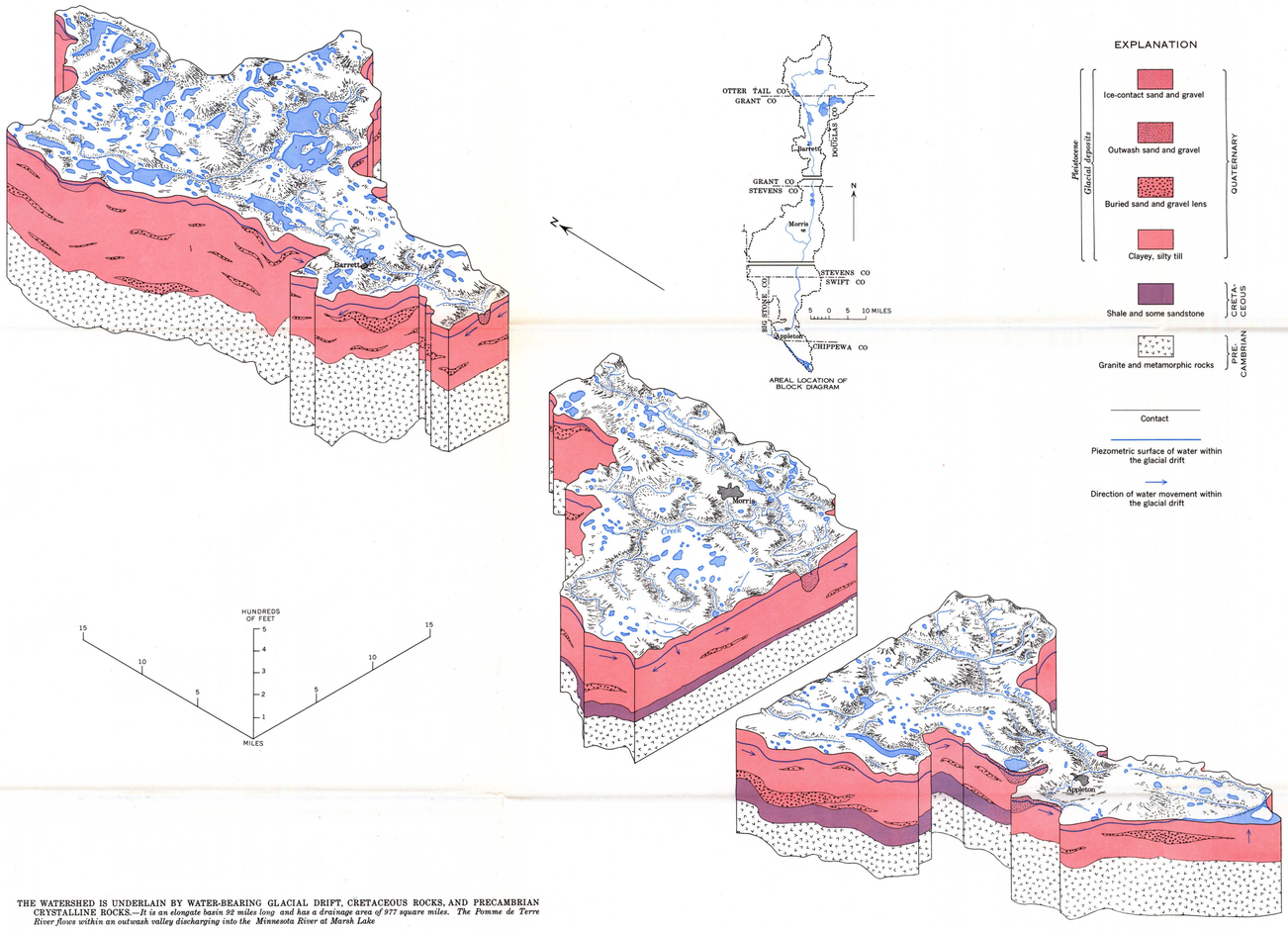
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-220 (SHEET 1 OF 4)

THE POMME DE TERRE WATERSHED



THE WATERSHED IS UNDERLAIN BY WATER-BEARING GLACIAL DRIFT, CRETACEOUS ROCKS, AND PRECAMBRIAN CRYSTALLINE ROCKS.—*It is an elongate basin 92 miles long and has a drainage area of 977 square miles. The Pomme de Terre River flows within an outwash valley discharging into the Minnesota River at Marsh Lake*

