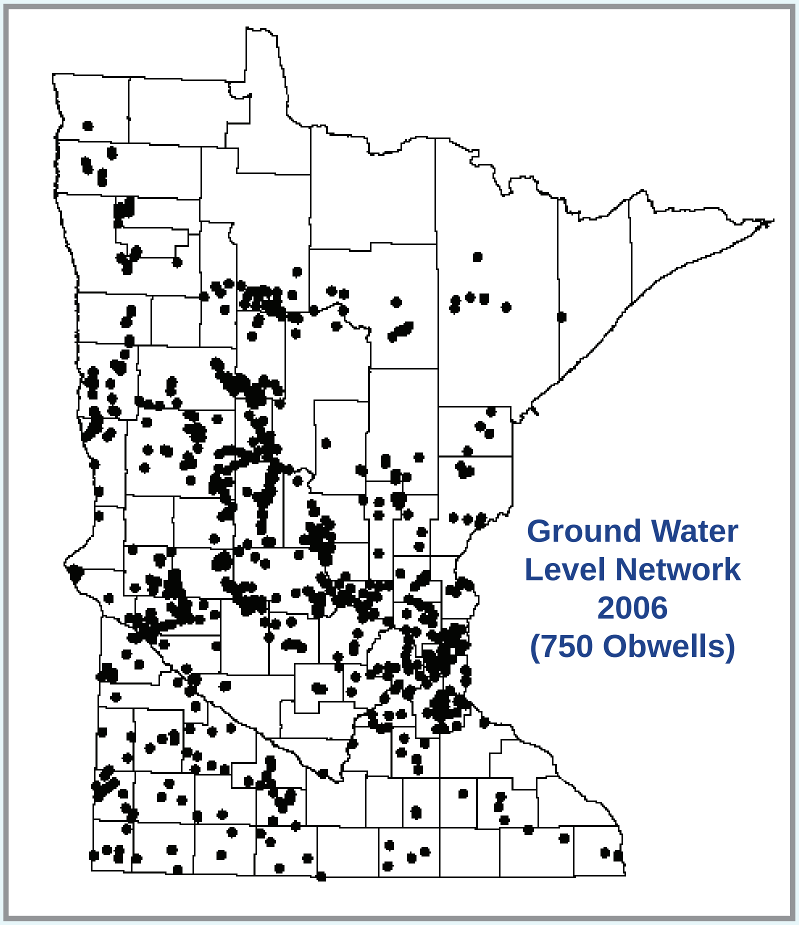
Chapter 3 Ground Water


Ground Water
Level Network
2006
(750 Obwells)

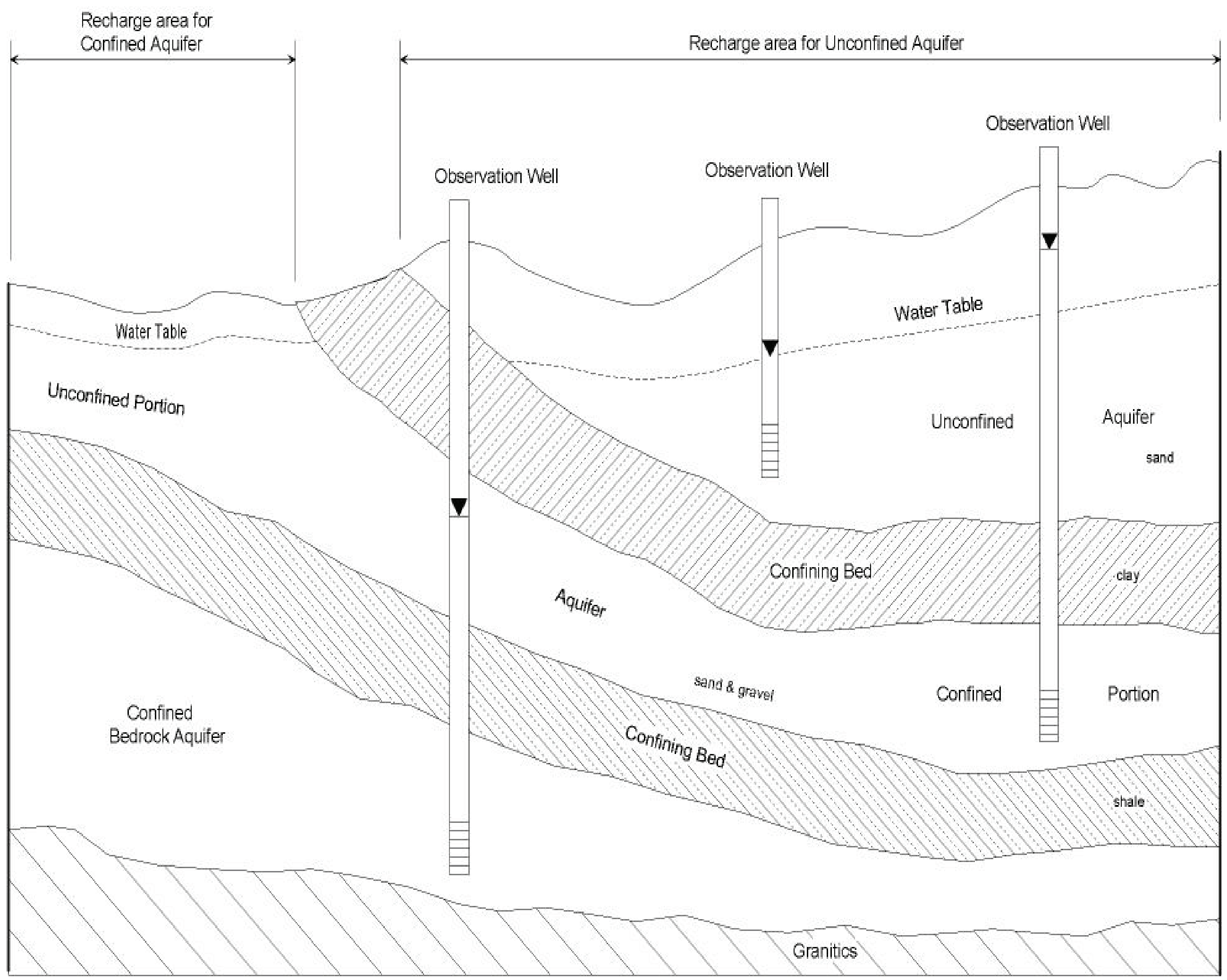

Michael MacDonald

Introduction

Ground water level monitoring began in Minnesota in 1942. In 1947, it was expanded with a cooperative program between the DNR and the United States Geological Survey (USGS). The number of wells monitored has increased since 1942 and now approximately 750 observation wells (obwells) are measured. Data from these wells are used to assess ground water resources, determine long-term trends, interpret impacts of pumping and climate, plan for water conservation, evaluate water conflicts, and otherwise manage the water resource. Soil and Water Conservation Districts (SWCD) and other cooperators under agreement with DNR Waters measure the wells monthly and report the readings to DNR Waters as part of the Ground Water Level Monitoring Program. Readings are also obtained from volunteers and electronically at other locations. Figure 1 presents a generalized ground water system showing the different types of aquifers and wells.

