GROUND-WATER LEVELS AND QUALITY AT CREX MEADOWS WILDLIFE AREA, BURNETT COUNTY, WISCONSIN

By G. L. PATTERSON

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CONVERSION FACTORS AND ABBREVIATIONS

For the use of readers who prefer metric (International Systems) units, rather than the inch-pound units in this report, the following conversion factors may be used:

Multiply inch-pound unit	*By*	*To obtain metric unit*
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.0283	cubic meter per second (m^3/s)
gallon (gal)	3.785	liter (L)
foot per second (ft/s)	0.3048	meter per second (m/s)
acre	4,047	square meter (m^2)

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)— a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

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ABSTRACT

During 1984, above-normal ground-water levels flooded the fields and basements in the vicinity of the Crex Meadows Wildlife Area. In response to concerns of neighboring farmers and homeowners, the Wisconsin Department of Natural Resources and the U.S. Geological Survey began a cooperative study to assess ground-water conditions in the area and to determine the causes of above-normal ground-water levels in and around the Crex Meadows Wildlife Area.

Data from an inventory of water levels in the Crex Meadows area measured in 1935 and 1937 were compared with data collected in 1986 and 1987. The comparison indicates that 1986 water levels were 5 to 10 feet higher throughout the area than in 1935 and 1937. Water levels declined about 5 feet throughout much of the area during 1987 and were only 0–5 feet higher than in the late 1930's. Hydrographs of water levels measured from 1985 to the fall of 1987 also indicate that water levels rose in 1985 and 1986 and fell abruptly in 1987

Water levels in two wells, one in northern Burnett County and the other in Polk County, were compared to those in the wildlife area to determine whether the wetland impoundments contributed significantly to above-normal water levels measured in 1986 or whether levels were high throughout northwestern Wisconsin. Water-levels at long-term observation wells Bt-2 (1936–present) and Pk-40 (1951–present) (13 miles northeast and 20 miles southeast of Crex Meadows, respectively) during 1986 were the highest of record.

Long-term discharge records for the St. Croix River upstream (Danbury) and downstream (St. Croix Falls) from Crex Meadows indicate that the river reached its highest historical discharge volume during 1986.

Hydrographs showing cumulative departure from mean annual precipitation at two stations (Danbury and St. Croix Falls) indicate that the above-normal ground-water levels in 1986 were preceded by several years of above-normal precipitation. It is probable that the above-normal ground-water levels and surface-water discharge throughout the area can be attributed to above-normal precipitation. Ground-water-level fluctuations corresponded directly to variations in precipitation during 1985–87.

Chemical analyses of water samples from 20 observation wells indicate that calcium and bicarbonate are the predominant ions in ground water in the Crex Meadows area. Iron concentrations ranged from 45 to 45,000 micrograms per liter, and 17 of 20 samples exceeded the 300-micrograms-per-liter recommended drinking-water standard of the Wisconsin Department of Natural Resources.

INTRODUCTION

Crex Meadows Wildlife Area encompasses more than 30,000 acres of brush prairie, wetland, and forest in Burnett County, Wisconsin (fig. 1). Above-normal ground-water levels that flooded farm fields and basements near the Crex Meadows Wildlife Area during 1984 caused concern among landowners and State officials.

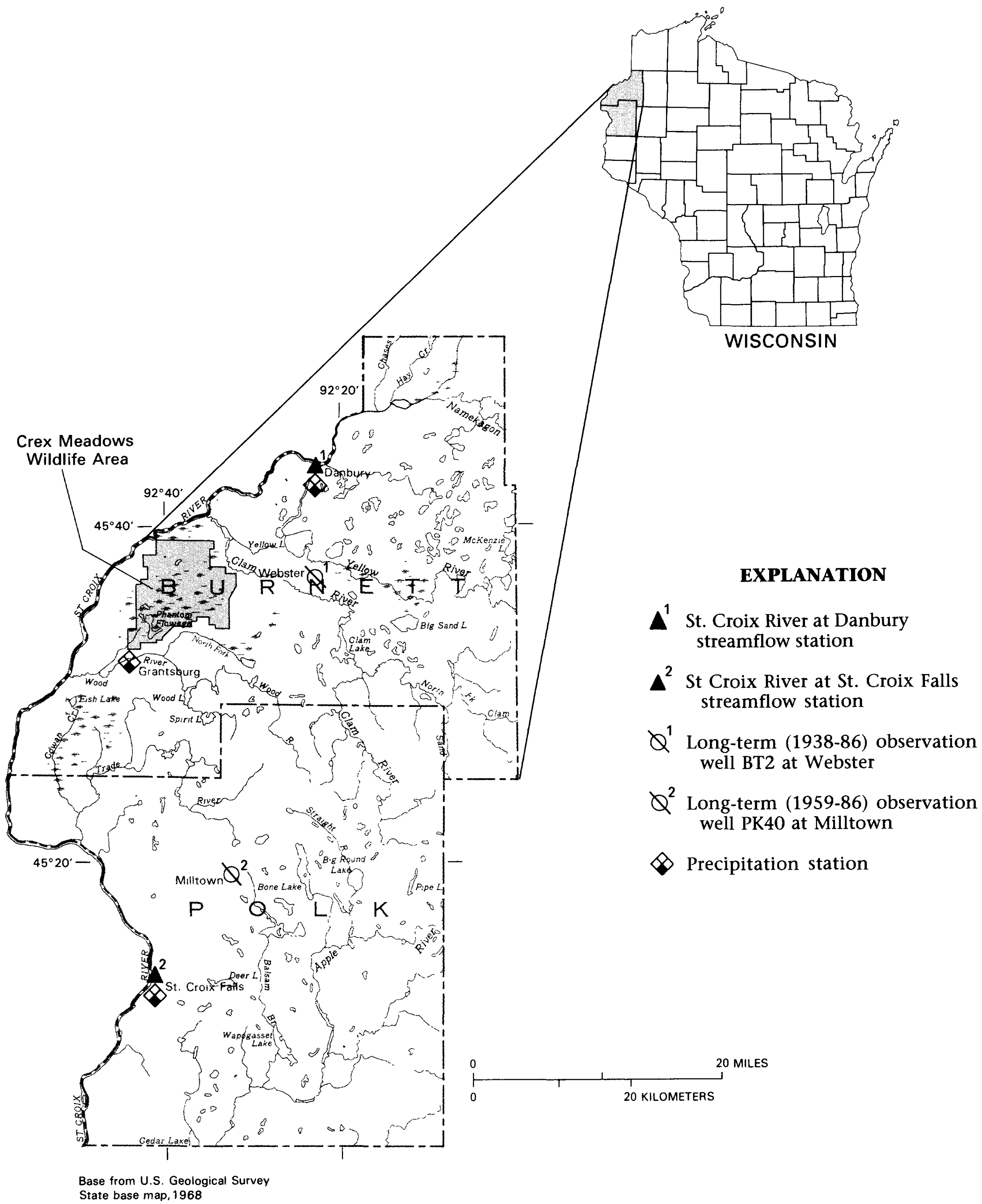


Figure 1. Location of the study area and data-collection sites used for regional analysis.

Surface-water impoundments within the wildlife area were suspected of being responsible for the flooding. A committee of landowners and officials of the Wisconsin Department of Natural Resources (WDNR) recommended a study to determine the causes of the above-normal ground-water levels and flooding. In October 1984, the U.S. Geological Survey and the WDNR began a cooperative study to investigate the ground-water conditions in and around the Crex Meadows Wildlife Area.

During the last advance of the Wisconsin glaciation, the St. Croix River was blocked by an ice dam. When the glacier receded the ice dam melted, leaving a series of shallow lakes that eventually formed marshland over much of the area. Attempts to drain the area for agricultural purposes were unsuccessful and, in 1945, the WDNR began managing the area to provide wildlife habitat. Since 1945, the WDNR has constructed more than 18 miles of dikes to form more than 15,000 acres of wetland wildlife habitat and about 5,000 acres of deep-water marshes.

PURPOSE AND SCOPE

This report describes the shallow ground-water system in the vicinity of the Crex Meadows Wildlife Area and discusses the relation between the ground-water levels in the Crex Meadows Wildlife Area and regional ground-water-level trends. Specifically, this report includes (1) descriptions and comparisons of ground-water levels and movement during the late 1930's and mid-1980's, (2) a discussion of precipitation and its relation to ground-water levels, (3) a discussion of regional surface-water discharge data and ground-water-level trends, and (4) a summary of ground-water-quality data in the vicinity of the wildlife area.

GENERAL PRINCIPLES OF GROUND-WATER OCCURRENCE AND FLOW

The source of all ground water is precipitation. Precipitation that does not evaporate, nourish plants, or fall directly upon or flow into surface-water bodies flows downward through the pores and fissures in soil and rocks to the ground-water reservoir. Ground water flows vertically and laterally through the soil and rock openings toward wetlands, streams, and lakes. Ground water tends to flow laterally toward such low-lying areas because it is driven by gravity and the differences in hydraulic head.

