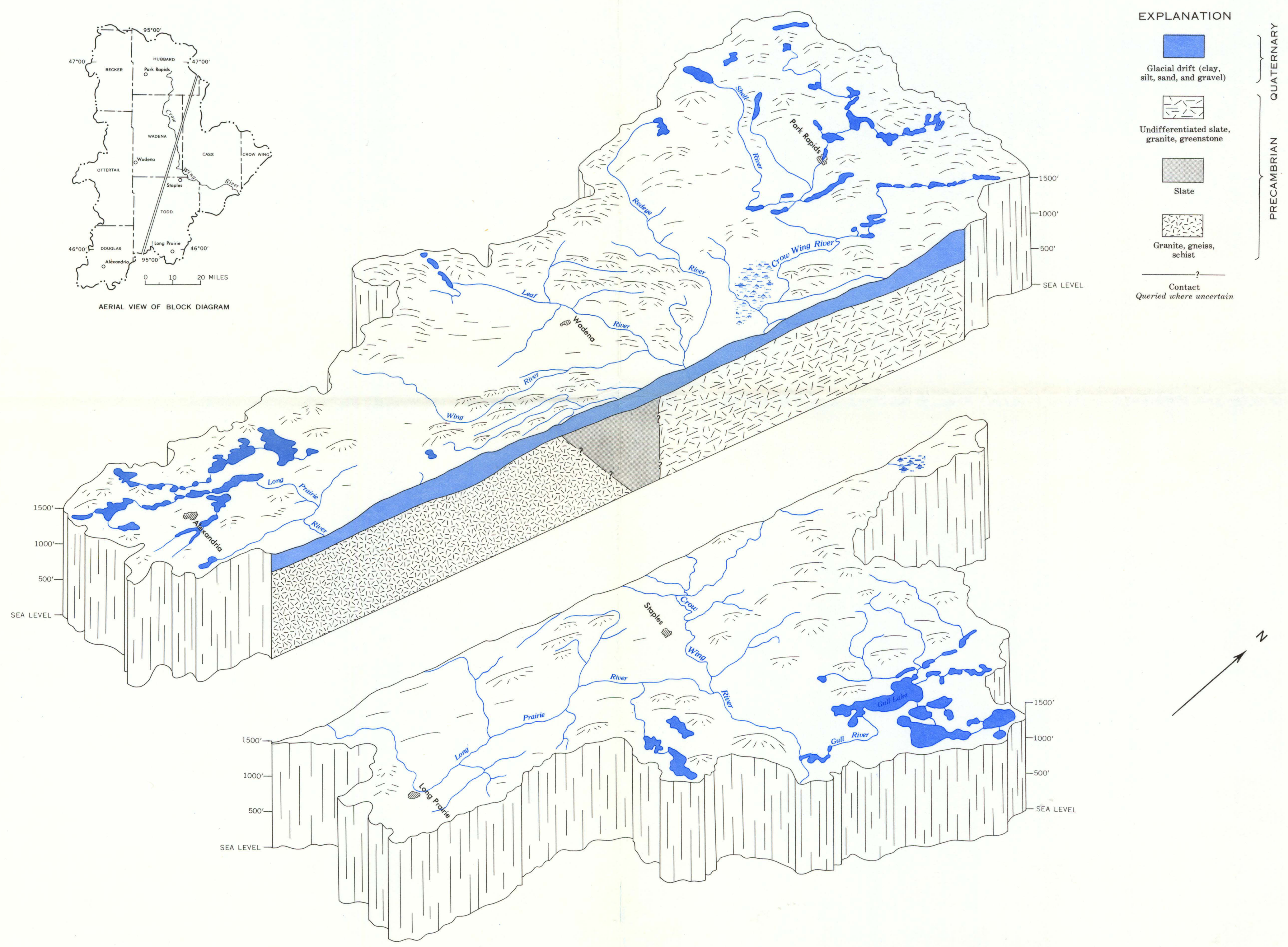
PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

THE CROW WING RIVER WATERSHED



THE CROW WING RIVER, A TRIBUTARY OF THE MISSISSIPPI RIVER, DRAINS AN AREA OF ABOUT 3760 SQUARE MILES, ESSENTIALLY ALL OF WHICH IS COVERED BY GLACIAL DEPOSITS

Topography of most of the watershed is slightly- to moderately-undulating and has local relief of up to about 50 feet. The margin of the watershed, particularly the southwestern and northwestern parts, is considerably higher and has local relief often exceeding 150 feet. The higher areas contain numerous lakes and, in the extreme north and east parts of the watershed, are heavily forested.