Figure 1

Hypothetical Unconfined and Confined Aquifer Systems



Aquifers

An aquifer is a water-saturated geologic formation which is sufficiently permeable to transmit economic quantities of water to wells and springs. Aquifers may exist under unconfined or confined conditions (Figure 1).

UNCONFINED AQUIFERS - In an unconfined aquifer, the ground water surface that separates the unsaturated and saturated zones is called the water table. The water table is exposed to the atmosphere through openings in the overlying unsaturated geologic materials. The water level inside the casing of a well placed in an unconfined aquifer will be at the same level as the water table. Unconfined aquifers may also be called water table or surficial aquifers.

For most of Minnesota, these aquifers are composed of glacial sand and gravel. Their areal extent is not always well defined nor is their hydraulic connection documented. They are often locally isolated pockets of glacial outwash deposited over an area of acres to square miles. Recharge to these units may be limited to rainfall over the area of the aquifer or augmented by ground water inflow. Consequently, care must be taken in extrapolating water table conditions based upon the measurements of a single water table well.

CONFINED AQUIFERS - When an aquifer is separated from the ground surface and atmosphere by a material of low permeability, the aquifer is confined. The water in a confined aquifer is under pressure, and therefore, when a well is installed in a confined aquifer, the water level in the well casing rises above the top of the aquifer. This aquifer type includes buried drift aquifers and most bedrock aquifers.

Buried drift aquifers consist of glacially deposited sands and gravels, over which a confining layer of clay or clay till was deposited. Their areal extent and hydraulic connections beneath the ground surface are often unknown; therefore, an obwell placed in one of these units may be representing an isolated system. Ground water investigations involving buried drift aquifers require considerable effort to evaluate the local interconnection between these aquifer units.

Bedrock aquifers are, as the name implies, geologic bedrock units which have porosity and permeability such that they meet the definition of an aquifer. Water in these units is either located in the spaces between the rock grains (such as sand grains) or in fractures within the more solid rock. While these aquifers can be unconfined, the ones measured in the ground water level monitoring network are generally bounded above and below by low-permeability confining units. Unlike buried drift aquifers, bedrock aquifers are fairly well defined in terms of their areal

Seasonal climatic changes affect the water levels in aquifer systems. Recharge, which is characterized by rising water levels, results as snow melt and precipitation infiltrate the soil and percolate to the saturated zone. Drawdown, characterized by the lowering of water levels, results as plants transpire soil water; ground water discharges into lakes, springs, and streams; or well pumping withdraws water from the aquifer. An unconfined aquifer generally responds more quickly to these changes than a confined aquifer since the water table is in more direct contact with the surface. However, the magnitude of change in water levels will usually be more pronounced in a confined aquifer.

Statewide Summary

Currently, the DNR monitors water levels in approximately 750 wells. Water levels are usually recorded monthly from March through November. For this report, water levels from representative monitoring wells from each region of the state and from four aquifer systems are presented. The aquifer systems are: the unconfined (water table) aquifer, the buried drift aquifer, the Prairie du Chien and Jordan aquifers, and the Mt. Simon aquifer. Figures 2, 3, 4, and 5 present the locations of the wells in each of the aquifer systems. Hydrographs of the water levels in these wells are presented at the end of this chapter. The hydrographs present the water levels for the length of record for each obwell. The current water year water levels are shown in red on the hydrograph. These hydrographs and the data for all past and present DNR obwells are accessible **here**.

Several parts of the state have experienced dry conditions during the Water Years 2003, 2004, 2005. In Water Year 2006 (WY06), the state experienced a statewide drought. In Water Year 2007 (WY07), the drought continued during the summer but was reduced in late summer and fall by above average rainfall including floods in southeastern Minnesota. The trend of low precipitation continued into Water Year 2008 (WY08) when there were drought conditions at various locations throughout the state during the summer. The impact of the reduced precipitation was lessened by average temperatures, which decreased evaporation and allowed the soil to retain its moisture.

The remainder of this chapter discusses the ground water levels in unconfined and confined aquifers during WY07 and WY08. This discussion focuses on a comparison of monitoring well (obwell) water levels in WY07 and WY08 to past water levels focusing on the past three to five years.

Unconfined Aquifers

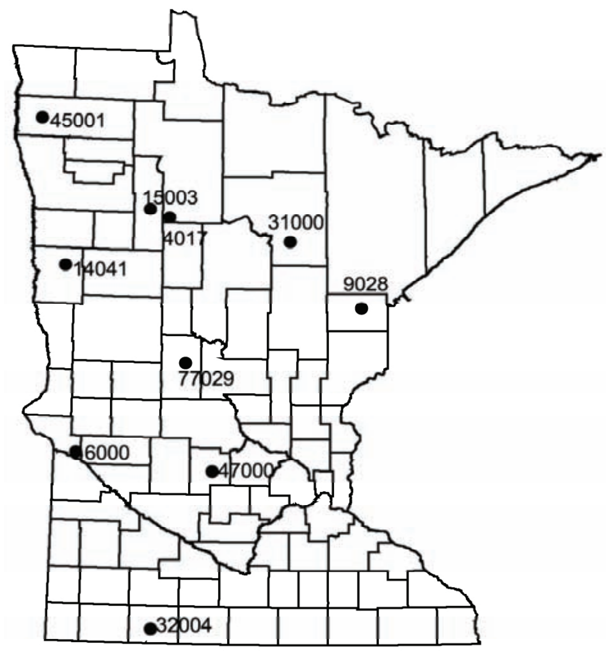
Water Table

While drainage from an unconfined aquifer continues throughout the winter, recharge is restricted. In general, winter precipitation is stored as snowpack, and frozen soil prevents or slows the infiltration of spring snowmelt. By the end of winter, water tables would be expected to be at a low point. As the soil thaws and spring rains occur, the water table aquifers are recharged resulting in the higher water tables.

The locations of the water table wells used in this report are shown in Figure 2. Hydrographs for these wells are shown in Figure 6 (page 58).