The water table (the upper surface of the ground-water reservoir) is at or near the land surface in wetlands and valleys, and deeper beneath hills and ridges. The proximity of the water table to the land surface fluctuates constantly, rising with replacement of water in the ground-water reservoir by recharge from precipitation and snowmelt, and falling as ground water discharges to wetlands, springs, lakes, or wells.

The amount and rate of recharge to the ground-water reservoir varies seasonally. Water levels rise rapidly during spring when snow melts and precipitation increases. Water levels decline during the summer when precipitation decreases, evaporation increases, and transpiration by plants increases during the growing season. Small amounts of precipitation during summer often provide little ground-water recharge until plant and soil needs are met. Water levels rise again during fall when plant transpiration decreases and precipitation increases. Ground-water levels decline during the winter because precipitation is in the form of snow and frozen ground inhibits infiltration.

Consecutive years of above- or below-normal precipitation cause longer cycles of ground-water-level changes, within which seasonal or shorter-term variations occur.

HYDROGEOLOGIC SETTING

Surface-Water Hydrology

The major streams draining the area are shown in figure 2. They are (1) the St. Croix River, which flows within a few miles of the northern and western boundaries of the wildlife area; (2) the Wood River and the North Fork Wood River, which flow along the southern edge of the wildlife area and eventually discharge into the St. Croix River to the southwest; and (3) the Clam River, which flows northerly, east of the wildlife area, and discharges into the St. Croix River to the northeast.

Dikes within the wildlife area channel water into several flowages and impoundments. Several creeks and flowages, tributary to the major streams, emanate from the wildlife area. Hay Creek in the southwestern corner of the wildlife area, flows from Hay Creek Flowage and discharges into the Wood River. Whiskey Creek, in the southwestern part of the wildlife area, flows from the Phantom Flowage and also discharges into the Wood River. The Upper North Fork and North Fork Flowages, in the eastern part of the wildlife area, are within the drainage basin of the North Fork Wood River. There are also several smaller flowages and lakes scattered throughout the wildlife area.

Geologic Setting

The wildlife area is underlain by clean, cross-bedded, sandstone. Overlying the sandstone are 20

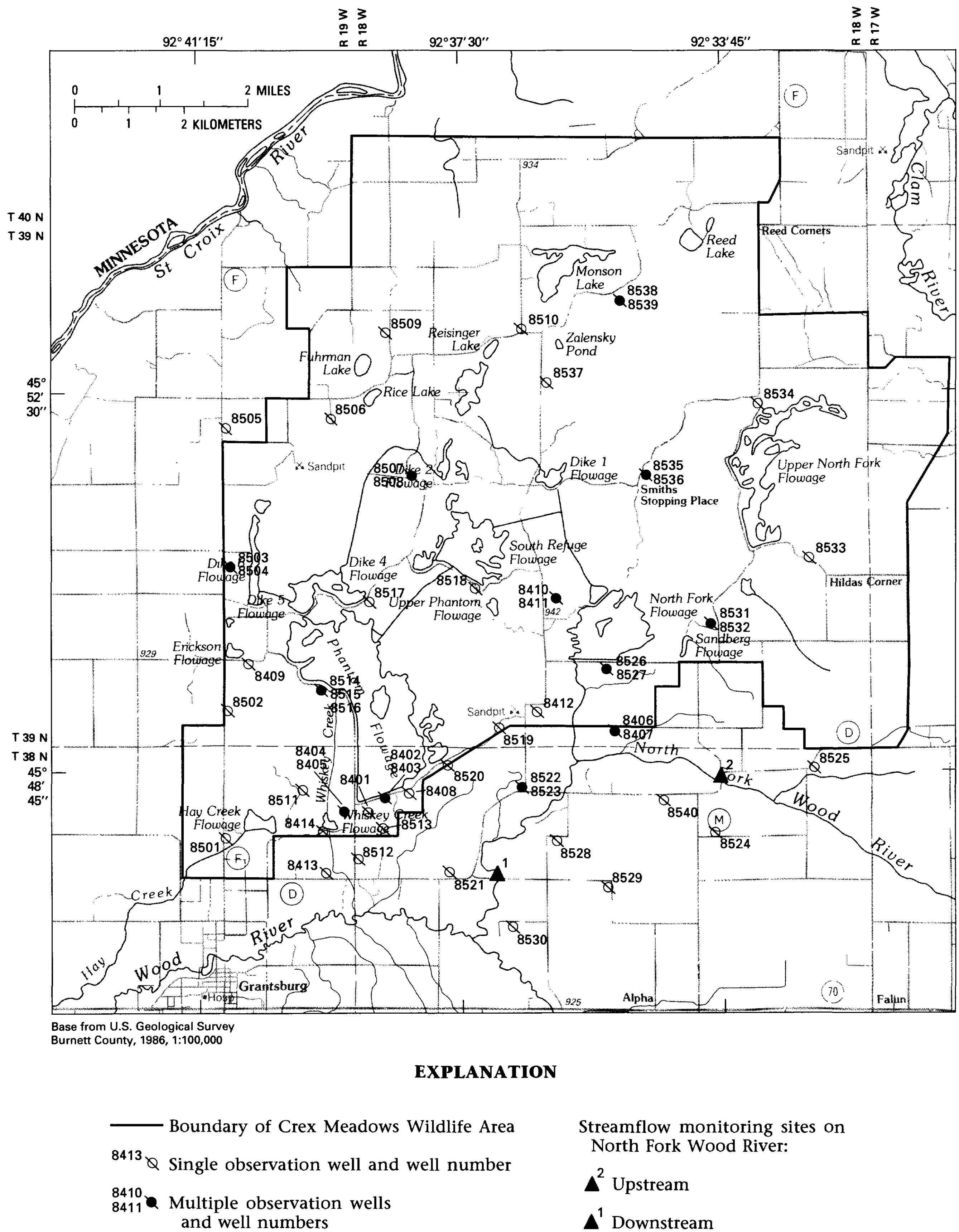


Figure 2. Location of local data-collection sites.

to 25 ft (feet) of varved lake clay. The lake clay was deposited in what was Glacial Lake Grantsburg (Martin, 1965, p. 456) during the Wisconsin glaciation in late Pleistocene time. Overlying the lake clay are 40 to 75 ft of sand and sand-and-gravel.

DATA-COLLECTION NETWORK

A network (fig. 2) of 54 wells, installed during the fall of 1984 and summer of 1985, was used to monitor ground-water altitudes. Forty-two of the wells are within the Crex Meadows Wildlife Area boundary and 12 are south of the area. Total depth and the geologic materials found when drilling each well are listed in table 1 (p. 16).

To determine the cause of the above-normal water levels in the study area, data were collected from several different sources. Ground-water levels from 1935 and 1937 were obtained from records of the Wisconsin Conservation Department. A network established by the WDNR was used to monitor surface-water levels of the North Fork and Phantom Flowages within the wildlife area (fig. 2). Discharge measurements and daily staff-gage readings were obtained from two stations on the North Fork Wood River (fig. 2).

Regional surface-water-discharge data were obtained from long-term gaging stations on the St. Croix River at Danbury and St. Croix Falls and regional ground-water levels were obtained from long-term observation wells at Webster and Milltown, Wisconsin (fig. 1).

Precipitation data were obtained from National Weather Service stations at Danbury, Grantsburg, and St. Croix Falls, Wisconsin (fig. 1).

GROUND-WATER LEVELS

HISTORICAL WATER LEVELS

Water Levels during 1935 and 1937

The Wisconsin Conservation Department inventoried shallow ground-water resources during the 1930's. Wells were driven into the shallow aquifer and static water level and yield were measured. After the yield tests were finished, the wells were removed. Although these data were collected over several years individual test sites were difficult to locate. It was possible to obtain only enough information to construct a general map of ground-water levels existing at that time. Figure 3 is a ground-water-level contour map prepared from 1935 and 1937 data. It was necessary to combine 1935 and 1937 data to obtain an adequate distribution of water levels. Precipitation at Danbury was about 3 in. (inches) above normal in 1935 and 5 to 6 in. below normal in 1936 and 1937. The water-table map is thought to represent an average water-table altitude for the period 1935–37.

Ground-water flow is perpendicular to the contour lines from higher to lower altitudes. This map indicates that ground water generally flowed into the area from the east and out of the area to the west and south, discharging into the Wood and St. Croix Rivers. The general gradient from east to west was from 8 to 10 ft/mi (feet per mile) and was steeper toward the south as ground water discharged to the North Fork Wood River.

Water Levels during 1986 and 1987

Data from the 54 observation wells installed in 1984 and 1985 were used to prepare similar maps representing the ground-water altitude on May 15, 1986, (fig. 4) and on June 16, 1987 (fig. 5).