SUMMARY

RELATIVE ADEQUACY OF WATER SOURCES

Purpose	Considerations	Surface water: Mainstem Crow Wing River below Shell River	Surface water: Shell, Leaf, Long Prairie, and Gull Rivers	Surface water: Tributaries	Surface water: Lakes
Municipal and industrial supply	For a moderate supply, principal needs are: Quantity: Minimum sustained supply of 2 cfs or 900 gpm. Quality: Total dissolved-solids content less than 500 ppm. Hardness less than 180 ppm.	Adequate supply, average flow varies from 300 cfs at mouth of Shell River to 1000 cfs at mouth of Crow Wing River. ——— Treatment for hardness may be necessary.	Dependable supply in lower reaches of streams. ——— May require storage near headwaters. Treatment for hardness may be necessary.	Dependable supply in lower reaches of larger tributaries. ——— Generally requires storage. Treatment for hardness may be necessary.	Natural storage good in larger lakes. ——— Treatment for hardness may be necessary.
Rural domestic and stock supply	For an adequate farm supply, needs are: Quantity: About 5 gpm or more. Quality: Total dissolved-solids content less than 1,000 ppm.	Adequate for stock. ——— Available only to riparian lands. Treatment necessary for domestic use.	Adequate for stock. ——— Available only to riparian lands. Treatment necessary for domestic use.	May be adequate for stock. ——— Available only to riparian lands. Treatment necessary for domestic use. Storage may be necessary.	Generally adequate for stock. ——— Available only to riparian lands. Treatment necessary for domestic use. Small lakes may dry up during drought.
Irrigation supply	For an average farm needs are: Quantity: Minimum flow of 2 cfs during growing seasons or wells yielding 250 gpm or more. Quality: Total dissolved-solids content less than 2,000 ppm. Suitability of water quality for irrigation as indicated by classification of U.S. Dept. of Agriculture.	Adequate supply. Suitable quality. ——— Available only to riparian lands.	Generally adequate supply. Suitable quality. ——— Available only to riparian lands.	Suitable quality. ——— Available only to riparian lands. Storage may necessary.	Suitable quality. ——— Available only to riparian lands. Lake levels may be affected.
Fish and wildlife habitat	Presence of wetlands. Natural cover. Stability of water levels.	Very little development, most of the river bank and adjacent land is in natural state. ———	Good wetlands. ———	Good wetlands. ——— Warm waters in late summer. Low flows not dependable.	Extensive marshlands adjacent to many lakes. ——— Large winterkill in shallow lakes.

Purpose	Ground water: Surficial outwash	Ground water: Till plain (partially buried by outwash)	Ground water: Moraine	Ground water: Bedrock
Municipal and industrial supply	Generally adequate supply. Rapid recharge from precipitation. Induced infiltration from streams possible. Generally good quality. Inexpensive to develop compared to other ground-water sources. ——— Easily polluted. Treatment for hardness and iron may be necessary.	Buried outwash may yield adequate supply. Wells may be open to more than one aquifer. Generally good quality. ——— Aquifer extent generally small. Slow recharge. Treatment for hardness and iron may be necessary. Costly to develop, test drilling required.	Ice-contact deposits and buried outwash may yield adequate supplies. Induced infiltration from lakes possible. Wells may be open to more than one aquifer. Generally good quality. ——— Aquifer extent generally small. Treatment for hardness and iron may be necessary. May be costly to develop, may require test drilling.	——— Supply generally small. Slow recharge. Generally deeply buried.
Rural domestic and stock supply	Adequate supply. Generally good quality. Inexpensive to develop compared to other ground-water sources. ——— Easily polluted. Treatment for hardness and iron may be necessary for domestic use.	Generally adequate supply. Generally good quality. ——— Treatment for hardness and iron may be necessary for domestic use.	Generally adequate supply. Generally good quality. ——— Treatment for hardness and iron may be necessary for domestic use.	——— Supply may be inadequate. Generally deeply buried.
Irrigation supply	Generally adequate supply. Rapid recharge from precipitation. Induced infiltration from streams possible. Good quality. Inexpensive to develop compared to other ground-water sources. ———	Buried outwash may yield adequate supply. Wells may be open to more than one aquifer. Good quality. ——— Aquifer extent generally small. Slow recharge. Costly to develop, test drilling required.	Ice-contact deposits and (or) buried outwash may yield adequate supplies. Induced infiltration from lakes possible. Wells may be open to more than one aquifer. Good quality. ——— Aquifer extent generally small. May be costly to develop, may require test drilling.	——— Supply probably inadequate. Generally deeply buried.
Fish and wildlife habitat	Suitable quality. ——— Available only to riparian lands. Lake levels may be affected.			

