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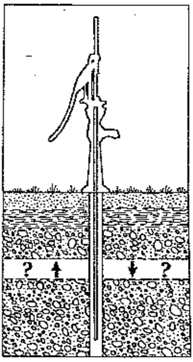

GROUND-WATER LEVELS IN CALUMET COUNTY

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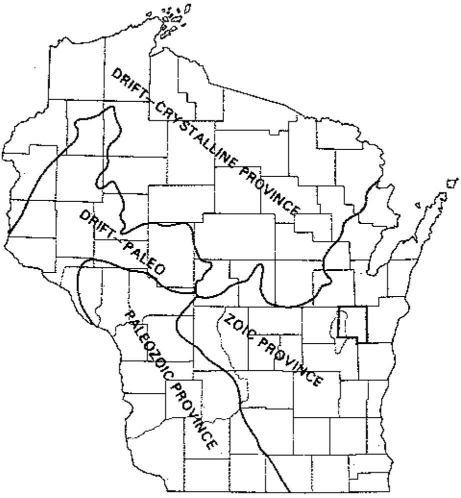
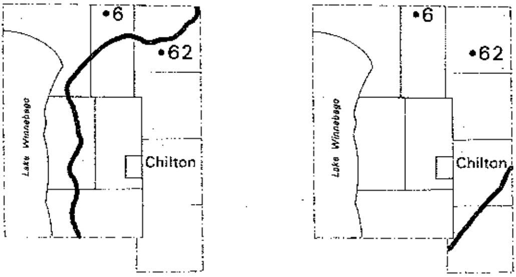


Ground-water divides:



Unconfined system

Confined system

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WHAT YOU SHOULD KNOW ABOUT GROUND WATER

HOW GROUND WATER OCCURS AND ORIGINATES

Hidden beneath the land surface of the county are natural reservoirs full of clean water that we call groundwater. The surface of an unconfined groundwater reservoir is called the water table. Contrary to popular belief, groundwater does not flow in veins. There are some underground streams and lakes in cavernous limestone or lava rock, but they are very rare. Groundwater simply fills numerous small openings, pores or cracks in subsurface rocks.

The source of groundwater is precipitation. When rain falls or snow melts, the first water is taken by plants and soil. After their thirst is satisfied and after some water runs off into streams, the excess water percolates down and joins the groundwater stored in subsurface rocks.

HOW GROUND WATER MOVES

Rocks not only store water, they also transmit it. Upon joining the body of groundwater, the percolating water moves through the openings in rocks and is constantly in motion. However, the groundwater does not flow as freely and rapidly as water in surface streams. It has to squeeze through the intricate maze of interconnected openings that offer natural frictional resistance to the flow. Therefore, the groundwater moves through this system (called an aquifer) very slowly. Flow is measured in feet per day or in feet per year (compared to the flow in streams, which is measured in feet per second).

Much of the water in an underground reservoir infiltrates the ground within a radius of a few tens of miles from where it is found. It does not travel for hundreds of miles, and it certainly does not come "all the way from Canada." Most groundwater originates within the county, although some comes from adjoining counties. After entering the aquifer, the water tends to move toward lower-lying places --being driven by gravity and difference in pressure between the higher-and lower-lying places--and ultimately discharges into streams or springs. Groundwater also can move upward when it is confined under artesian pressure (a pressure higher than atmospheric pressure).

In Calumet County there are two major systems of aquifers, the upper, unconfined or water-table system, and the lower, confined or artesian system. These two systems have separate flow directions and different groundwater divides (see county maps on title page).

Groundwater in the water-table system flows from uplands toward the major streams, and the groundwater divide closely follows the surface-water divide. Groundwater west and north of the divide flows toward Lake Winnebago and the Fox River; south and east of the divide, it flows toward tributaries of the Manitowoc River.

The groundwater divide in the artesian system is unrelated to the surface-water divide. In most of Calumet County groundwater in the artesian system generally flows to the northeast; only southeast of the divide does it flow eastwardly toward Lake Michigan.

