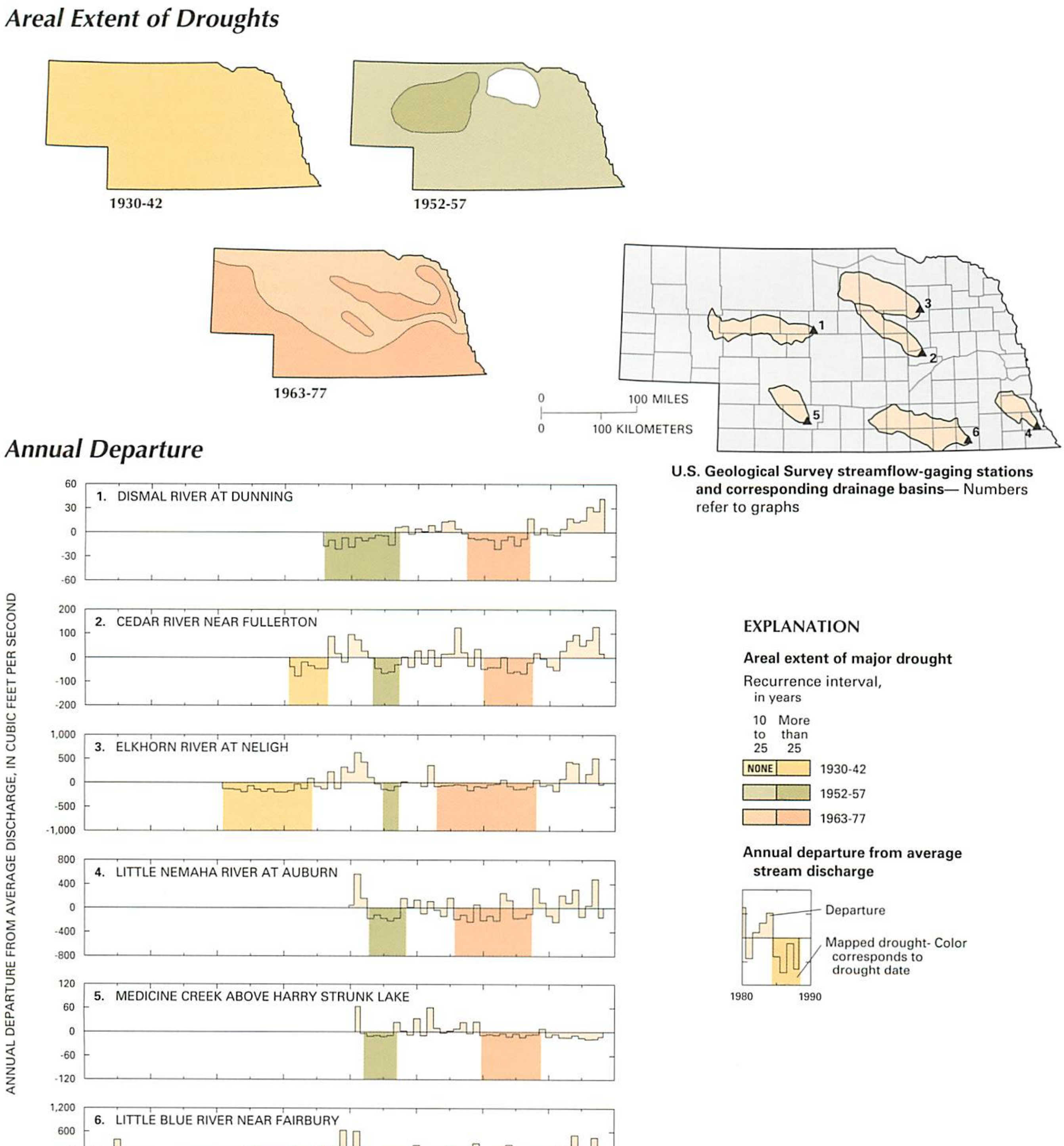


Figure 4. Areal extent of major droughts with a recurrence interval of 10 years or more in Nebraska, and annual departure from average stream discharge for selected sites, water years 1911–88. (Source: Data from U.S. Geological Survey files.)

drought (fig. 4, sites 3–6). These drought conditions have extended into 1989 and are generally statewide.