EXPLANATION

Desirable features above line.
Undesirable features below line.

Good — Fair — Poor
Color indicates overall adequacy of water source as evaluated for specific purposes

CONCLUSIONS

1. On a long-term basis, about 22 inches of the 26 inches of annual precipitation in the Crow Wing River Watershed is lost through evaporation and transpiration. The remaining 4 inches leaves the basin as surface runoff.
2. High evapotranspiration during the growing season commonly causes a moisture deficit in sandy soils which have low moisture retention. Areas of surficial outwash, where sandy soils are prevalent, benefit most from supplemental irrigation.
3. Essentially all water supplies in the watershed are derived from glacial drift aquifers. Adequacy of this source of water generally precludes development of bedrock aquifers.
4. Surficial outwash, which covers about half of the watershed, is the most readily available source of ground water. Where sufficient saturated thickness occurs, yields of several hundred gallons per minute can be obtained from wells completed in the outwash. In other areas, thickness of surficial outwash is inadequate for extensive ground-water development. Further evaluation is needed to provide a basis for effective management of the ground-water supply in a particular area.
5. Most ground water in till plain and morainal areas comes from confined aquifers of relatively small areal extent. Although many wells have been drilled in till plain areas, comparatively little ground-water development has taken place in morainal areas. The moraines consist of thick drift which may include ice-contact as well as buried outwash deposits. Morainal areas may therefore contain potentially productive aquifers of significant extent which have thus far been untapped.
6. All water in the watershed is of the calcium-bicarbonate type and is very hard. Ground-water quality varies according to source, whereas, in streams throughout the watershed, quality of water is fairly uniform when base-flow conditions exist.
7. Flow in the main stem of the Crow Wing River is stable because of the regulating effect of lakes and marshes at medium and high flows and the sustaining effect of ground-water discharge from outwash areas during low-flow periods.