WHY STREAMS FLOW IN THE WINTER

Have you ever wondered why streams continue to flow in the middle of winter even though air and ground temperatures are below freezing and even though there is no rainfall? The answer is that winter streamflow is largely groundwater continuously seeping into streams, and groundwater is relatively warm, having a constant temperature between 46°F to 52°F. This shows that groundwater and surface water do not represent isolated systems, as is commonly believed. Nor is groundwater isolated from other water in nature's gigantic solar-driven machine, called the hydrologic cycle. After entering a stream, groundwater continues in its path until it reaches its home base, the sea, where the sun causes water to evaporate and rise into the atmosphere. Moisture-laden clouds are blown by winds over the land, clash with cold air and produce rain. The water falls again on the land and replenishes the streams and groundwater reservoirs, thus closing the never-ending water cycle.

HOW DEEP IS GROUND WATER?

The depth to the water table is not the same throughout the county, and it varies both in time and place. The water table tends to be closest to the land surface in river valleys and marshes, and at greater depths beneath hills and ridges. It usually resembles a flattened form of the surface relief. Groundwater levels are fluctuating almost constantly, and decline and rise within a relatively short period of time, mainly in response to precipitation and to withdrawal of water from wells. The speed of the response depends mainly on the character of the aquifer, and for rainfall, the depth to groundwater.

Besides short-term fluctuations, variations in precipitation cause seasonal variations of water levels. Water levels rise relatively rapidly in the spring due to recharge from snowmelt and spring rains and then gradually decline throughout the summer when evapotranspiration exceeds precipitation, which means that less water is available for infiltration. A small rise occurs in the fall due to fall rains. It is followed by a decline during the winter, when precipitation is stored on the land surface as snow. In addition, alternating series of wet and dry years produce gradual, long-term changes in water levels.

The depth to the potentiometric surface (the level to which water will rise in a well) of the confined aquifer system also varies throughout Calumet County, both in time and place. It is unrelated to the local overlying topography, and it fluctuates much more slowly in response to precipitation than the water table does. However, the depth to the potentiometric surface changes more rapidly and more dramatically in response to pumping of water from wells.

Based on records from water wells in Calumet County, the depth to the water table ranges from 0 to 120 feet below the land surface, and averages 30 feet. The depth to the potentiometric surface of the artesian aquifer ranges from flowing at the surface to 270 feet below the land surface, and, for wells constructed in the 1970s, averages 110 feet.

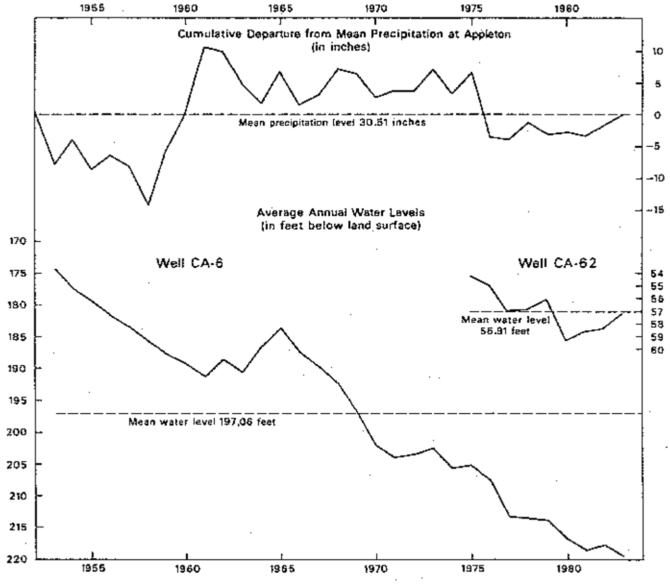
TRENDS IN WELL DENSITY AND DISTRIBUTION

The maps above illustrate that the number of wells constructed in Calumet County has increased greatly since the 1930s and '40s. During the period 1936 through 1949, a total of 225 wells were reported. Of these, 218 wells were in the unconfined system of aquifers, and 7 wells (or 3%) were in the confined system of aquifers. During the years 1970 through 1979, 621 wells were constructed; with 503 in the unconfined system, and 118 (or 19%) in the confined system. In general, a well constructed today will probably be deeper than a well constructed a decade or more ago, and will have a greater probability of being in the deeper confined aquifer.