In general, the water table in WY07 dropped to levels similar to those of WY06 but in WY08 the water table rose above the levels of WY06 and WY07. The hydrographs show that in the central, west, and north central parts of the state spring recharge in both WY07 and WY08 raised the water table to levels equivalent to or higher than in the preceding years. In the northwest, spring recharge in WY07 did not raise the water table to levels of previous years but in WY08, the water levels rose to those of past years. In the northeastern part of the state, the recharge did not raise the water levels to previous year levels.

Figure 2 **Water Table Obwells**



Because of continued summer drought conditions, water levels in the summer of WY07 declined to levels similar to or lower than those observed in WY06. In the summer of WY08, the water table levels were generally higher than in WY06 and in WY07 and were generally similar to or higher than the water levels in past years. In the northeast part of the state, the water levels are lower than have been seen since 1990. There is a small downward trend observed in water levels in some of the obwells in this part of the state.

In northwest Minnesota, as represented by the Clearwater County obwell, the low water table levels in both WY07 and WY08 were similar to or slightly above those in WY06 and appear to be showing an upward trend. In Central Minnesota the obwell in Todd County, situated in an area where the drought was severe in 2006, indicated that the water level in WY07 was lower than in WY06 but in WY08 the water levels were similar to the levels in WY06. The spring recharge in both years is similar to earlier years. There appears to be a slight upward trend in water levels from this obwell.

In southwest Minnesota, as represented by the Jackson County obwell, the WY07 summer water levels were lower than in WY06 but above historical lows. The summer water levels in WY08 were above those recorded in WY06 or WY07. The spring recharge levels are similar or above historical levels.

Confined Aquifers

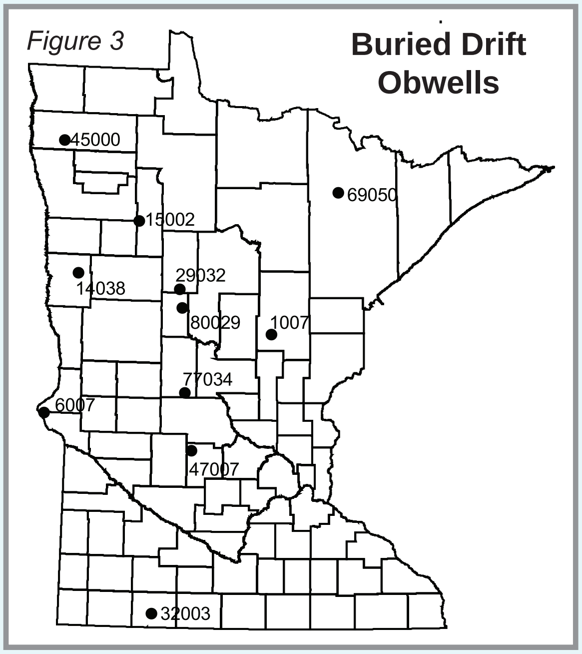
Water levels in confined aquifers may respond to changes in precipitation patterns differently than they would in water table aquifers – the presence of an overlying confining bed inhibits the movement of rain or snowmelt downward into the confined aquifer thereby delaying the recharge of the aquifer. During dry periods, the demand for increased water use from a confined aquifer will be reflected in declining water levels. As the dry period ends and precipitation returns to normal, recovery of water levels will be delayed due to the slow movement of water into the confined aquifer. Recovery may take two or more years.

Likewise, wetter than normal periods may not cause a rise in water levels because of the retarded water movement through the confining layers.

Buried Drift Aquifers

Under confined conditions, these aquifers generally respond more slowly to seasonal inputs from snowmelt and precipitation than water table aquifers do. However, buried drift aquifers can be near the surface with their extent poorly defined and have some connection to adjacent unconfined aquifers. As a result, response of buried drift aquifers to recharge is determined by individual characteristics. The response is therefore difficult to predict.

The approximate locations of the buried drift wells used in this report are shown in Figure 3. Hydrographs for these wells are shown in Figure 7 (page 62).



As in the case with water table wells, the buried drift hydrographs show that throughout the state, spring recharge in both WY07 and WY08 raised the water levels in the aquifers. The increases are not as large as those seen in WY06, so that the water levels at the beginning of the summer season were generally lower than those observed in WY05 and WY06.

In WY07, the summer water levels were similar to or lower than those observed in WY06. This may reflect the delay in recharge that is often seen in confined aquifer systems. In the summer of WY08, the water levels are generally higher than seen in the past few years. This may represent the delay expected in recharging confined aquifers. Of the wells presented here only two, in Marshall and Meeker counties, had water levels in the summer of WY08 similar to or lower than those recorded in WY06. The most dramatic increase in water levels between WY07 and WY08 occurred in Clay, Hubbard, St. Louis, and Todd Counties.

Nearly all of the buried drift aquifer hydrographs show a return to water levels similar to those before the onset of the WY06 drought.