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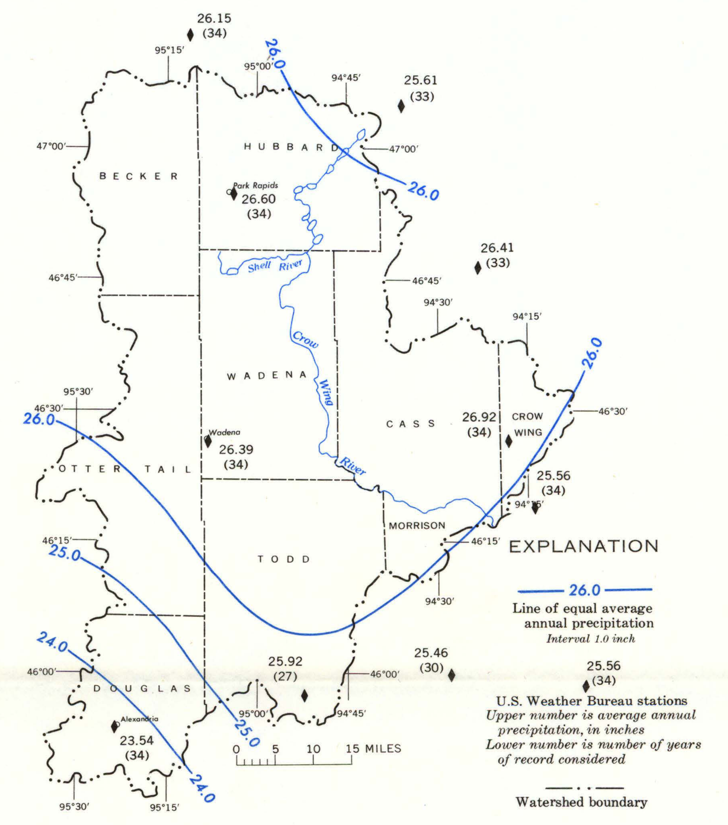
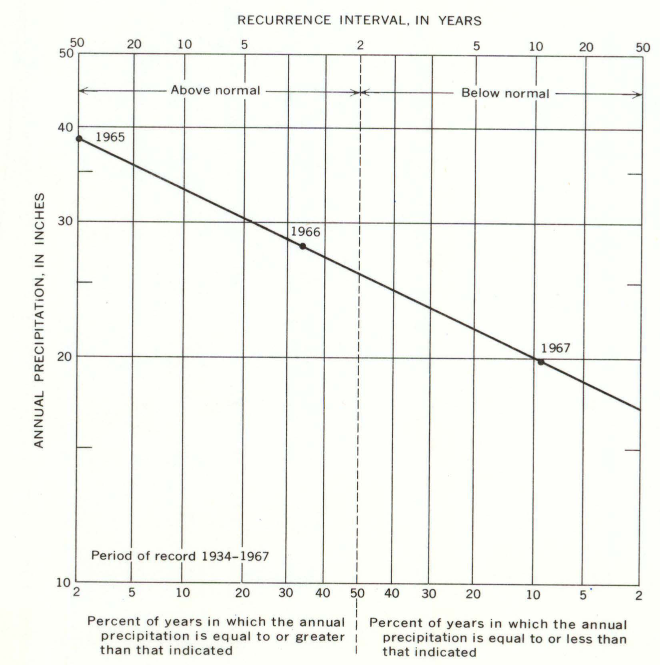
CLIMATE AND WATER BUDGET

		Station	Alexandria	Wadena	Park Rapids
		Years of record	1934–1967	1934–1967	1934–1967
Temperature, in degrees Fahrenheit		Maximum (Year)	105 (1936)	112 (1936)	112 (1936)
		Mean	40.8	40.9	39.0
		Minimum (Year)	−38 (1936, 1951)	−42 (1936)	−45 (1939)
Precipitation, in inches	Annual	Maximum (Year)	36.76 (1941)	38.00 (1965)	38.75 (1944)
		Mean	23.54	26.39	26.60
		Minimum (Year)	10.46 (1936)	14.92 (1936)	16.93 (1934)
	Apr-Sept	Maximum (Year)	31.97 (1941)	30.31 (1965)	33.90 (1944)
		Mean	18.40	20.35	20.12
		Minimum (Year)	8.59 (1936)	9.76 (1936)	10.07 (1936)
	Jan-Mar Oct-Dec	Maximum (Year)	10.57 (1951)	12.46 (1949)	11.63 (1946)
		Mean	5.08	6.03	6.48
		Minimum (Year)	1.87 (1936)	3.17 (1944)	3.32 (1961)

CLIMATIC RECORDS FROM U.S. WEATHER BUREAU STATIONS FOR 1934-67 INDICATE THAT THE WATERSHED IS SUBJECT TO SEASONAL CLIMATIC EXTREMES.—*Records listed are from three stations which illustrate precipitation differences across the watershed. Precipitation during the growing season, April through September, generally comprises 75-80 percent of the annual total. Winter precipitation is mainly in the form of snow, most of which is held in storage until the spring thaw.*