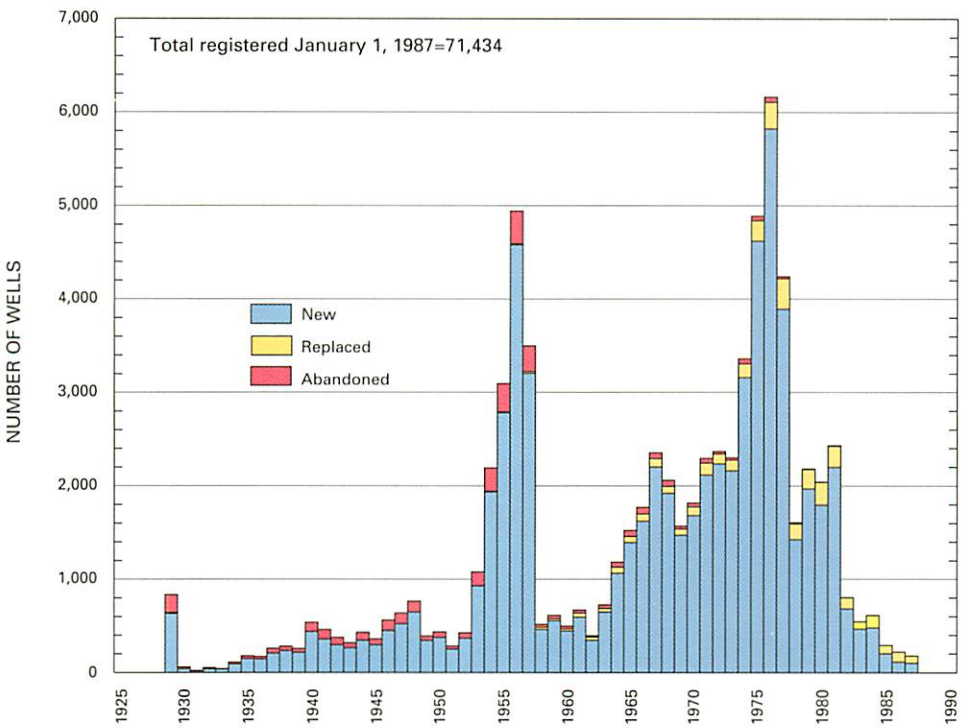


Figure 5. Annual installation, replacement, and abandonment of irrigation wells in Nebraska through 1987 (estimated from historical surveys and irrigation-well registration data). (Source: Ellis and Wigley, 1988.)

WATER MANAGEMENT

Responding to floods or droughts requires coordination and cooperation of many levels of government—Federal, State, county, and local. Water-management responsibilities include flood-plain management, flood-warning systems, and water-use management during droughts.

Flood-Plain Management.—Municipalities and counties that have flood-plain-management programs under the National Flood Insurance Program regulate flood-plain development. The flood-plain-management programs have been implemented by the Federal Emergency Management Agency through the Nebraska Natural Resources Commission, the coordinating agency for Nebraska. Currently (1989), 272 communities are either in the regular phase or in the emergency phase of the National Flood Insurance Program (A.E. Mathews, Nebraska Natural Resources Commission, oral commun., 1988). The Nebraska Department of Water Resources regulates development in designated flood plains not regulated by local government. The Department also annually reviews the emergency action plans submitted by owners of dams in locations of large potential hazard (R.F. Bishop, Nebraska Department of Water Resources, written commun., 1988). The U.S. Army Corps of Engineers regulates the dumping of fill materials within natural waterways through permits issued under Section 404 of the Clean Water Act. Uncontrolled filling within waterways can aggravate damage during flooding.