Bedrock Aquifers

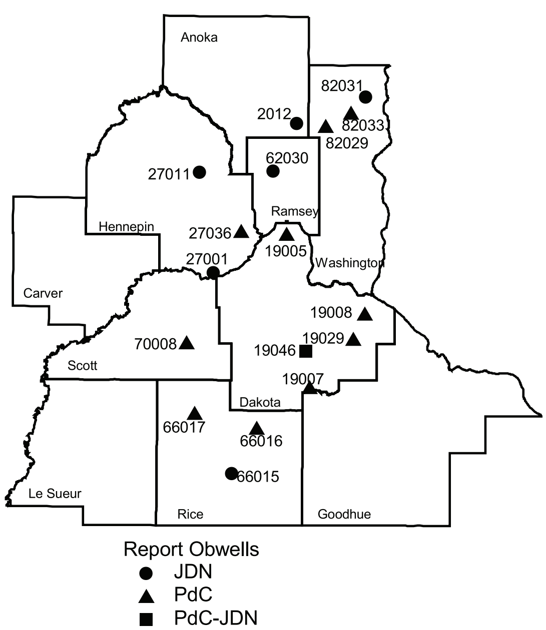
Jordan and Prairie du Chien Aquifers

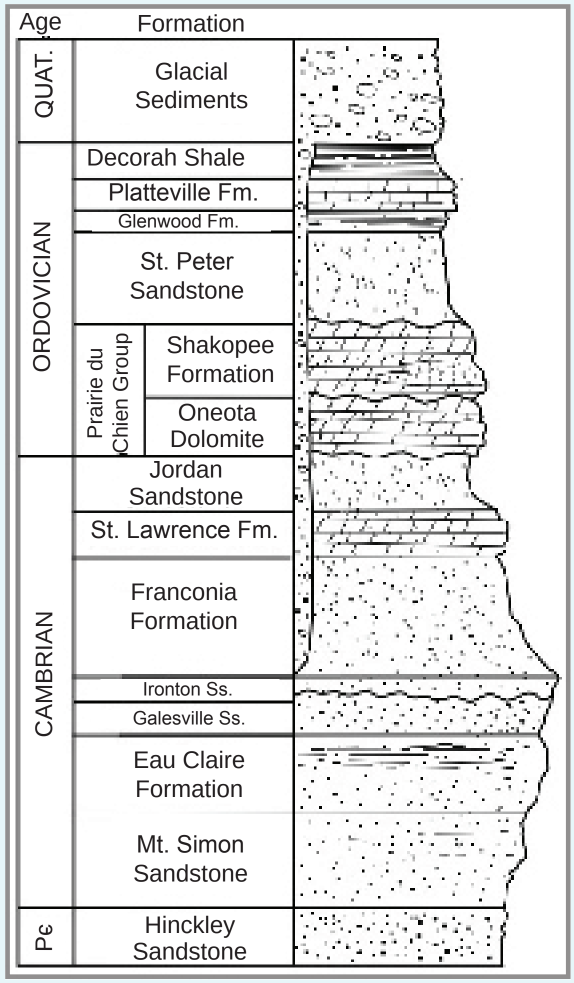
In past years, the Jordan and Prairie du Chien aquifers have been considered hydrologically linked and generally considered as one hydrologic unit. Conditions in the "Prairie du Chien/Jordan Aquifer" were considered to be to be represented by water level monitoring wells completed in the Prairie du Chien, the Jordan or in both the Prairie du Chien and Jordan formations.

Studies in recent years, especially those of the Minnesota Geological Survey (MGS), have begun to question the lumping of the two formations into one hydrologic unit. The information presented here relative to water levels in WY07 and WY08 is not meant to offer support for either the "lumping" or the "splitting" of these two geologic units. The water level measurements from WY07 and WY08 do not show clear evidence that the formations are one or two distinct aquifers. To continue the discussion as presented in the 2005-2006 Water Year Data Summary

Figure 4

Jordan & Prairie du Chien Obwells





Example of a generalized geologic column for the 7-county metropolitan area.

report, the formations are presented and discussed here as two separate units.

Locations of the Jordan (JDN) and Prairie du Chien (PDC) wells used in this report are shown in Figure 4. Wells identified by number are those wells for which hydrographs are shown in Figures 8A (page 66) and 9A (page 69) that follow.

For this report there were adequate numbers of wells distributed around the metro area to allow the JDN and PDC aquifer levels to be looked at separately. One exception was in Dakota County where a distinct JDN well was not available. Looking at many of the wells completed in both the PDC and JDN in Dakota County, it appeared as if they were responding to climatic events in a manner similar to JDN wells. Consequently, in examining the Jordan aquifer levels in the metro area, one PDC/JDN well in southern Dakota County was included (Figure 9K, page 72).

Jordan Aquifer

Water levels in the Jordan aquifer system throughout the metro area generally show a decline in summer water levels below the WY06 levels in both WY07 and WY08. Most of these wells also have lower winter water levels then have been seen in the past few years. Only two wells, those in Olmstead and Ramsey Counties, showed an increase in water levels over the course of the past two water years. In general most of the Jordan aquifer wells are showing a declining water level since the drought of WY06.

Prairie du Chien

Water levels in the Prairie du Chien aquifer showed variable response to the conditions of WY07 and WY08. In Hennepin County, the summer water levels were lower than those in WY05 and WY06 but are not as low as those seen in 2003 and earlier years. In Scott County, the water levels have decreased since the levels observed in the summer of WY06 and the water levels at the end of WY08 are similar to those in the summer of WY05. This decrease is not observed in nearby obwells in Rice or Hennepin Counties.

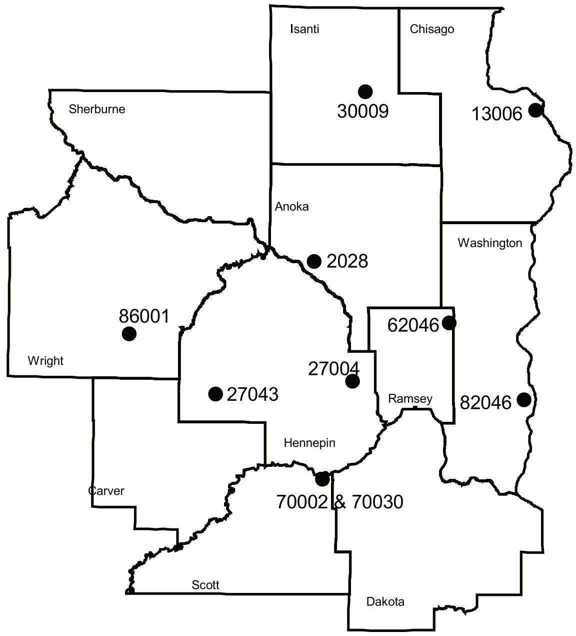
In Rice County there was a varied response to the conditions. In obwell 66016, water levels fluctuated in a manner similar to recent preceding years, with no appreciable declines in either water year. In obwell 66017, there are declining water levels in both water years with the WY08 summer levels comparable to the levels observed in 1993 and 2004.

Dakota County PDC obwells showed a lot of variation: obwell 19005 in the north looked like a continuation of recently increasing water level trends; obwells 19008 and 19029 continue to exhibit water level declines; and obwell 19007 showed a large decline in water level for summertime WY07 with a similar but smaller declines in WY08. This was in keeping with patterns of water levels from this well in recent years. The Dakota County obwell 19046, which is a Prairie du Chien/Jordan well, shows a small rise in water levels over the two water years. The hydrograph shows an unusual upward trend, which is resembles water level increases seen in the well periodically before about 1995.

In northern Washington County, water levels showed a decline similar to those in northern and eastern Dakota County. It is interesting to note that the hydrographs for PDC well 82033 and JDN well 82031 are similar. These two wells are located in close proximity and one would probably conclude that the two formations are functioning as one, interconnected aquifer.

Figure 5

Mt. Simon Obwells



Mt. Simon Aquifer

With some exceptions, the Mt. Simon aquifer is a confined aquifer. It may respond as an unconfined aquifer in the atypical instances where the aquifer is adjacent to unconfined materials, such as along deeply incised buried glacial valleys or at the outer edges of the formation.

Locations of the Mt. Simon wells used for this summary are shown in Figure 5. Hydrographs depicting representative water levels across the metro area are shown in Figure 10A (page 73).

Many of the Mt. Simon obwells have a fairly short period of record; consequently it is difficult to place the WY 07 and 08 readings in a long-term perspective. However, the data that are available provide a look at how the aquifer is responding to recent climate.