MUNICIPAL SUPPLY POTENTIAL AND WATER USE

SUMMARY OF MUNICIPAL SUPPLIES

Municipality	Description of present source											Potential for obtaining additional water	
	Well data						Water quality						
	Well numbers	Year completed	Depth (feet)	Diameter (inches)	Screen length (feet)	Avg. pumping rate (gpm)	Year analyzed	Hardness as $CaCO_3$ (ppm)	Dissolved solids (ppm)	Iron (ppm) [3]	Aquifer	Ground water	Surface water
Alberta	1 1946 193 6 12 15 1949 830 0.5										Buried sand and gravel $T=4\times10^3$ to 10^4 [4] $S=4\times10^{-3}$ to 7×10^{-4} [5]	Fair–Present source will probably not support much increased use. Detailed study may locate additional sand and gravel aquifers. Probably underlain by Cretaceous rocks [1]	Very poor–No reliable source nearby
	2 1962 192 8 15 135												
Appleton	1 1936 80 8 10 300 1938 262 985 3.5										Outwash sand and gravel	Very good–Present source will yield much more than present use. Probably underlain by Cretaceous rocks [1]	Very good–Located on the Pomme de Terre River, and within 3 miles of Lac qui Parle Reservoir
	2 1941 94 12 30 600 1964 401 540 1.1												
Ashby	1 1934 185 8 10 110 1947 430 0.8										Buried sand and gravel	Good–Present source may possibly support limited increased use. One mile east, ice-contact sand and gravel will yield large amounts of water	Good–Within 2 miles of Pelican and Christina Lakes
	2 1950 185 8 22 150 1949 540 0.8												
Barrett	1941 100 8 15 100 1946 510 2.6										Buried sand and gravel	Good–Present source may possibly support limited increased use. Thick outwash sand and gravels to the east will yield large amounts of water	Good–Adjacent to Barrett Lake
Chokio	3 1948 192 8 20 115 1949 688 2.6										Buried sand and gravel $T=10^4$ [4]	Fair–Present source will possibly not support much increased use. Detailed study may locate additional sand and gravel aquifers. Probably underlain by Cretaceous rocks [1]	Very poor–No reliable source nearby
	5 1955 195 8 20 115 1964 740 1600 7.4												
Dalton	1 1937 240 8 16 75 1949 460 1.0										Buried sand from 207 feet to bottom	Good–Present source may possibly support much increased use. Ice-contact sand and gravels, ½ mile northwest of Dalton will yield large amounts of water	Good–Within 3 miles of Tenmile Lake and Pomme de Terre River
	2 1952 227 10 20 75												
Milan	1920's 30 [2] none 80										Buried sand and gravel	Undefined–Testing would be required to determine the potential. Probably underlain by Cretaceous rocks [1]	Good–Within 2 miles of Lac qui Parle Reservoir
Morris	1 1941 75 16 24 450 1953 514										Outwash sand and gravel T approx. 10^5 [4]	Very Good–Present source will yield much more than present use. Possibly underlain by Cretaceous rocks [1]	Good–Located about 1 mile from the Pomme de Terre River
	2 1948 78 16 25 600												
	3 1954 64 26 20 300												
	4 1962 64 24 25 600 1964 693 970 1.8												

[1] The Cretaceous rocks may yield water, but probably not enough for a municipal supply
[2] This well is 15 feet across with a hexagonal wall
[3] See also the quality of water section above
[4] Coefficient of transmissibility
[5] Coefficient of storage

No municipal water is obtained from surface-water sources

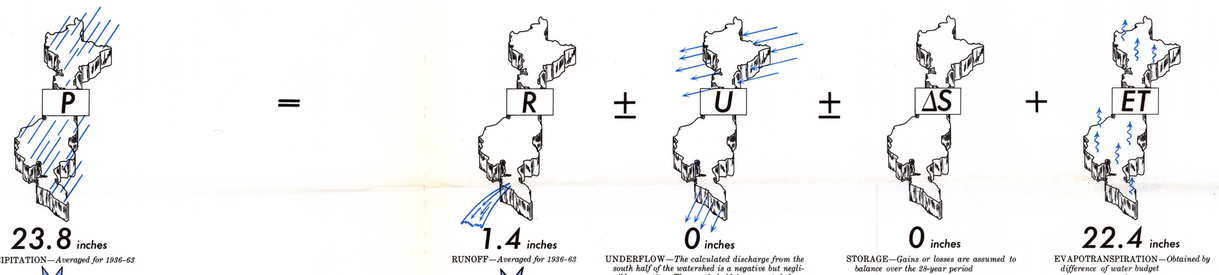
ESTIMATED WATER USE
(In million gallons per year)