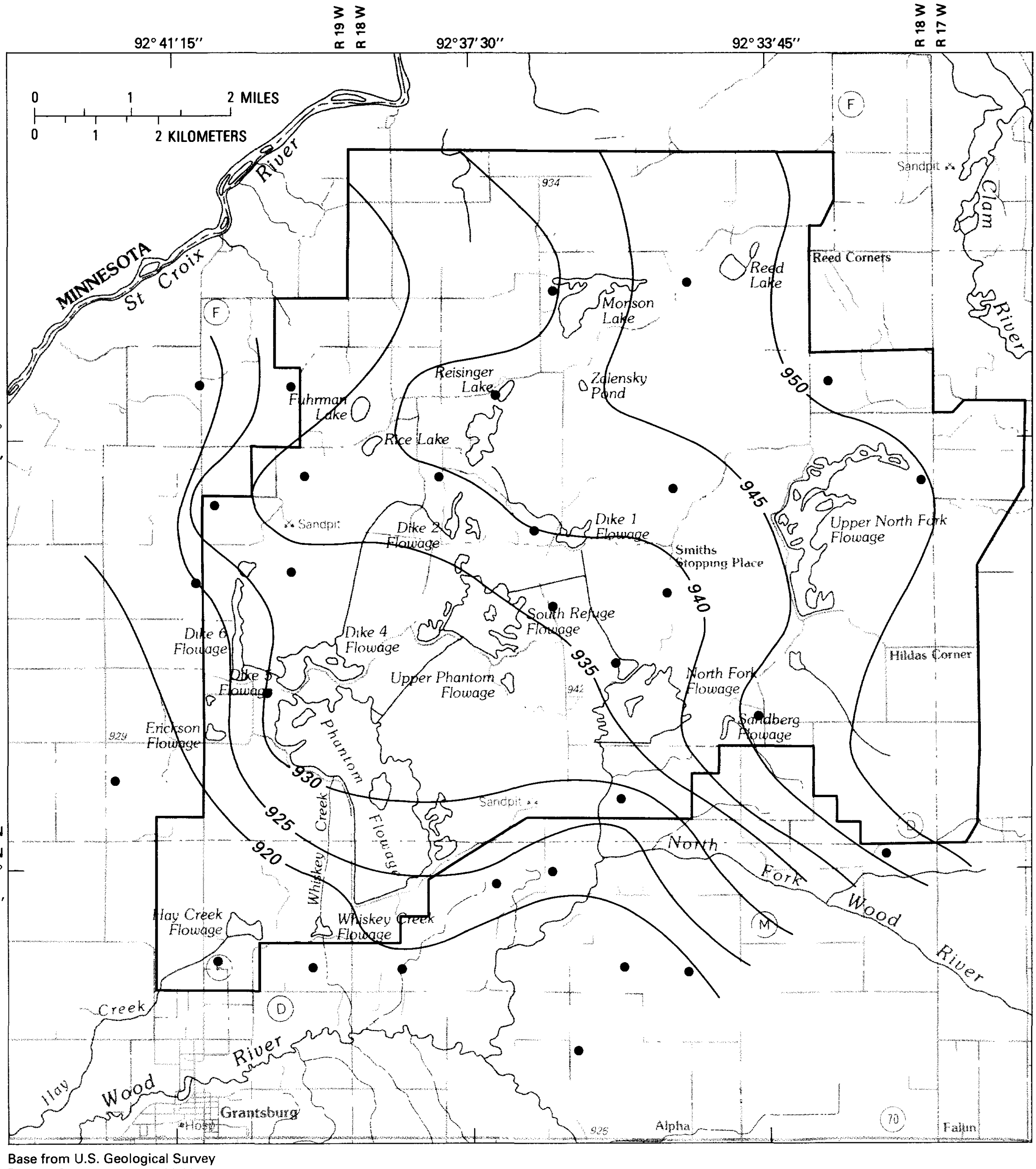
Figures 3 and 4 both show the same general east-to-west flow in the wildlife area. A rise in ground-water levels through the Crex Meadows area is shown on figure 4 by the location of the elongated lobe-shaped contour of the 945 ft altitude. The gradient from the eastern edge to the western edge of the site has remained from 8 to 10 ft/mi, but there is a much flatter surface at the center of the site and the water table does not drop off until it reaches the site's western edge. The shape of the water table on the southern half of the site has remained essentially the same, but in May 1986 water levels were 5 to 10 ft higher throughout much of the area.

Figure 5 shows that the water table in June 1987 had essentially the same shape as that for May 1986, but the water levels were approximately 5 ft lower throughout much of the area. Water levels for June 1987 were only 0 to 5 ft higher than in the late 1930's (fig. 3).

WATER-LEVEL FLUCTUATIONS

Hydrographs of water levels in wells measured during 1985, 1986, and 1987 (fig. 6), show water-level fluctuations in the Crex Meadows Wildlife Area. Water levels in wells at the perimeter of the site, wells 8504, 8510, 8534, 8528, and 8511, show distinct seasonal variations. However, during 1987 there was a distinct change. The water levels show no spring rise, and the water levels continued to decline until the fall when there was a slight rise.

Comparing monthly precipitation during 1986 and 1987 at Grantsburg, Wisconsin, with ground-water levels from well 8504 (fig. 7) demonstrates the effect of precipitation on water levels. The water level declined from November 1985 through February 1986 because precipitation was in the form of snow.



Base from U.S. Geological Survey
Burnett County, 1986, 1:100,000

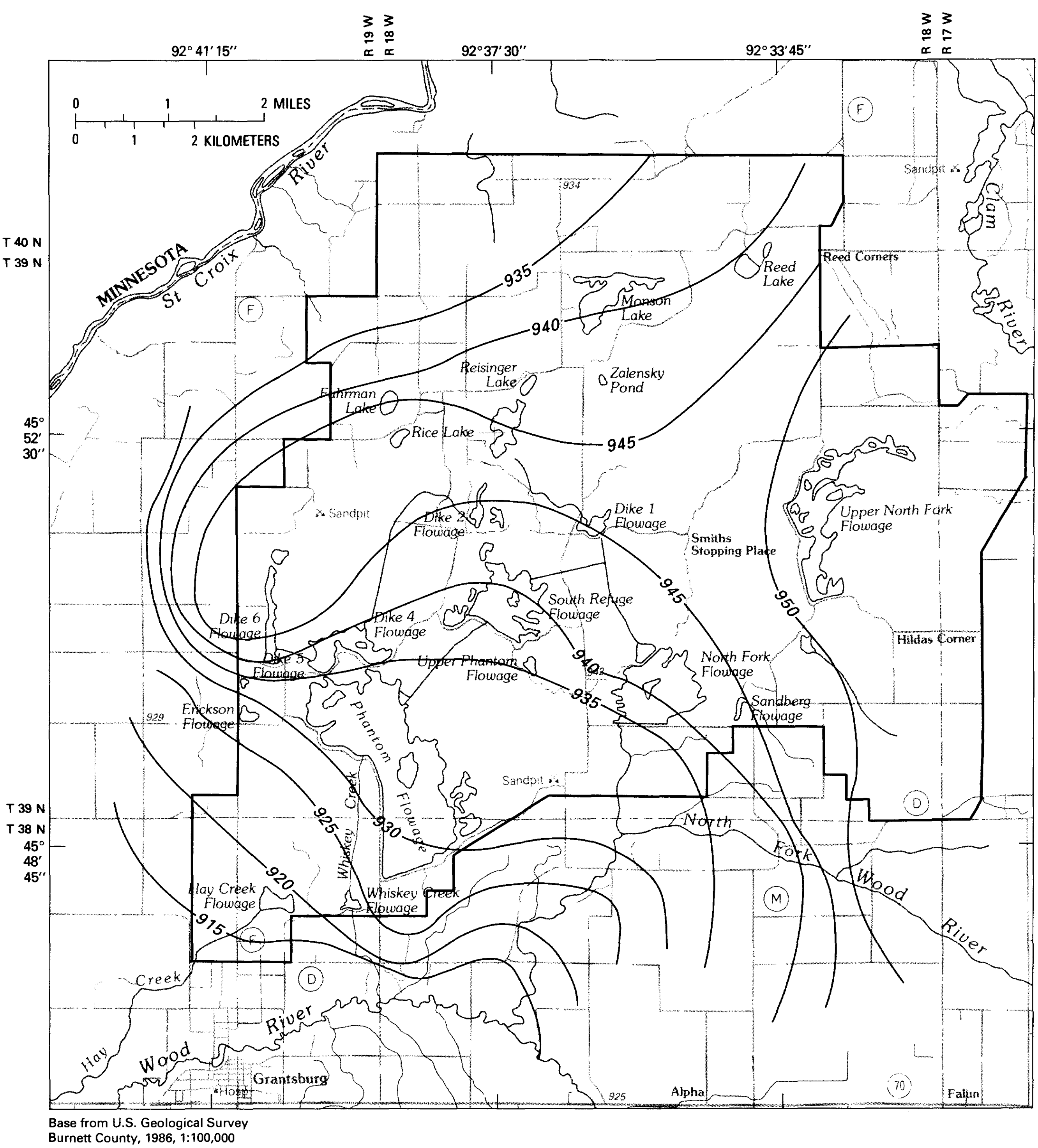
EXPLANATION

——— Boundary of Crex Meadows Wildlife Area

—*920*— Ground-water-level contour, contour interval is 5 feet. Datum is sea level

● Water-level measurement point from 1935 or 1937 ground-water inventory

Figure 3. Ground-water levels in the Crex Meadows area, 1935–1937.