Generally the WY07 and WY08 Mt. Simon water levels fluctuated within the bounds of recent previous years and springtime high water levels were similar to preceding recent spring times.

A couple of exceptions did occur. In Hennepin County, the water level at the end of WY06 was at its lowest measured level since 1989. The spring recharge of the WY08 was higher than the levels in WY05 and 06 and the WY08 summer water levels were similar to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WY05 levels. The Isanti County obwells shows a water level rise from the low levels measured in the summer of WY06 to levels comparable to those measured in WY05. In Ramsey County, the water level in the summer of WY07 was the lowest ever measured while the water levels measured in the spring of WY08 are comparable to levels from WY05 and earlier.

In the southern metro area, the Scott County obwell showed a situation where the summer water levels in WY08 were the lowest ever measured and continue a downward trend in water levels that began around 1980. No measurements were collected in WY07 because changes in DNR personnel did not allow for data collection.

One can also note on this Scott County hydrograph that the Mt. Simon aquifer water levels in the Savage area are continuing their long-term decline; while some of this is climatically induced, part of the decline must be attributed to pressures exerted on this aquifer by increasing development in the area.

Program Highlights

During the water years presented in this document, a number of activities were initiated or continued.

WY07

- Began work to assess the location and condition of the obwells in the state.
- Continued to manage and maintain the obwell network.

WY08

- Added two wells to the obwell network in cooperation with the Minnesota Geological Survey. These were deep, buried aquifer wells and the cost to install them was $11,200.
- Replaced three existing wells in the obwell network, which had been damaged or were no longer functioning properly. The wells were replaced using DNR personnel and equipment and cost approximately $5,000.
- Sealed three wells from the obwell network because of damage to the well or because the well was no longer functioning properly. The cost to seal the wells was approximately $2,500.
- Continued to work on the obwell assessment. By the end of WY08, the condition and validity of 279 obwells in 37 counties had been assessed.
- Began investigation work to determine the limits and conditions of the Mt. Simon aquifer in the south central and metropolitan parts of the state. This included drilling new wells and collecting geophysical data. Results of this work are expected to be available in WY10.
- Began work on upgrading the database system used to collect, store, and analyze the obwell groundwater data collected.
- Continued to manage and maintain the obwell network.


Michael MacDonald

Figure 6A

Beltrami County - Water Table #4017

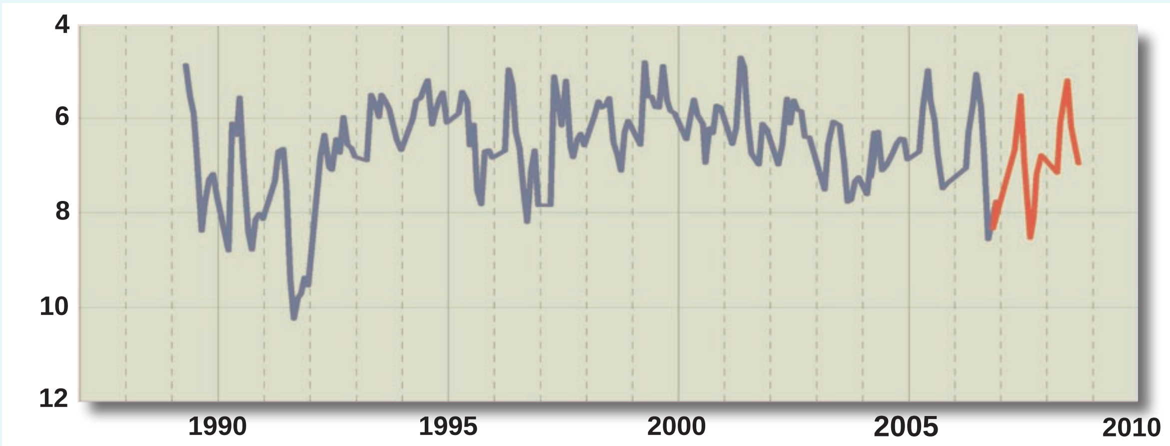
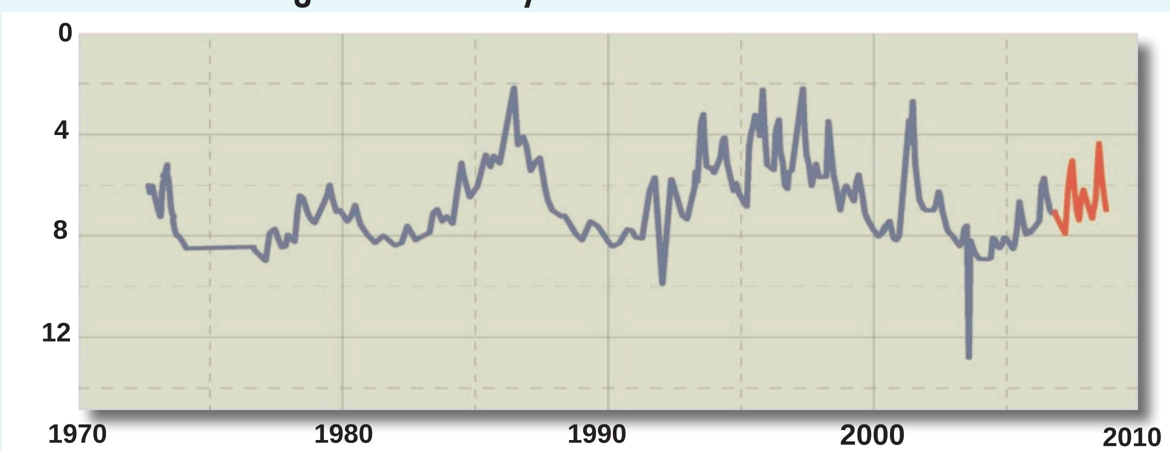


Figure 6B

Big Stone County - Water Table #6000



Depth to Water below ground surface, ft.