The unconfined aquifer system consists mainly of the sand and gravel aquifer and the Niagara Dolomite aquifer, and occasionally the Maquoketa Shale aquifer. In the northwestern corner of Calumet County, where the Maquoketa Shale is absent, it also includes the Platteville/Galena Dolomite aquifer.

Except in northwestern Calumet County, the confined aquifer system consists of those aquifers which are below the Maquoketa Shale--the Platteville/Galena Dolomite aquifer, the St. Peter aquifer, and the lower dolomite and sandstone aquifers. In northwestern Calumet County, the St. Peter aquifer is partially confined, becoming more confined with increasing depth. Most of the wells in the confined system are withdrawing their water from the St. Peter aquifer, which is mainly sandstone.

HISTORICAL TRENDS IN WATER LEVELS



Two of the wells in Calumet County are included in a statewide network of observation stations where the changes in water levels are measured at regular intervals. One of the main purposes of collecting these data is to determine the relationship of precipitation and other natural factors to fluctuations in water level. For most observation wells there is a similarity between trends in precipitation and trends in water levels, which permits both the estimate of future behavior of groundwater levels and the reconstruction of past, unrecorded water-level fluctuations.

The lack of similarity of the water-level record for well Ca-6, which is in the artesian aquifer, and the cumulative departure* from mean precipitation at Appleton is due to the effects of heavy pumping in the Fox River valley.

The overall trend for Ca-6 is one of steadily declining water levels. This trend is likely to continue as long as the withdrawal of water from the aquifer does.

The water-level record for well Ca-62, which is in the unconfined aquifer, is somewhat similar to the cumulative departure from mean precipation at Appleton. However, the correlation is not perfect; a longer period of observation is needed to identify any definite trends.

EXTREME WATER LEVELS

The change from high to low groundwater levels is irregular and usually gradual. For example, groundwater levels do not change as quickly as yearly rainfall totals, which can change from extremely high one year to extremely low the next. Minimal groundwater levels do not occur immediately after maximum groundwater levels and vice versa. At least one year of moderate groundwater levels--more commonly several years of such levels--intervene between the years of extreme levels. Well Ca-62 does not have a long enough period of record for determining the long range extremes in annual high or low water levels. The record of well Ca-6 does not show natural fluctuations, only declining water levels, resulting from continuous pumping of municipal and industrial wells in the sandstone aquifer. The highest water level was recorded in 1953 when observations started. The rise in water levels in 1962, '64-65, and '73 is probably due to the increase in precipitation in 1960-61, '64, and '72 and/or a temporary decrease in the amount of water pumped from the aquifer by some municipalities.

SUMMARY DATA FOR OBSERVATION WELLS CA-6 & 62

Characteristics	Feet below land surface Ca-6	Feet below land surface Ca-62	Date Ca-6	Date Ca-62
Mean Water Level	197.06	56.91	(calculated)	
Highest Recorded Level	172.36	52.72	4/7/53	5/31/74
Lowest Recorded Level	224.16	61.10	8/14/81	9/9/80
Maximum Range of Fluctuations	51.80	8.38	(calculated)	
Average Annual Fluctuation	6.25	2.39	(calculated)	
Highest Monthly Mean	194.67	55.86	April	May
Lowest Monthly Mean	198.84	57.51	October	September
Highest Average Annual Level	174.45	54.18	1953	1975
Lowest Average Annual Level	219.25	59.23	1983	1980

OBSERVATION WELLS IN CALUMET COUNTY

Well Number	Location	Measur. Started
Ca-6	Town of Woodville, NW¼ SW¼ Sec. 2 T 20 N. R 19 E.; in Dundas	1952
Ca-62	Town of Brillion, SW¼ NW¼ Sec. 22 T 20 N. R 20 E.; 2 miles NW of Brillion	1974

*Cumulative Departure: The difference between measured rainfall and average value for a selected period of time--in our case, a year--summed, or cumulated, for the entire period of record.