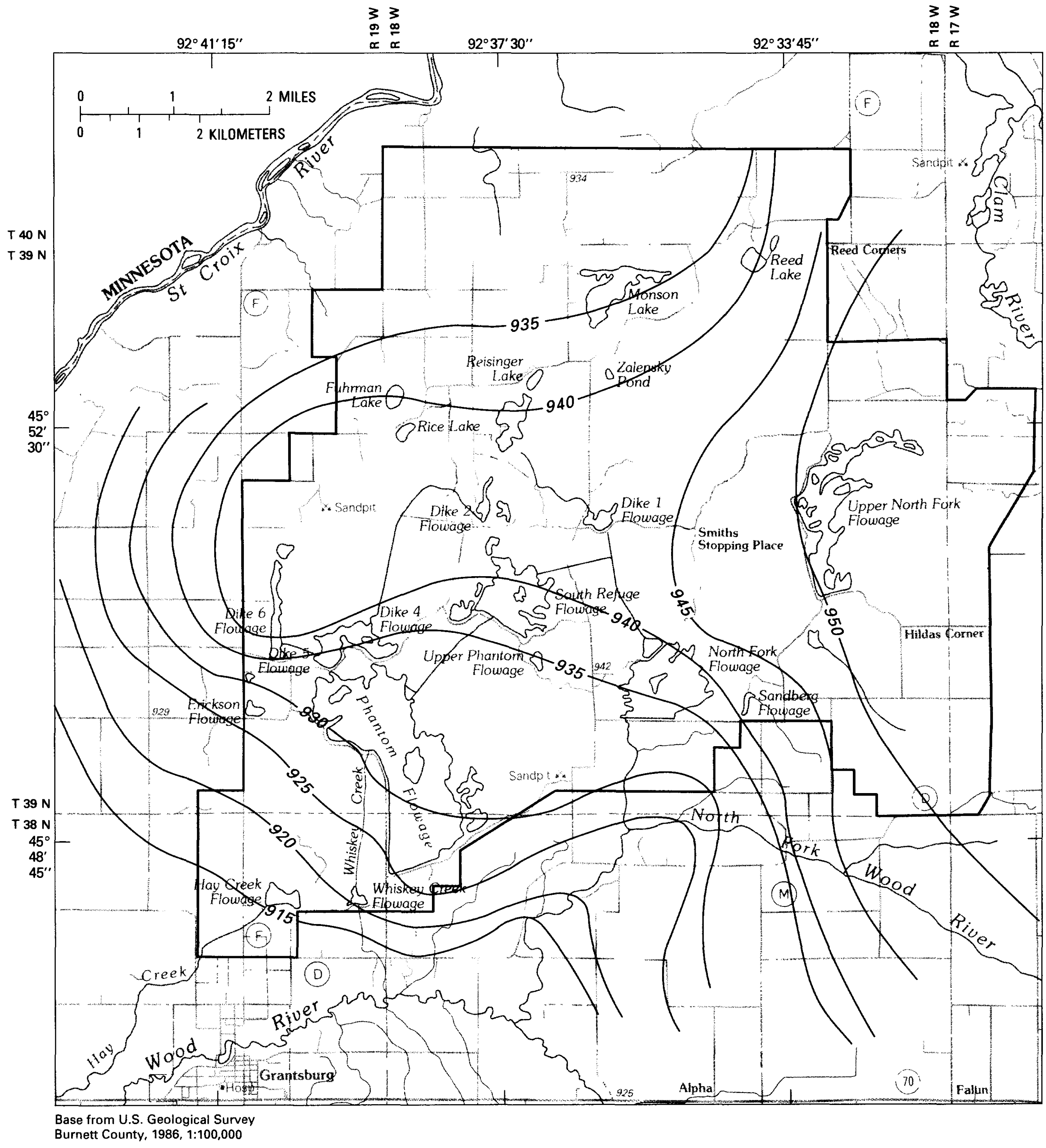


EXPLANATION

——— Boundary of Crex Meadows Wildlife Area

—915— Ground-water-level contour, contour interval is 5 feet. Datum is sea level

Figure 4. Ground-water levels in the Crex Meadows area, May 1986.



EXPLANATION

——— Boundary of Crex Meadows Wildlife Area

—*915*— Ground-water-level contour, contour interval is 5 feet. Datum is sea level

Figure 5. Ground-water levels in the Crex Meadows area, June 1987.

The water level rose in March, April, and May 1986 in response to snowmelt and rainfall during April and May. The water level then fell throughout the summer because the rainfall was used by vegetation. There was a rise in water level in October 1986 caused by rainfall during September and less water use by vegetation. After October 1986 the water level continued to decline throughout the winter and summer of 1987 because there was little snowfall or rainfall. Rainfall during the summer of 1987 had little effect on the ground-water level because the rainfall was used by vegetation and to restore depleted soil moisture.

Water levels in the interior of the wildlife area vary seasonally, but did not decline during 1987. Figure 8 is a water-level hydrograph for Phantom Flowage from May 1985 through October 1987. The low water levels in August of 1985 and 1986 are the result of opening the control structures to partially drain the lake and allow repair on the dikes. The above-normal water levels in the spring and fall are the result of closing the control structures to raise the water level and provide waterfowl habitat. This hydrograph does not show the steady decline through 1987 that was seen on the ground-water hydrographs from the perimeter of the site because water is pumped

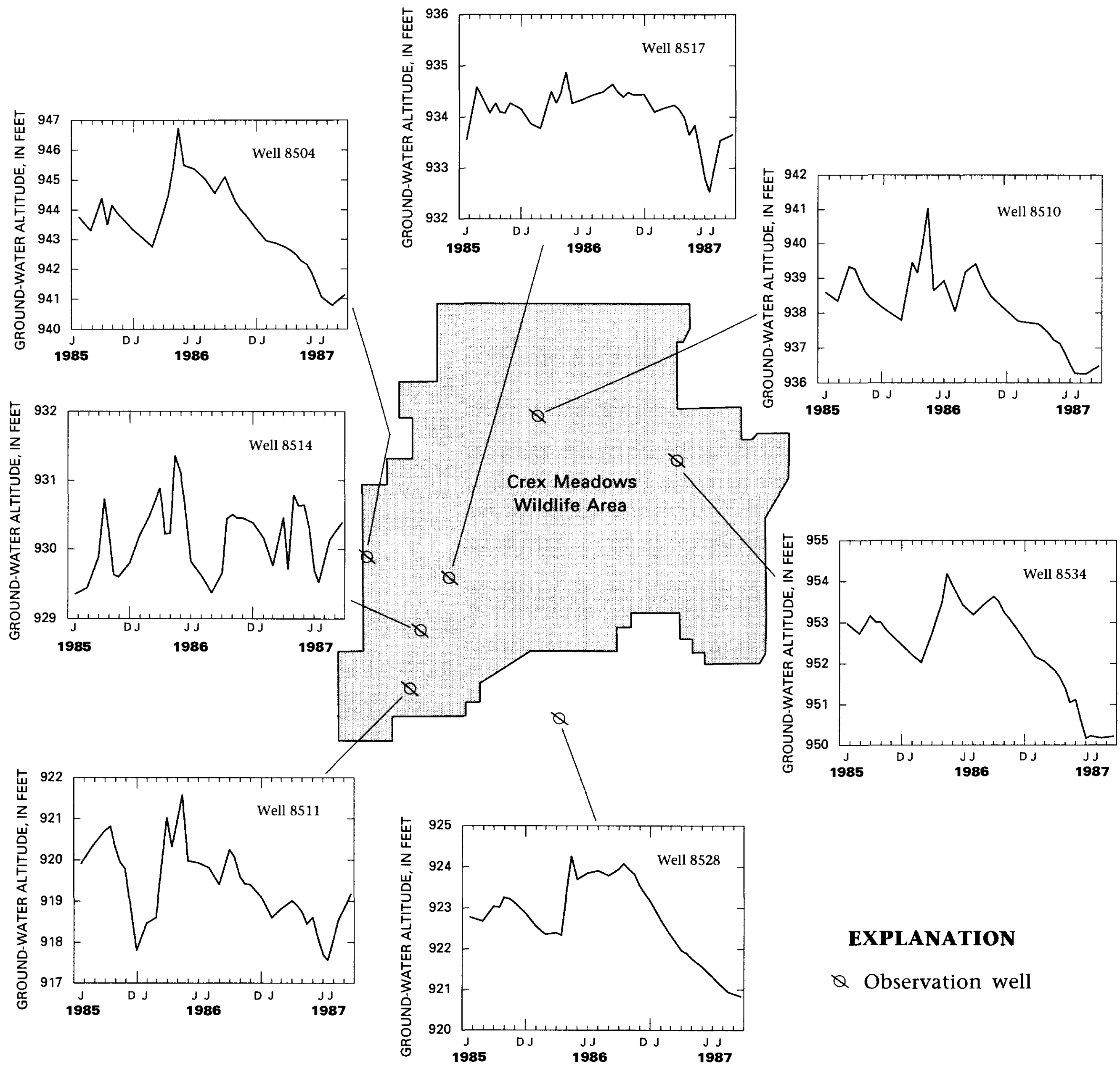


Figure 6. Ground-water levels at selected wells in the Crex Meadows area.