Figure 6C

Carlton County - Water Table #9028

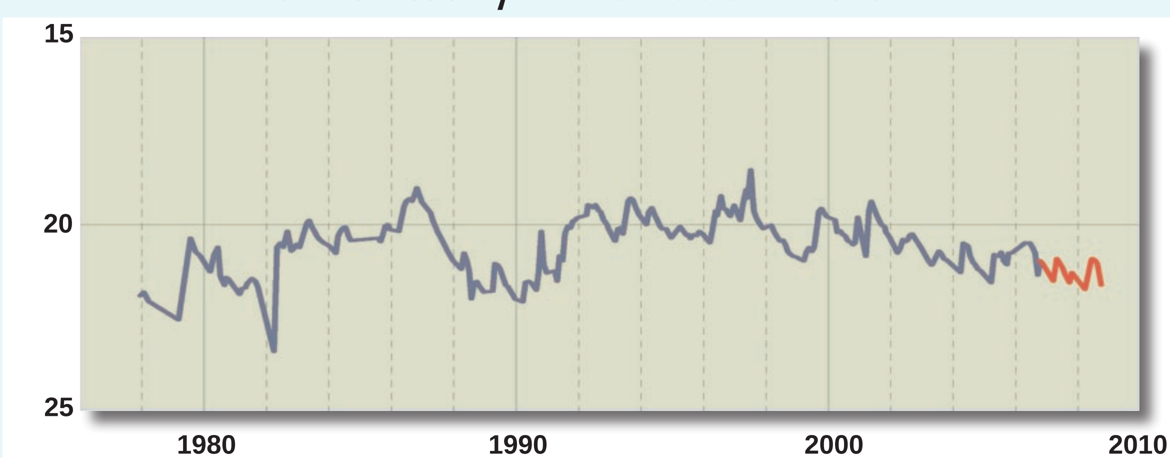


Figure 6D

Clay County - Water Table #14041

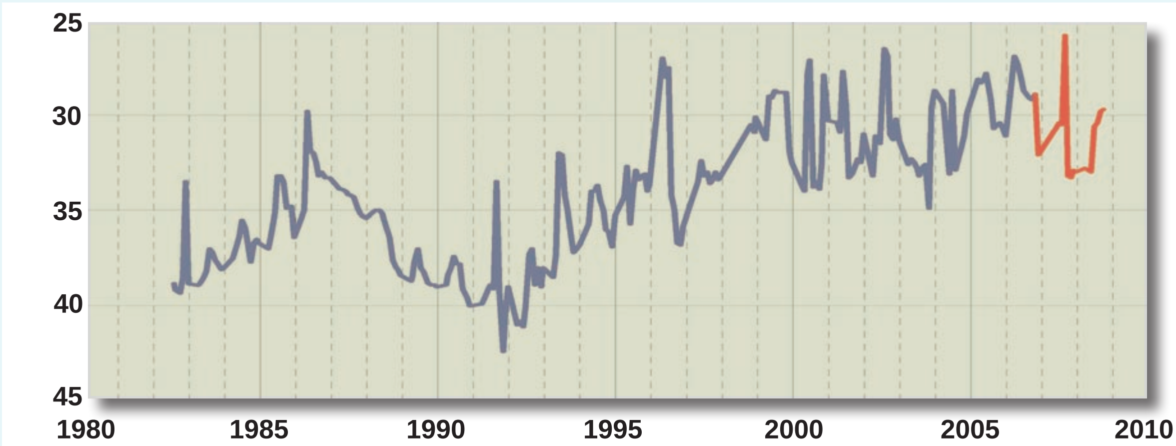


Figure 6E

Clearwater County - Water Table #15003

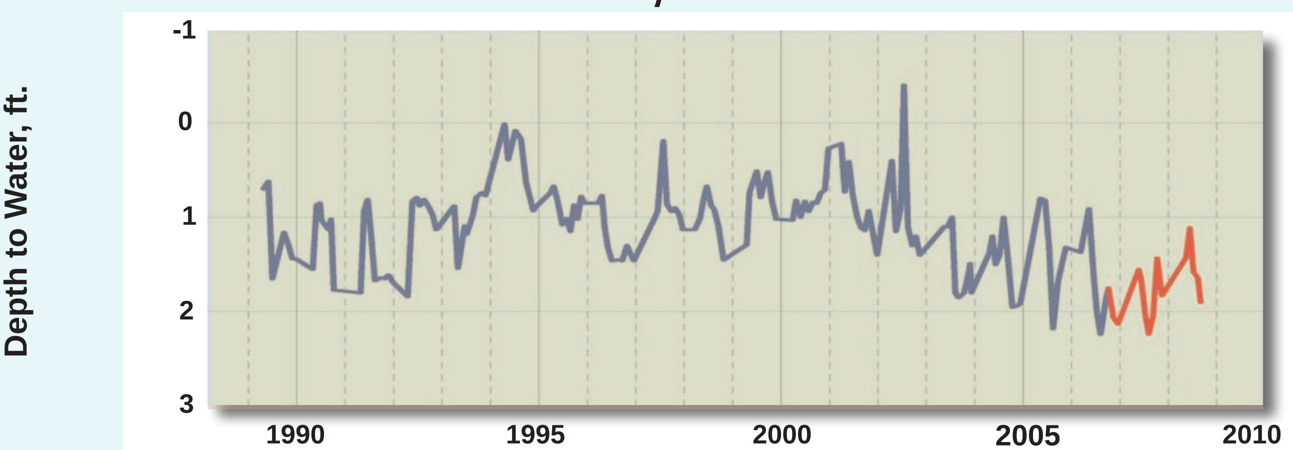


Figure 6F

Itasca County - Water Table #31000

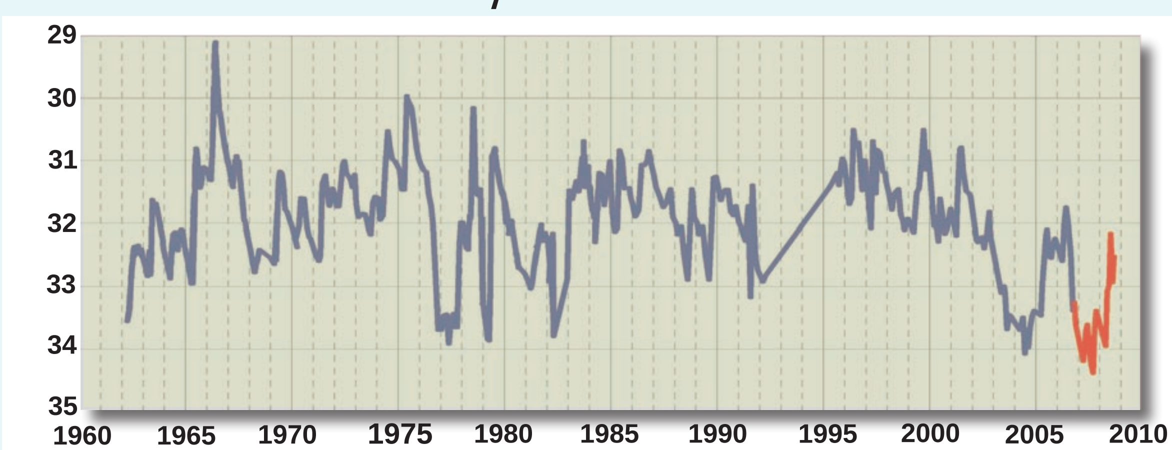