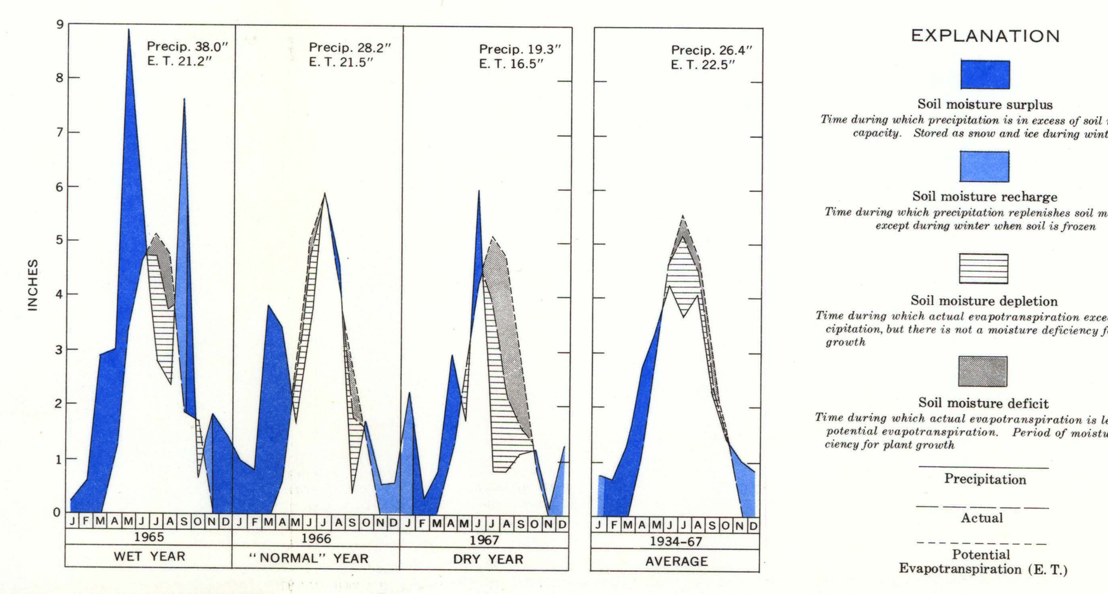


DISTRIBUTION OF PRECIPITATION ACROSS THE WATERSHED IS FAIRLY UNIFORM ON A LONG-TERM BASIS.—*The map is based on 1934–67 precipitation records, which are complete for most stations. Variations from the long-term averages can be expected for any specific year, but the amount of variation is not uniform across the watershed.*



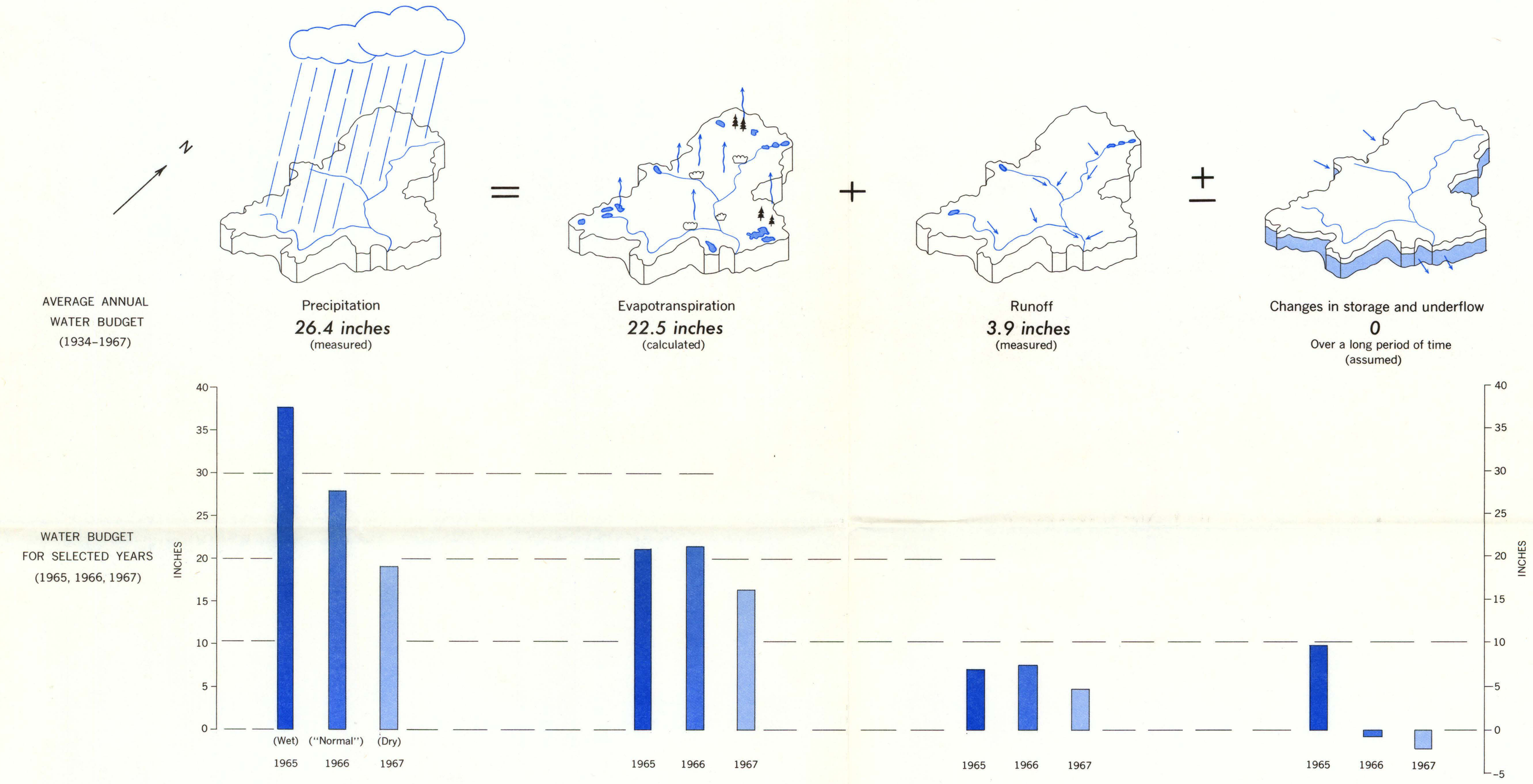
ANNUAL PRECIPITATION PROBABILITIES FOR THE WATERSHED CAN BE APPROXIMATED FROM THE PRECIPITATION FREQUENCY CURVE FOR THE WADENA STATION.—*Precipitation frequency curves based on data from the Alexandria and Park Rapids stations are nearly identical to that shown above. Furthermore, mean annual precipitation at Wadena (26.39 inches) is close to the mean annual precipitation for the watershed (26.11 inches) computed by the Thiessen polygon method.*