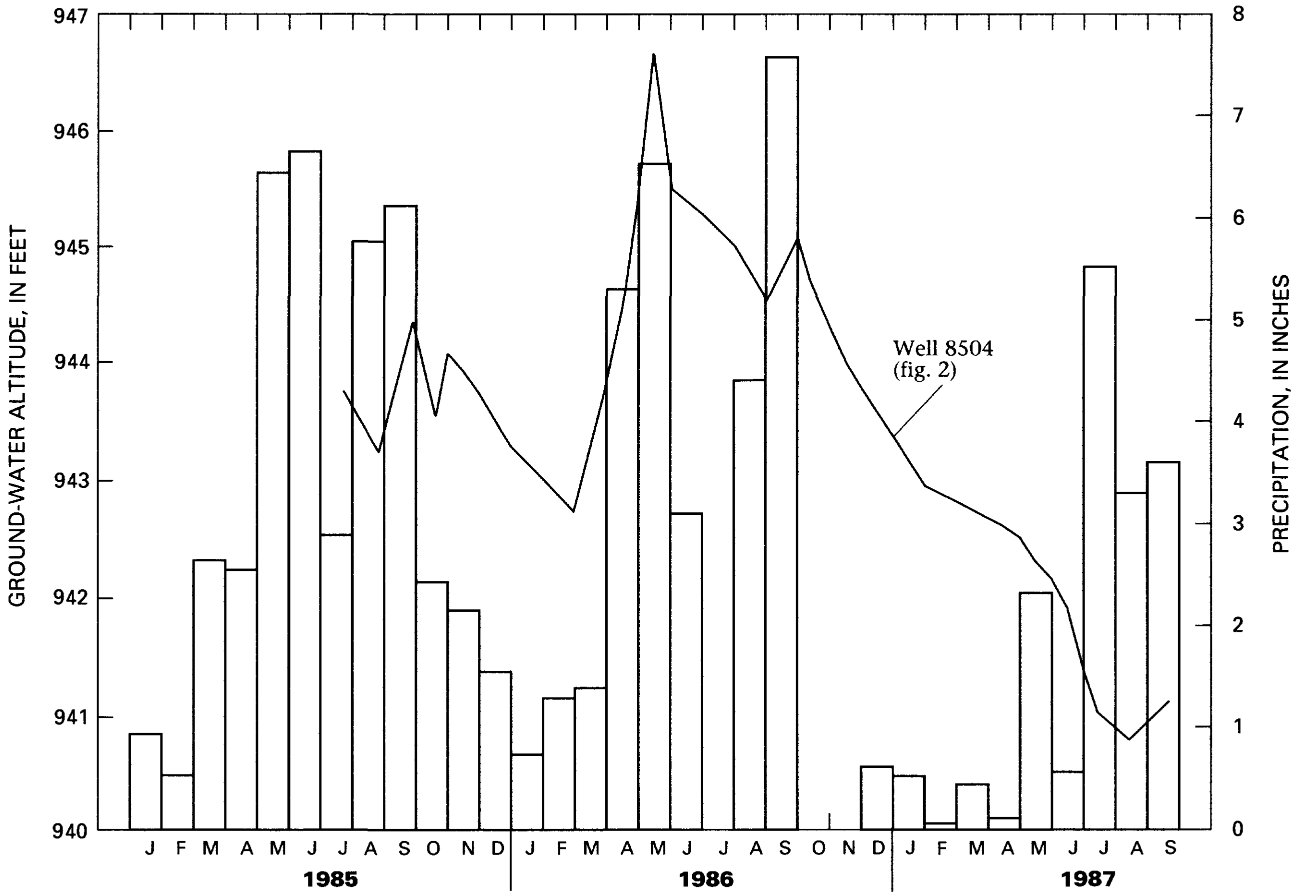


Figure 7. Hydrograph of monthly mean water levels at well 8504 and bar graph of monthly precipitation at Grantsburg, Wisconsin.

into and out of various impoundments during dry periods to maintain optimum wildlife habitat. The maintenance of water levels in Phantom Flowage resulted in similarly maintained ground-water levels near the flowage in the interior of the site, as exhibited on the hydrographs from wells 8517 and 8514 (fig. 6).

High ground-water levels during periods of high water levels in the impoundments appears to be limited to wells very near the impoundments. If high water levels in the impoundments were primarily responsible for areal flooding in 1985 and 1986, the effects of high water levels in the impoundments on ground-water levels probably would be more widely distributed.

Although water-table contours for the late 1930's are lower than those for 1986 and 1987, the precipitation and ground-water level hydrographs discussed earlier suggest that natural fluctuations may be responsible for the recent above-normal water levels.

Long-term water-level fluctuations in well Bt-2 in Webster (about 13 mi northeast of the site) and well Pk-40 in Milltown (about 20 mi southeast of the site) (fig. 1) are shown in figures 9 and 10. These wells are far enough from the Crex Meadows area that they could not be affected by water levels in the impoundments, but they are close enough to be influenced by similar climatic conditions.

Water levels in well Bt-2 (fig. 9) during the late 1930's indicate that water levels in the area were relatively low as the area recovered from the drought during the mid-1930's. The water levels continued to rise until roughly 1947, and until 1982 fluctuated between about 33 and 35 ft below land surface. Since 1982 the water level in Bt-2 increased steadily until late 1986, when it reached its highest level of record—slightly greater than 31 ft below land surface. The water level then declined throughout 1987.

The hydrograph for well Pk-40 (fig. 10) begins in 1957, and thus does not show the low levels in the 1930's, but the fact that the water level in Pk-40 also reached its shallowest depth below land surface in 1986 indicates that water levels were high throughout the region. The water level in Pk-40 also declined sharply during 1987.

The relation between precipitation and ground-water levels at wells Bt-2 and Pk-40 is shown by

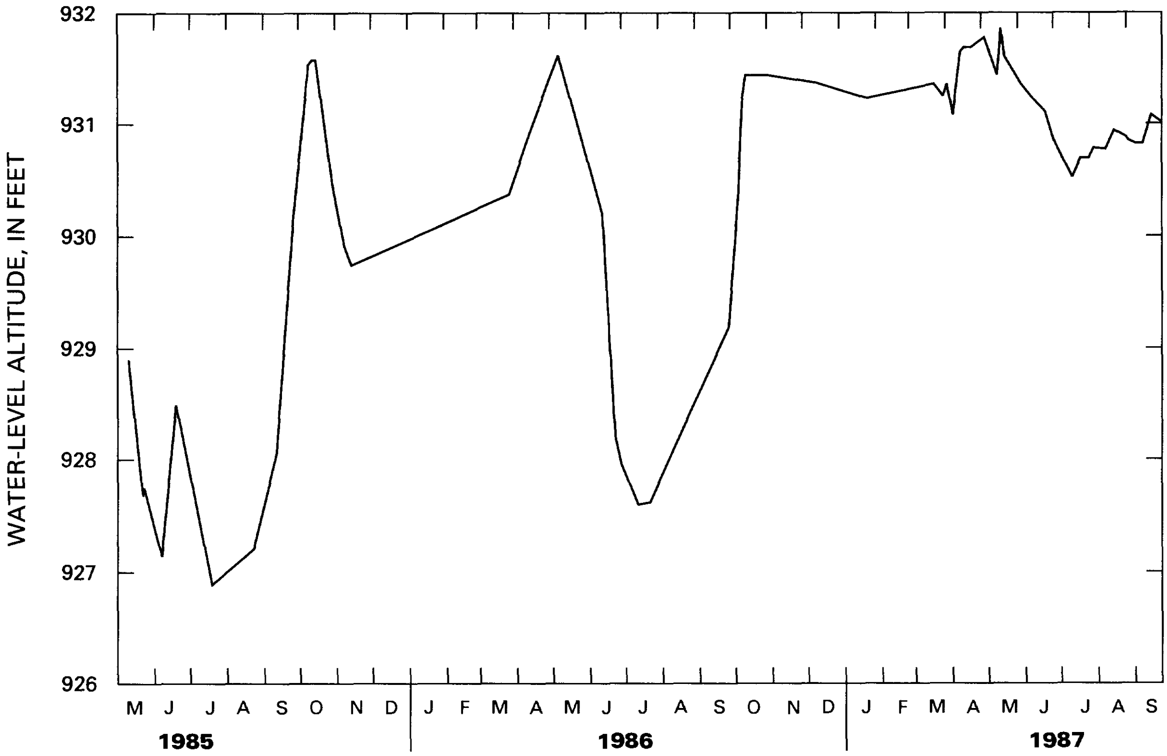


Figure 8. Water levels at Phantom Flowage from May 1985 through September 1987.

comparing cumulative departure from mean annual precipitation at Danbury (fig. 9) and at St. Croix Falls (fig. 10) with respective ground-water levels. Cumulative departure is the accumulated difference between the measured annual precipitation for a given year and the mean annual precipitation for the period of record. In figures 9 and 10 the mean annual precipitation is represented by a straight line across the plot located at 0 inches on the right hand axis. The dashed line represents the cumulative departure from the mean. Consecutive years of above- or below-average precipitation will move the cumulative departure farther from the mean.