Use	Municipal supply wells									Private wells	Surface water	Total
	Alberta	Appleton	Ashby	Barrett	Chokio	Dalton	Milan	Morris	Eight village total			
Domestic	1.6	43.4	1.9	3.5	5.6	4.9	5.1	83.2	149.2	121	0	270
School Industrial and commercial	2.5	3.3	0.2	1.1	2.2	0.1	1.2	[1]7.8	18.4			
	0.5	17.9	10.4	6.4	1.7	13.7	11.7	46.3	108.6	127	0	254
Livestock	0.3	0	0.5	0	0.5	0	0	0	1.3	14	131	146
Irrigation	0	0	0	0	0	0	0	0	0	12	3	15
Total	4.9	64.6	13.0	11.0	10.0	18.7	18.0	137.3	277.5	274	134	685

[1] University of Minnesota

The average per capita domestic use in the watershed is about 42 gallons per day. The major industrial and commercial users are creameries, locker plants, and laundromats. Although about 24 percent of the total water used in the watershed is for agricultural purposes, only about 2 percent is used for irrigation

THE WATER BUDGET



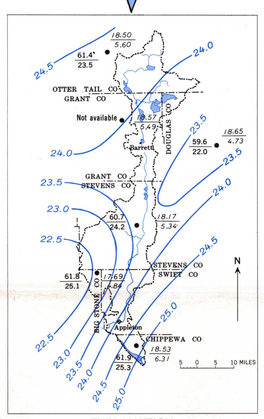
23.8 inches
PRECIPITATION—*Averaged for 1936-63*

1.4 inches
RUNOFF—*Averaged for 1936-63*

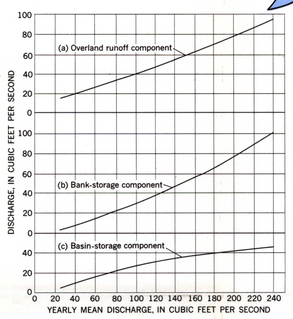
0 inches
UNDERFLOW—*The calculated discharge from the south half of the watershed is a negative but negligible quantity. The north half is separated from the south by a ground-water divide. Water flows through the north half from northeast to southwest. The inflow is assumed to equal the outflow*

0 inches
STORAGE—*Gains or losses are assumed to balance over the 28-year period*

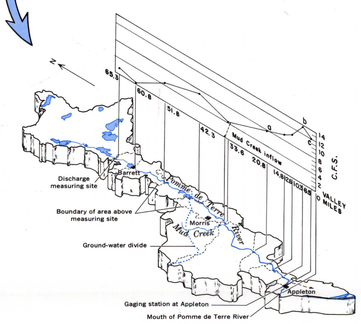
22.4 inches
EVAPOTRANSPIRATION—*Obtained by difference of water budget*



PRECIPITATION IS FAIRLY UNIFORM OVER THE ENTIRE WATERSHED.—*The average of 23.8 is 95 percent of the state average. Three quarters of it occur during the period April to September*