Flood-Warning Systems.—On a statewide basis, the NWS has more than 100 flood-forecast sites on rivers and streams and other monitoring sites that aid in flood forecasting from its Missouri Basin Regional Forecast Center in Kansas City, Mo. The NWS also has about 340 observers who read precipitation gages throughout the State; some of these observers also read river-stage gages to provide early warning of floods (Roy Osugi, National Weather Service, written commun., 1988). About 20 gaging stations operated in Nebraska by the U.S. Geological Survey are equipped with telemetry, either through telephone access or satellite transmitters. Also, about 10 electronic data loggers, some of which can be accessed by telephone, are operated in the Platte River basin by the Nebraska Department of Water Resources. During floods, local community officials and volunteers receive important information about flood conditions. This information is invaluable to the Nebraska Civil Defense Agency for emergency preparedness.

Water-Use Management During Droughts.—In Nebraska, the Drought Assessment and Response System, a task force implemented by the Governor's office, provides an effective and systematic means of evaluating drought conditions. The task force is composed of representatives of several State and Federal agencies. The functions of the system include monitoring moisture conditions and assessing the effect of depleted moisture conditions. Within the task force, the Moisture Situation Committee, of which the U.S. Geological Survey is a member, meets during the first week of each April and throughout the summer as conditions warrant; the Committee assesses the conditions of precipitation, streamflow, reservoir levels, ground-water levels, and soil moisture. The assessments may initiate responses from other agencies that have programs to alleviate the effects of drought (Dayle Williamson, Nebraska Natural Resources Commission, written commun., 1985).

The Nebraska Department of Water Resources and officials from irrigation districts monitor water diversions and streamflows daily during the irrigation season. Water diversions are regulated by the Department and are allocated according to available supplies and priority of use (R.F. Bishop, Nebraska Department of Water Resources, written commun., 1988).

SELECTED REFERENCES

Brice, H.D., and West, R.E., 1965, Floods of March–April 1960 in eastern Nebraska and adjacent States: U.S. Geological Survey Water-Supply Paper 1790–A, 144 p.

Ellis, M.J., and Wigley, P.B., 1988, Groundwater levels in Nebraska, 1987: The University of Nebraska—Lincoln, Conservation and Survey Division, Nebraska Water Survey Paper 65, 70 p.

Engel, G.B., and Benson, R.D., 1987, Floods in eastern Nebraska and southeastern South Dakota, June 1984: U.S. Geological Survey Open-File Report 87–215, 31 p.

Fenneman, N.M., 1946, Physical divisions of the United States: Washington, D.C., U.S. Geological Survey special map, scale 1:7,000,000.

Follansbee, Robert, and Spiegel, J.B., 1937, Flood on Republican and Kansas Rivers, May and June 1935: U.S. Geological Survey Water-Supply Paper 796–B, p. 21–52.

Lawson, M.P., Dewey, K.F., Neild, R.E., and Magill, J.D., 1977, Climatic atlas of Nebraska: Lincoln, University of Nebraska Press, 88 p.

Nace, R.L., and Pluhowski, E.J., 1965, Drought of the 1950's with special reference to the midcontinent: U.S. Geological Survey Water-Supply Paper 1804, 88 p.

National Oceanic and Atmospheric Administration, 1986, Climatological data annual summary, 1986, Nebraska: Asheville, N.C., National Climatic Data Center, v. 91, no. 13, 40 p.

Nicoll, B.H., 1967, Nebraska, a pictorial history: Lincoln, University of Nebraska Press, 232 p.

Shaffer, F.B., and Braun, K.J., 1967, Flood of August 1966 in the lower Loup River basin, Nebraska: U.S. Geological Survey Hydrologic Investigations Atlas HA–188.

______1970, Flood of June 1967 at Grand Island, Nebraska: U.S. Geological Survey Hydrologic Investigations Atlas HA–352.

Steele, E.K., Jr., 1988, Estimated use of water in Nebraska, 1985: The University of Nebraska—Lincoln, Conservation and Survey Division, Nebraska Water Survey Paper 64, 125 p.

U.S. Geological Survey, 1953, Floods of May–July 1950 in southeastern Nebraska: U.S. Geological Survey Water-Supply Paper 1137–D, p. 351–411.

______1986, National water summary 1985—Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, 506 p.

______1990, National water summary 1987—Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

U.S. Weather Bureau, 1947, Climatological data, June 1947, Nebraska Department of Commerce: v. 52, no. 6, 6 p.

______1959, Climates of the States, Nebraska: Climatography of the United States, no. 60–25, 16 p.

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