Figure 9 shows that the above-normal ground-water level that occurred in well Bt-2 in 1986 was preceded by 5 consecutive years of above-average precipitation at Danbury. Figure 10 shows that the above-normal ground-water level at well Pk-40 in 1986 was preceded by 10 consecutive years of above-average precipitation.

Annual precipitation at Grantsburg, Wisconsin, from 1981 through 1987 is shown in figure 11. Precipitation increased from 33 in. in 1981 to 39 in. in 1986. Figure 11 also shows that precipitation decreased to 28 in. in 1987.

Comparing the regional and local precipitation data with the regional and local ground-water altitudes suggests that the above-normal ground-water levels that occurred during 1984, 1985, and 1986 were primarily due to several consecutive years of above-normal precipitation. This conclusion also is supported by the fact that ground-water levels declinedwhen precipitation was below normal in 1987.

RELATION OF GROUND-WATER LEVELS TO SURFACE-WATER DISCHARGE

Stream discharge is generally composed of three components, overland flow that enters streams during rainfall events, snowmelt runoff, and discharge from the ground-water reservoir. In the absence of overland flow in the basin, essentially all of the water flowing in a stream is from ground-water discharge. When ground-water levels are high, surface-water discharge generally is also high, and when ground-water levels are low surface-water discharge generally is also low. The only exception to this relation is during rainfall when there is a large component of overland flow into streams.

Monthly discharge at two stations on the North Fork Wood River—(1) upstream and (2) downstream from study area—from August 1985 through October 1987 is shown on figure 12. These hydrographs show the similarity between the flow rates at each station. Discharge during 1987 is much lower at each station than during 1986 or the fall of 1985. At the upstream station, annual mean discharge per square mile during water year (WY) 1986 (October 1, 1985, to September 30, 1986) was 1.24 $(ft^3/s)/mi^2$ (cubic feet per second per square mile) and during WY 1987 (October 1, 1986, to September 30, 1987) was 0.43 $(ft^3/s)/mi^2$. At the downstream station, the annual mean discharge per square mile during WY 1986 was 1.17 $(ft^3/s)/mi^2$ and during WY 1987 was 0.31 $(ft^3/s)/mi^2$.

Much of the Crex Meadows site is included in the drainage area for the lower station. If the Crex Meadows site impoundments were primarily responsible for the above-normal ground-water levels in 1985 and 1986, the discharge per square mile would

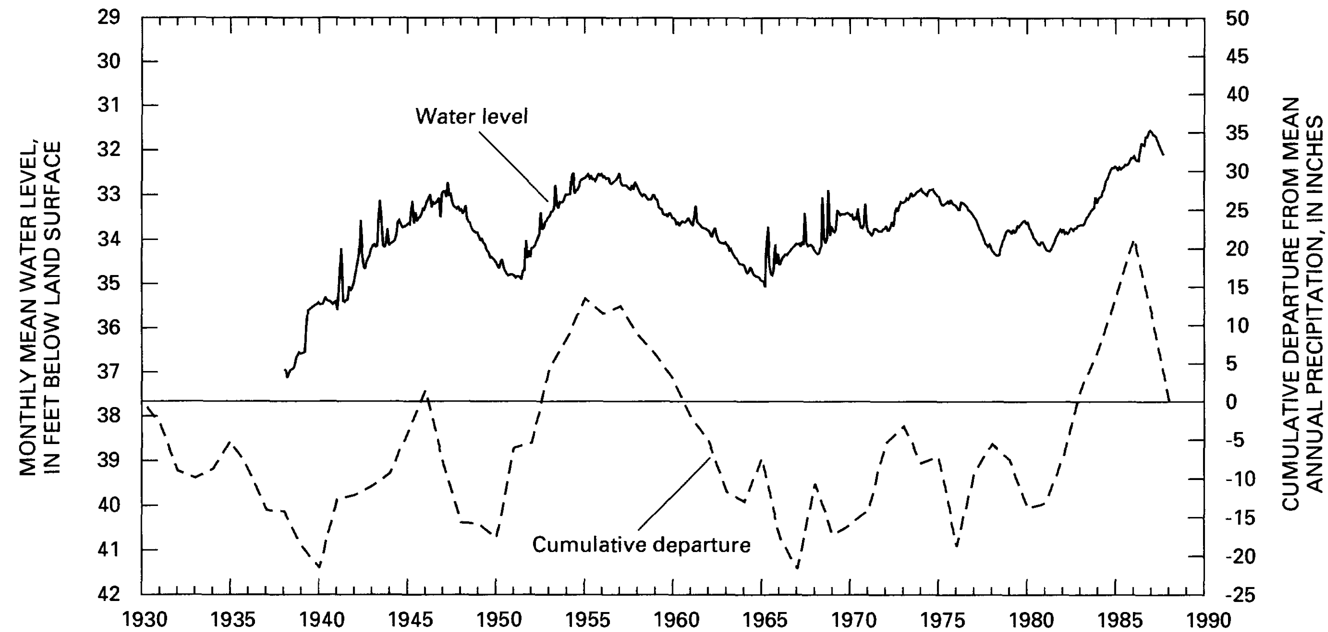


Figure 9. Ground-water levels at well Bt-2 and cumulative departure from mean annual precipitation at Danbury, Wisconsin.

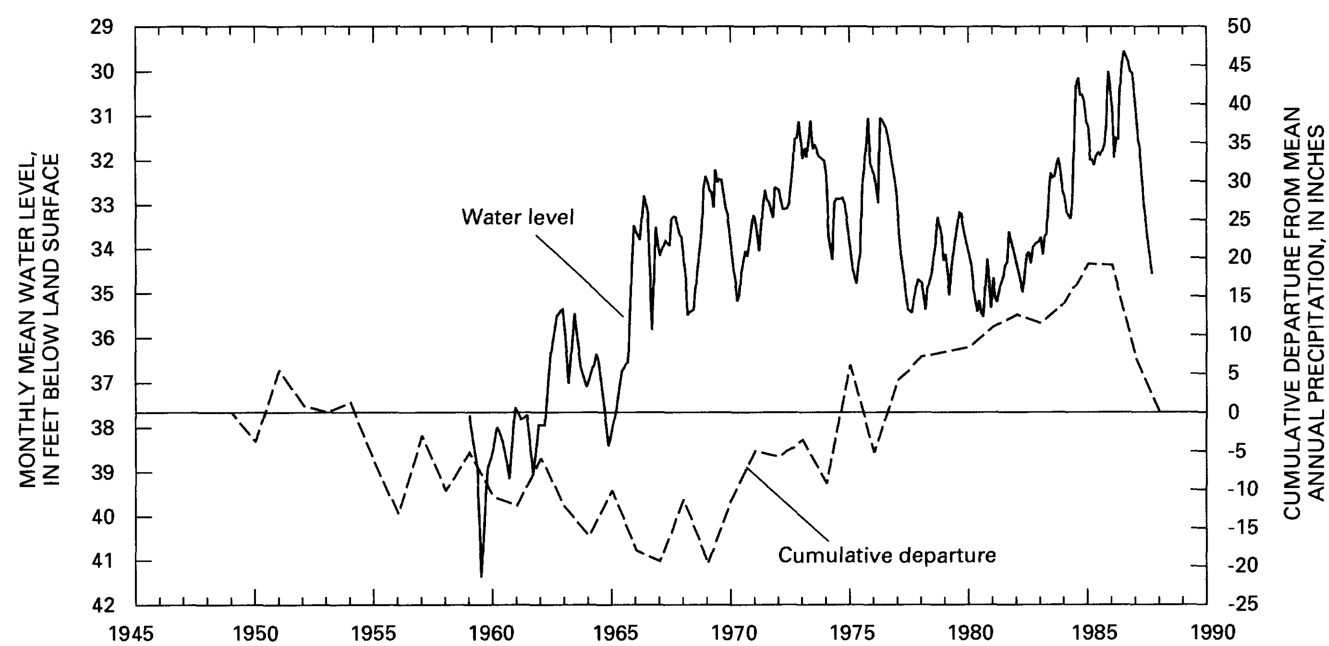


Figure 10. Ground-water levels at well PK–40 and cumulative departure from mean annual precipitation at St. Croix Falls, Wisconsin.

be greater at the downstream station than the upstream station, which does not include the flowage area. The annual mean discharge per square mile actually decreases slightly between the two stations.

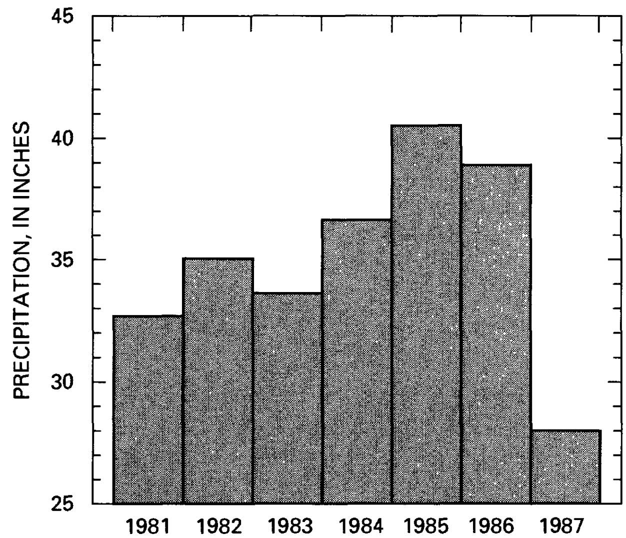


Figure 11. Annual precipitation at Grantsburg, Wisconsin, 1981–87.