Figure 6G

Jackson County - Water Table #32004

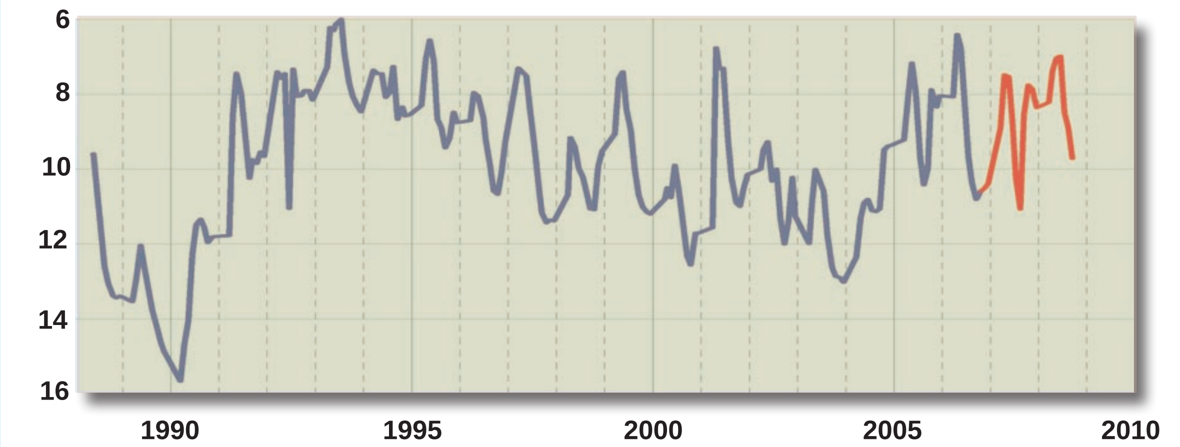


Figure 6H

Marshall County - Water Table #45001

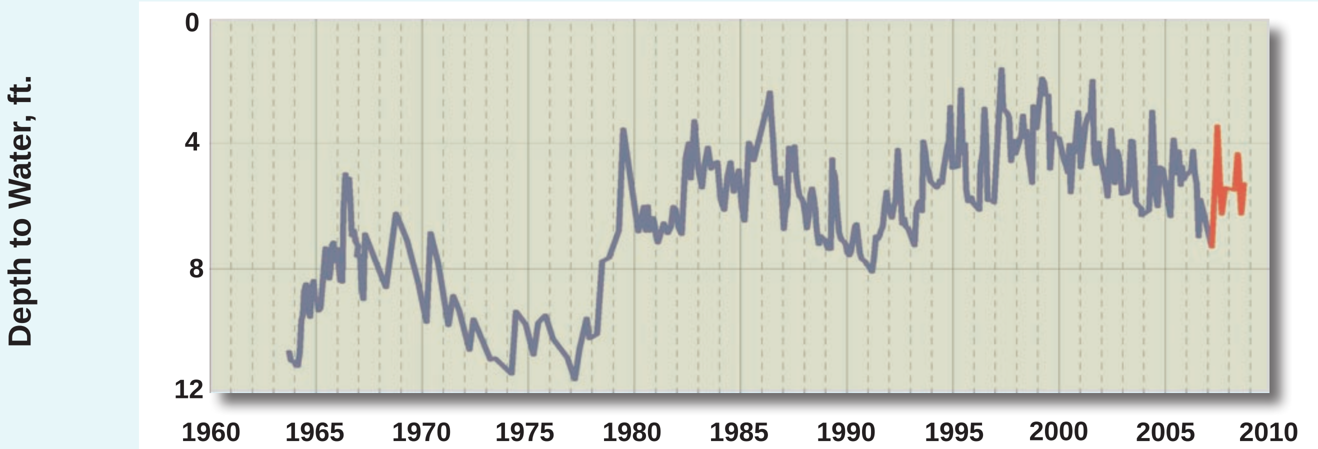


Figure 6i

Meeker County - Water Table #47000

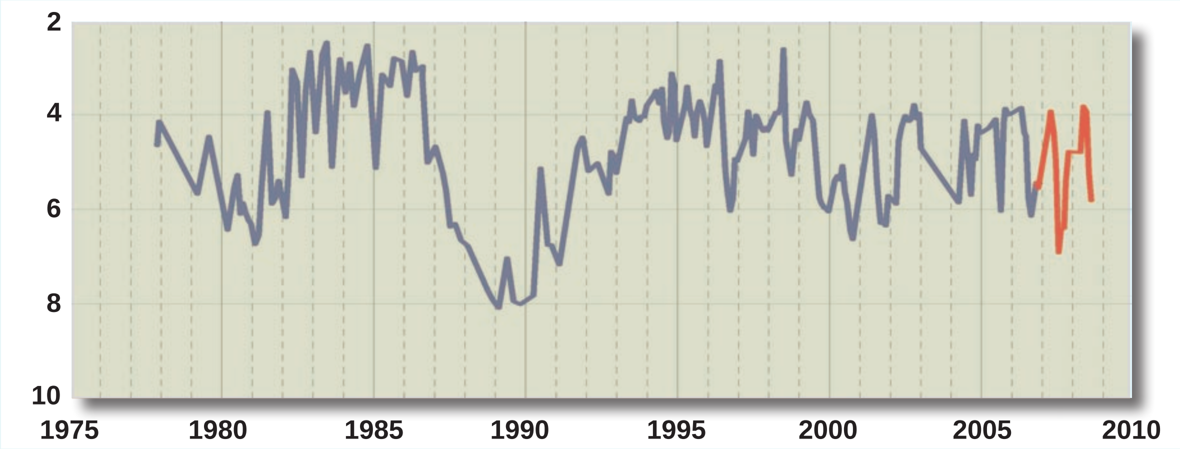


Figure 6J

Todd County - Water Table #77029

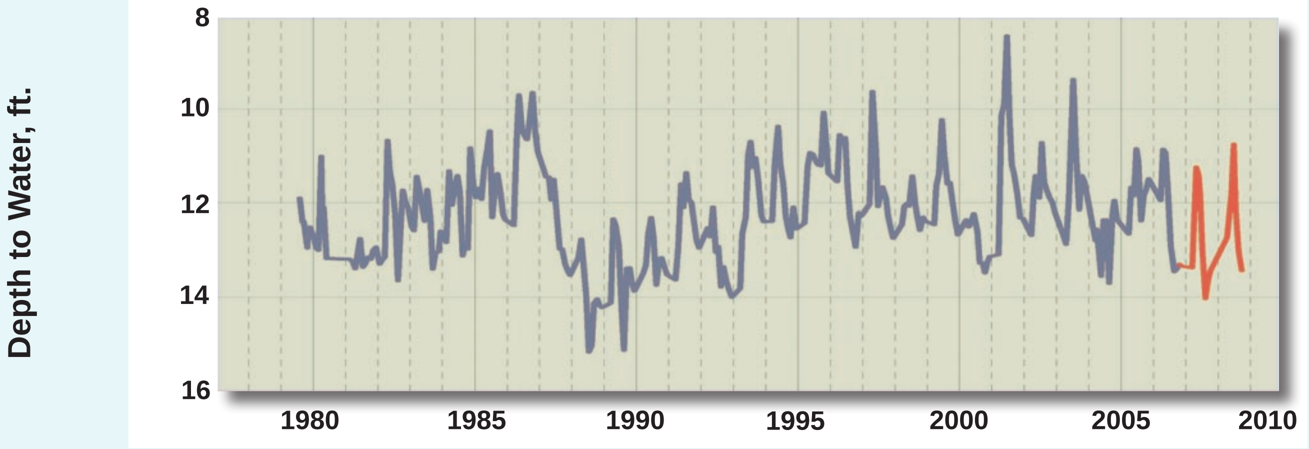