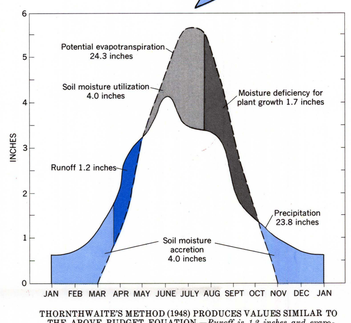


KUNKLE'S METHOD (1962) WAS USED TO SEPARATE 6 YEARLY STREAMFLOW HYDROGRAPHS INTO COMPONENTS; OVERLAND RUNOFF, BANK STORAGE DISCHARGE, AND BASIN STORAGE DISCHARGE.—*The above curves show:*
(a) The overland runoff increases directly with the yearly mean discharge.
(b) The bank-storage curve steepens as the yearly mean discharge increases. This shows as the yearly mean runoff increases it becomes more affected by—(1) water stored on the floodplain, (2) water that entered the ground-water reservoir from the stream and remained for a few days to a few weeks, during which time it gradually discharged back into the stream, and in a small part, (3) water added to the ground-water reservoir from precipitation on the floodplain.
(c) The basin-storage curve flattens with an increase in yearly mean discharge as it approaches the limit of capacity of the ground-water reservoir for storing and transmitting precipitation falling on the watershed area beyond the floodplain



LOW-FLOW DISCHARGE WAS MEASURED AT 10 SITES ALONG THE POMME DE TERRE RIVER AND 1 SITE ON MUD CREEK ON AUG. 11, 1964.—*Mud Creek discharge was the only surface inflow within the reach of the river measured. The flow at the gaging station at Appleton was 12.0 cfs which on the average is equaled or exceeded 83 percent of the time (see flow-duration curve, sheet 3). It is assumed to be entirely from the basin-storage component of streamflow.*
The low flow runoff per square mile is 5 percent of the watershed average. This is due in part to the ground-water divide within this sub-basin (see piezometric map, sheet 2). Also, Mud Creek has no outwash in its valley to sustain flow during dry periods.
The increase in flow through "a–b" is much greater than for the rest of the river, "a" is at the head of an outwash fan which has slightly lower permeability than the valley outwash to the north (see ground-water availability map, sheet 2). Consequently, the piezometric surface and stream gradient steepens. The greater width of the outwash fan accepts more recharge than the narrow outwash valley to the north, and its lower permeability releases it more slowly to the stream, thus sustaining higher flows further into periods of low precipitation.
The decrease flow in reach "b–c" is partly due to streamflow entering the outwash aquifer above Appleton as shown by the arrow.
The loss in the central part of the watershed may be partly the result of pumping from Morris city wells in the valley outwash which induces recharge from the stream, only a part of which is replaced by return sewage.
Evaporation from lakes and ponds on the main stream of the river decreases streamflow and accounts for measurable water loss.
Based on data of the U.S. Weather Bureau (Technical Bulletin No. 37) the average evaporation per square mile of lake or pond surface during May to October is 3¾ cfs, and during November to April is ¾ cfs. The following table shows the average annual open-water evaporation from lake and pond surface in the watershed

	MAY-OCT	NOV-APR	YEAR
INCHES	1.3	0.3	1.6
CFS	92	19	111



THORNTHWAITE'S METHOD (1948) PRODUCES VALUES SIMILAR TO THE ABOVE BUDGET EQUATION.—*Runoff is 1.2 inches and evapotranspiration is 22.6 inches. (The latter value agrees very well with the 22.4 obtained by difference.) The diagram shows a moisture deficiency for plant growth from August to October*