Because above-normal ground-water levels generally result in increased ground-water discharge to rivers and streams, long-term discharge monitoring of the St. Croix River at Danbury (about 20 mi northeast of the site) and St. Croix Falls (about 26 mi south of the site)(fig. 1) also provide valuable information pertaining to regional ground-water levels. The hydrographs in figure 13, show that the St. Croix River at both stations reached their highest discharge of record during 1986, which was followed by a sharp decline in 1987. This relates directly to above-normal precipitation and ground-water levels throughout their drainage areas. The station at Danbury represents a drainage area of 1,580 mi^2 (square miles) and the station at St. Croix Falls represents an area of 6,240 mi^2.

GROUND-WATER QUALITY

Because it was thought that the Crex Meadows impoundments might be responsible for the increased water levels in the area, there was additional concern that they may also have an adverse effect on the ground-water quality. To address this concern, 20 ground-water samples were collected in August 1985 from observation wells selected to provide a uniform areal distribution. These samples were analyzed for

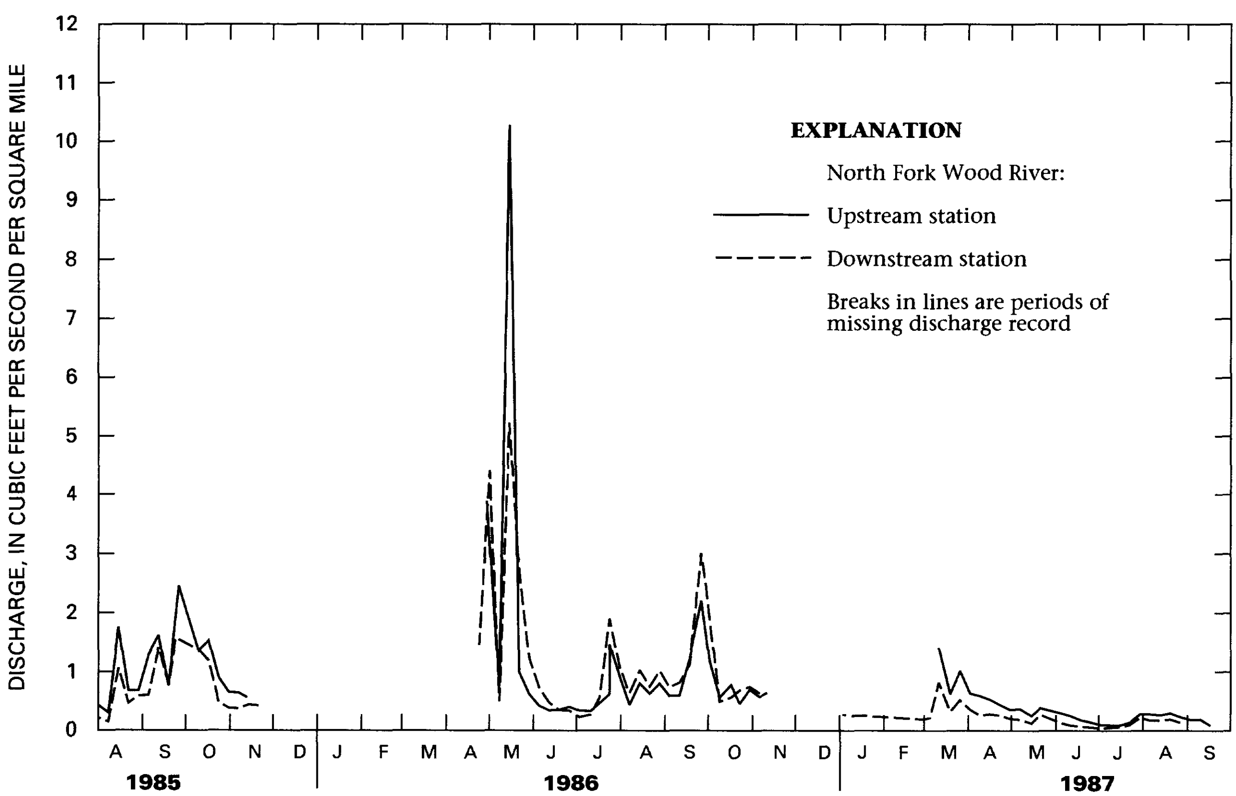


Figure 12. Discharge from two streamflow-gaging stations on the North Fork Wood River.

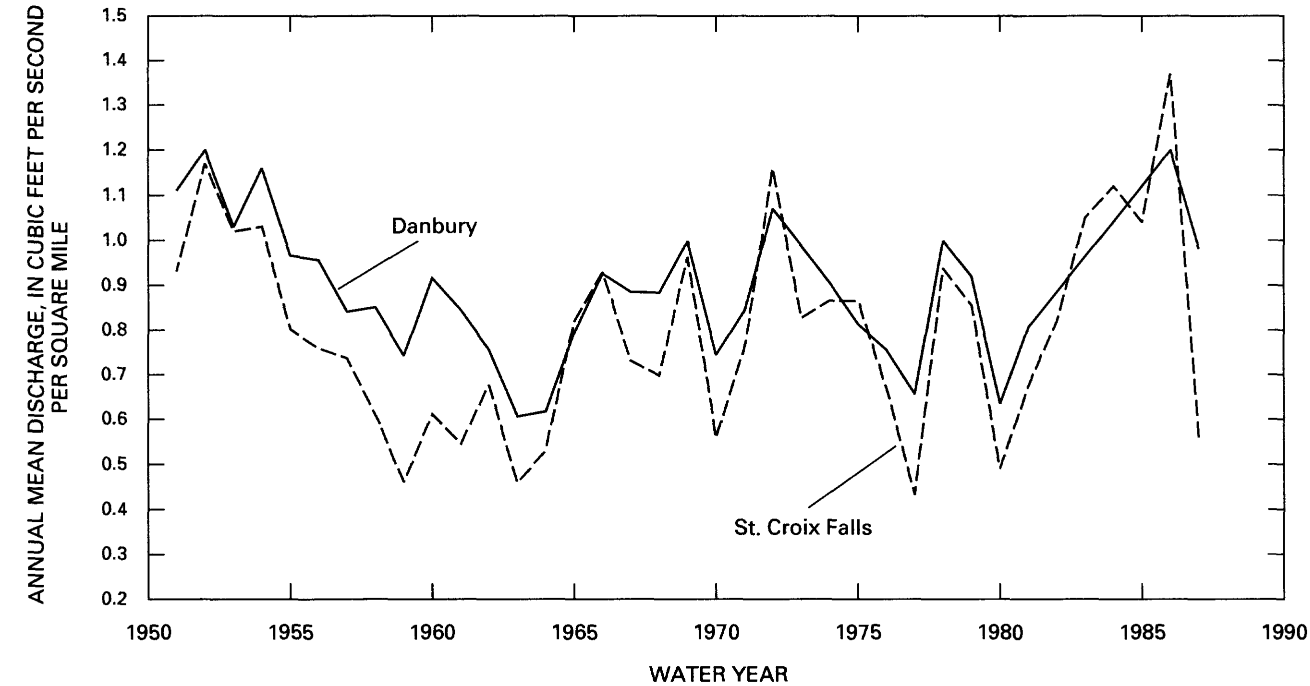


Figure 13. Discharge of the St. Croix River at St. Croix Falls and Danbury, Wisconsin.

major inorganic constituents. The results of these analyses are shown in table 2.

Calcium and bicarbonate (the primary components of alkalinity) are the major dissolved constituents in ground water in the vicinity of Crex Meadows.

Calcium and magnesium together compose more than 70 percent of the cations in all wells but one. Calcium alone makes up 50 percent or more of the cations in 17 of the 20 samples. Samples can be divided into two general groups based on anion concentrations: those samples where bicarbonate is more than 70 percent of the anions and those samples where bicarbonate is between 40 and 60 percent of the anions. In the later group sulfate comprises a higher percentage of the anions than it does in the former group.

Iron concentrations ranged from 45 to 45,000 µg/L (micrograms per liter) and had a median value of 1,100 µg/L. Samples from 17 of the wells had iron concentrations exceeding the State maximum recommended level of 300 µg/L for drinking water (Wisconsin Department of Natural Resources, 1978). This recommendation is to reduce esthetic problems of bad taste and staining of clothing and fixtures. There are no known adverse health effects from elevated iron concentrations in drinking water.

Iron is abundant and widely distributed in rocks and soils and the chemical and biological processes affecting the chemistry of iron in ground water are complex and rapid. This complicates the description of the occurrence and movement of iron in ground water. Iron is present in plant debris in soils, and the activities in the biosphere may have a strong influence on the occurrence of iron in water (Hem, 1985, p. 77).