The years 1965, 1966, and 1967 are selected as recent examples of wet, "normal", and dry years respectively. Precipitation at Wadena during these years was 38.00, 28.17, and 19.31 inches, respectively, whereas that for the watershed computed by the Thiessen polygon method was 34.72, 27.60, and 19.68 inches, respectively.



ANALYSIS OF CLIMATIC RECORDS FROM THE WADENA STATION INDICATE THAT A SOIL MOISTURE DEFICIENCY FOR PLANT GROWTH COMMONLY OCCURS DURING THE SUMMER

Evapotranspiration was calculated using the method of Thornthwaite and Mather (1957). A 6-inch maximum soil moisture retention was assumed as an average for the watershed. Although average calculated evapotranspiration is 22.5 inches, variations occur during specific years, depending upon temperature and the amount and timeliness of precipitation. Despite the high total prepcipitation during 1965, low rainfall in July and August caused a greater soil moisture deficit than might occur during other wet years. Precipitation is normally sufficient for crop production in areas of heavy soils. Droughty conditions during the growing season are common in areas of sandy soils, where soil moisture retention is low.



THE LONG-TERM WATER BUDGET SHOWS THAT ABOUT 85 PERCENT OF ANNUAL PRECIPITATION IS LOST FROM THE WATERSHED BY EVAPOTRANSPIRATION

Values of precipitation and evapotranspiration are based on data from the Wadena Weather Bureau station. Runoff was determined from power plant records at Pillager, near the mouth of the Crow Wing River. Over a long period of time changes in storage and underflow are approximately zero.

Short term climatic variations cause deviations from long-term averages in the water-budget equation, as illustrated for the years 1965, 1966, and 1967. Annual variations in evapotranspiration are due mostly to differences in temperature and in the amount and distribution of precipitation. The differences in runoff and ground-water storage reflect, in addition, high antecedent precipitation conditions and subsequent delayed ground-water discharge to streams. This delayed base flow sustained an above average runoff during 1965, 1966, and 1967. Accordingly, increasingly negative changes in ground-water storage occurred.

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WATER RESOURCES OF THE CROW WING RIVER WATERSHED, CENTRAL MINNESOTA

By
G. F. Lindholm, E. L. Oakes, D. W. Ericson, and J. O. Helgesen

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