SUMMARY

RELATIVE ADEQUACY OF WATER SOURCES

Purpose \ Source	Pomme de Terre River	Laq qui Parle Reservoir	Large lakes	Small lakes and sloughs	Ice-contact sand and gravel	Outwash sand and gravel	Buried lenses of sand and gravel	Cretaceous sandstone
Municipal and industrial supply	Adequate with development of storage facilities. Favorable location Storage necessary Low flow in some reaches Treatment necessary	Adequate storage capacity for present demand Enlargement possible Adequate inflow Limited usable storage capacity without further development Treatment necessary	Adequate for limited use Additional storage possible Some have adequate ground-water inflow Restricted areal distribution Treatment necessary Some have limited surface inflow	Wide areal distribution Inadequate storage capacity Many dry up during droughts Treatment necessary Inadequate inflow	Well yields of several hundred gpm probable Generally good quality Good recharge Limited to north part of watershed Easily contaminated	Well yields of several hundred gpm probable Underlies most of the river valley Generally good quality Good recharge Easily contaminated	Well yields of a few hundred gpm possible Wide areal distribution Generally good quality No surficial expression-test drilling required Limited recharge	Low well yields Limited to south part of watershed Quality may be unsuitable Limited recharge
Rural domestic and stock supply	Adequate for stock Restricted areal distribution Treatment necessary for domestic use	Adequate storage capacity. Adequate inflow Restricted areal distribution Treatment necessary for domestic use	Adequate storage capacity Adequate inflow Restricted areal distribution Treatment necessary for domestic use	Adequate for stock Wide areal distribution Many dry up during droughts Treatment necessary for domestic use	Adequate well yields Generally good quality Limited to north part of watershed Easily contaminated	Adequate well yields Generally good quality Restricted areal distribution Easily contaminated	Adequate well yields Wide areal distribution Generally good quality	"Soft" water preferred by some Limited to south part of watershed Quality may be undesirable
Irrigation supply	Adequate with development of storage facilities Storage required Restricted areal distribution Low flow during irrigation season	Adequate storage capacity Enlargement possible Adequate inflow Restricted areal distribution	Adequate for limited use Additional storage possible Some have adequate ground-water inflow Restricted areal distribution Some have limited surface inflow	Wide areal distribution Inadequate storage capacity Many dry up during droughts Inadequate inflow	Well yields of several hundred gpm probable Good quality Good recharge Limited to north part of watershed	Well yields of several hundred gpm probable Good quality Good recharge Restricted areal distribution	Well yields of a few hundred gpm possible Wide areal distribution Good quality No surficial expression-test drilling required Limited recharge	Low well yields Limited to south part of watershed Quality may be detrimental to plant growth Limited recharge
Recreation	Suitable for hunting and fishing Favorable location Variation in flow	Adequate area and depth Enlargement possible Favorable for hunting, fishing, and water sports Floods	Suitable for fishing, hunting, and watersports Most are permanent Lakeshore resorts and summer cottages Most are located in north part of watershed	Suitable for hunting Wide areal distribution Many dry up during droughts Shallow	Each of eight water sources are evaluated against several purposes. The quantity, distribution, and quality of each source in relation to the entire watershed is considered, as well as recharge, inflow, and general suitability			
Fish and wildlife habitat	Suitable for wildlife along banks Variation in flow	Marsh areas suitable for wildlife habitat Conservation pool maintained Floods	Excellent habitat Most are permanent Most have adequate inflow	Excellent habitat for wildlife Many dry up during droughts				

EXPLANATION

Color indicates relative worth of source over entire water shed

Excellent habitat for wildlife — Many dry up during droughts
- Desirable features above the line
- Undesirable features below the line

Good
Fair
Poor

CONCLUSIONS

The Pomme de Terre River and large lakes would provide an adequate water supply for most uses within the watershed if storage and transmission facilities were constructed. Evaporation of about 2¼ cfs per square mile of lake or reservoir surface must be considered in design of storage reservoirs. Lakes in the north part of the watershed are effective in reducing peak flows on the river. Extreme low flow is primarily the result of winter freezeup and does not represent depletion of ground-water storage. The effect of basin shape, and differences in topography, geology and lake distribution within the watershed, balance resulting in fairly uniform runoff per square mile throughout the watershed. Lakes, sloughs, Pomme de Terre River, and Lac qui Parle Reservoir provide important and excellent recreational facilities and habitat for fish and wildlife. Surface water in the watershed is suitable for most purposes although commonly hard

Ground water is available anywhere in the watershed, but aquifers that will yield several hundred gallons per minute are largely confined to the outwash valley of the river and to the ice-contact deposits in the north. The sand and gravel making up these two aquifer types commonly extends to the land surface. Thus, these aquifers receive high recharge. Lenses of buried sand and gravel occur within the glacial till throughout the watershed, but yield relatively less water to the wells. Bedrock is not an important aquifer. Ground water in the watershed is suitable for most purposes although commonly hard and high in iron

Heavy pumping from outwash or ice-contact aquifers would lower water levels in wells and lakes and decrease ground water in storage. The cones created around the wells would increase recharge by diverting to the wells natural discharge from lakes and streams. Because water moves readily between the Pomme de Terre River and the adjacent valley outwash, wells in the outwash induce significant recharge from the river. Heavy pumping from buried sand and gravel lenses would have little effect on lake levels but would substantially reduce streamflow

ACKNOWLEDGMENTS

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WATER RESOURCES OF THE POMME DE TERRE RIVER WATERSHED, WEST-CENTRAL MINNESOTA

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