Because of the widespread presence of high concentrations of iron in ground water both upgradient and downgradient from the Crex Meadows flowages it seems unlikely that elevated iron concentrations in ground water are caused by the flowages.

SUMMARY AND CONCLUSIONS

Ground-water levels in 54 wells installed at the Crex Meadows Wildlife Area generally rose between 1985 and the fall of 1986, but declined throughout most of 1987. The general rise was due to the higher than normal precipitation between 1980 and 1986. Precipitation during 1987 was below normal, which accounts for the water-level declines in 1987.

Comparisons between a ground-water level map of the Crex Meadows Wildlife Area constructed from combined data from 1935 and 1937 and ground-water level maps constructed for 1986 and 1987 show an overall increase in ground-water levels throughout the study area. Analysis of regional data, including ground-water levels measured since 1935 in well Bt-2 and since 1957 in well Pk-40, long-term discharge measurements on the St. Croix River at Danbury and St. Croix Falls, and precipitation records from weather stations at Danbury, Grantsburg, and St. Croix Falls, Wisconsin, suggests that this increase in ground-water levels was caused by increased precipitation.

Results of chemical analysis of 20 water samples collected from selected observation wells indicate that calcium and bicarbonate are the predominant ions in ground water in the Crex Meadows area. Iron concentrations range from 45 to 45,000 µg/L and exceeded the State recommended maximum level of 300 µg/L for drinking water in 17 of the 20 samples.

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Table 1.—*Well-construction data and brief description of geologic materials at observation wells*

[All wells have 3-foot screens; ft, feet]

Well no.	Depth of observation well (feet)	Lithology from test boring	
8401	20	0–20 ft	medium sand
8402	12	0–13 ft	medium sand
8403	20	0–20 ft	medium sand
8404	11	Lithology same as well 8405	
8405	20	0–5 ft	medium sand
		5–11 ft	silty sand
		11–20 ft	medium sand
8406	20	0–3 ft	silty sand
		3–6 ft	medium sand
		6–12 ft	silty sand
		12–20 ft	medium sand
8407	11	Lithology same as well 8406	
8408	23	0–4 ft	silty sand
		4–23 ft	medium sand
8409	15	0–4 ft	sandy silt
		4–12 ft	medium sand
		12–15 ft	sandy silt
8410	19	0–6 ft	silty sand
		6–19 ft	medium sand
8411	11	Lithology same as well 8410	
8412	15	0–15 ft	medium sand
8413		Unknown	
8414		Unknown	
8501	12	0–12 ft	coarse sand
8502	12	0–2 ft	coarse sand
		2–10 ft	organic silt and clay
		10–11 ft	organic sandy silt
		11–12 ft	coarse sand
8503	27	0–17 ft	coarse sand
		17–27 ft	fine sand
8504	12	Lithology same as well 8503	
8505	12	0–12 ft	medium sand
8506	17	0–17 ft	coarse sand
8507	12	Lithology same as well 8508	
8508	64	0–47 ft	coarse sand
		47–52 ft	fine sand
		52–67 ft	coarse sand
		67–72 ft	varved lake clay
8509	12	0–12 ft	medium sand
8510	14	0–17 ft	medium sand
8511	18	0–18 ft	fine sand

Table 1.—*Well-construction data and brief description of geologic materials at observation wells*—Continued

[All wells have 3-foot screens; ft, feet]

Well no.	Depth of observation well (feet)	Lithology from test boring	
8512	18	0–18 ft	medium sand
8513	18	0–18 ft	fine sand
8514	54	0–7 ft	fine sand
		7–22 ft	medium sand
		22–42 ft	coarse sand
		42–57 ft	medium sand
		57–62 ft	fine sand
		62–72 ft	varved lake clay
8515	30	Lithology same as well 8514	
8516	12	Lithology same as well 8514	
8517	12	0–12 ft	medium sand
8518	16	0–12 ft	fine sand
		12–17 ft	coarse sand
8519	13	0–12 ft	medium sand
8520	17	0–17 ft	medium sand
8521	18	0–17 ft	coarse sand
8522	35	0–37 ft	medium sand
		37–40 ft	lake clay
8523	10	Lithology same as well 8522	
8524	18	0–9 ft	clayey till
		9–12 ft	silty sand
		12–18 ft	medium sand
8525	23	0–10 ft	clayey till
		11–12 ft	silty sand
		12–22 ft	medium sand
8526	20	0–20 ft	medium sand
8527	7	Lithology same as well 8526	
8528	23	0–10 ft	silty sand
		10–22 ft	medium sand
8529	15	0–8 ft	clayey till
		8–15 ft	medium sand
8530	15	0–15 ft	medium sand
8531	57	0–5 ft	silty sand
		5–10 ft	clayey till
		10–22 ft	medium sand
		22–37 ft	fine sand
		37–47 ft	medium sand
		47–67 ft	coarse sand
		67–72 ft	medium sand
		72–77 ft	fine sand
8532	21	Lithology same as well 8531	

Table 1.—*Well-construction data and brief description of geologic materials at observation wells*—Continued

[All wells have 3-foot screens; ft, feet]

Well no.	Depth of observation well (feet)	Lithology from test boring	
8533	14	0–22 ft	medium sand
8534	12	0–12 ft	medium sand
8535	23	0–17 ft	medium sand
		17–22 ft	coarse sand
8536	13	Lithology same as well 8535	
8537	12	0–12 ft	medium sand
8538	22	0–12 ft	medium sand
		12–22 ft	coarse sand
8539	13	Lithology same as well 8538	
8540	13	0–6 ft	clayey till
		6–8 ft	silty sand
		8–12 ft	medium sand

Table 2.—*Common inorganic constituents and properties of ground water at Crex Meadows Wildlife Area*

[M-D-Y,month-day-year; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 °Celsius; µg/L, micrograms per liter; <, less than]

Well no.	Date of sample (M-D-Y)	Specific conductance (µS/cm)	pH (standard units)	Hardness (mg/L as $CaCO_3$)	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/l as SiO_2)	Nitrogen, NO2+NO3 dissolved (mg/L as N)	Iron, dissolved (µg/L as Fe)
8403	08-06-85	137	6.7	48	12	4.3	1.8	2.2	58	1.8	0.7	0.2	7.8	0.10	630
8404	08-06-85	57	5.9	17	4.4	1.4	1.7	.80	12	7.2	2.4	<.10	9.8	<.10	940
8406	08-07-85	152	6.6	70	23	3.1	1.3	<.10	65	7.9	.80	<.10	5.5	.17	390
8412	08-07-85	151	7.0	59	16	4.6	1.1	13	67	6.7	.40	<.10	5.4	1.0	45
8502	08-07-85	237	6.5	40	11	3.1	1.6	.60	50	20	5.6	<.10	28	<.10	45,000
8505	08-07-85	22	6.9	7	1.8	.54	.50	.40	5	3.9	.30	<.10	7.1	.19	220
8507	08-06-85	41	6.0	11	2.7	.94	.70	.70	7	4.2	1.6	<.10	7.4	.53	1,200
8509	08-06-85	29	5.9	9	2.4	.80	.50	.40	7	4.4	.20	<.10	7.9	.15	360
8512	08-06-85	56	6.1	20	5.4	1.6	1.6	1.5	6	16	1.7	<.10	11	.45	46
8513	08-06-85	61	6.2	13	3.4	1.1	.80	1.0	11	6.0	.90	.10	13	<.10	7,200
8515	08-06-85	84	6.4	20	5.2	1.7	.90	1.1	22	1.9	1.8	<.10	3.9	<.10	8,800
8517	08-06-85	124	6.3	30	6.5	3.3	1.1	1.4	35	2.2	1.7	<.10	10	<.10	13,000
8518	08-06-85	132	6.2	20	5.5	1.4	1.5	2.7	22	4.5	3.1	<.10	9.7	<.10	22,000
8522	08-07-85	116	6.7	27	7.1	2.2	2.7	.70	25	13	2.3	<.10	28	<.10	10,000
8524	08-07-85	520	7.4	250	67	19	5.0	.50	252	14	2.6	.30	31	<.10	1,800
8526	08-07-85	450	6.8	160	41	14	5.8	.60	166	16	5.3	.1	27	.11	39,000
8532	08-07-85	94	6.4	36	8.7	3.5	3.0	.40	36	7.7	1.0	.10	40	<.10	470
8534	08-07-85	288	6.0	53	13	5.1	25	1.8	30	16	47	<.10	19	1.7	1,700
8535	08-07-85	44	6.1	12	3.3	.98	.80	2.3	11	6.5	.40	<.10	12	.13	770
8537	08-07-85	37	6.1	11	3.0	.96	.60	.90	9	5.9	.30	<.10	9.2	<.10	990
Maximum		520	7.4	250	67	19	25	13	252	20	47	.3	40	1.7	45,000
Minimum		22	5.9	7	18	.54	.5	.4	5	1.8	.2	.05	3.9	.1	45
Median		105	6.4	23.5	6	1.95	1.4	.9	23.5	6.6	1.65	.05	9.9	.18	1,095