Figure 7A

Aitken County - Buried Drift #1007

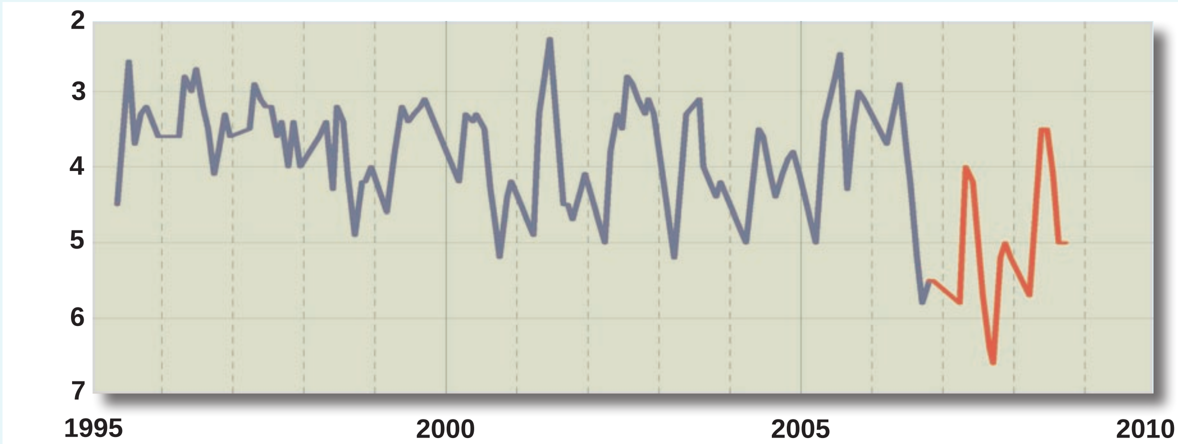


Figure 7B

Big Stone County - Buried Drift #6007

Depth to Water, ft.

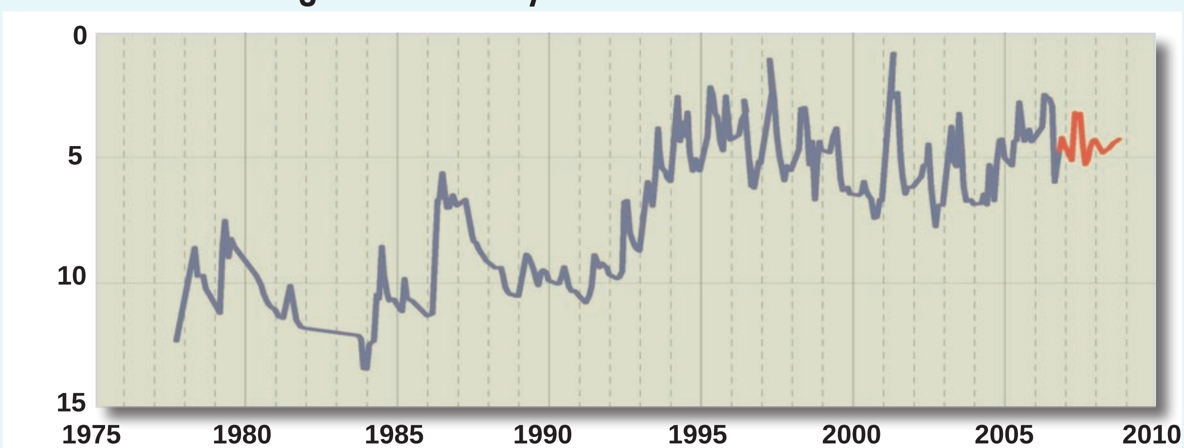


Figure 7C

Clay County - Buried Drift #14038

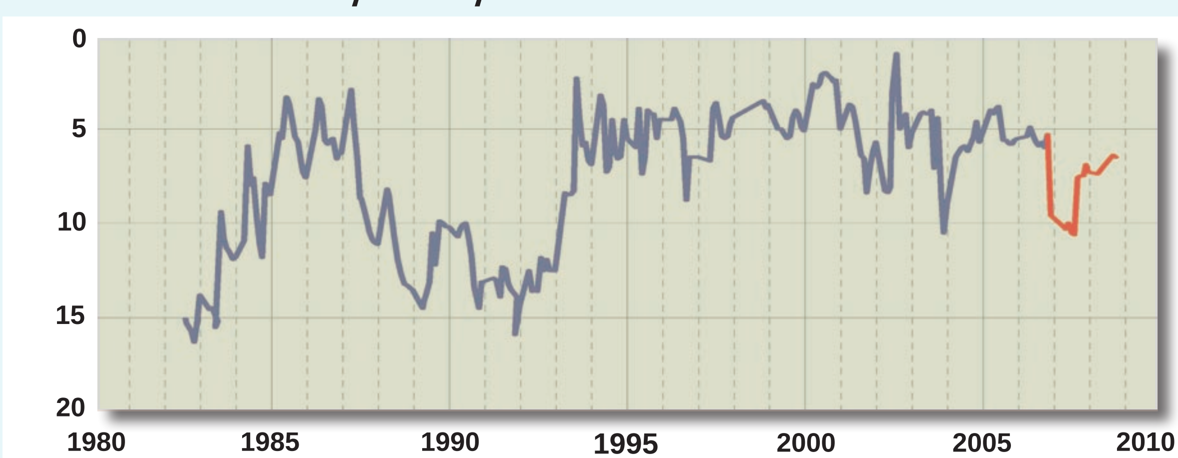


Figure 7D

Clearwater County - Buried Drift #15002

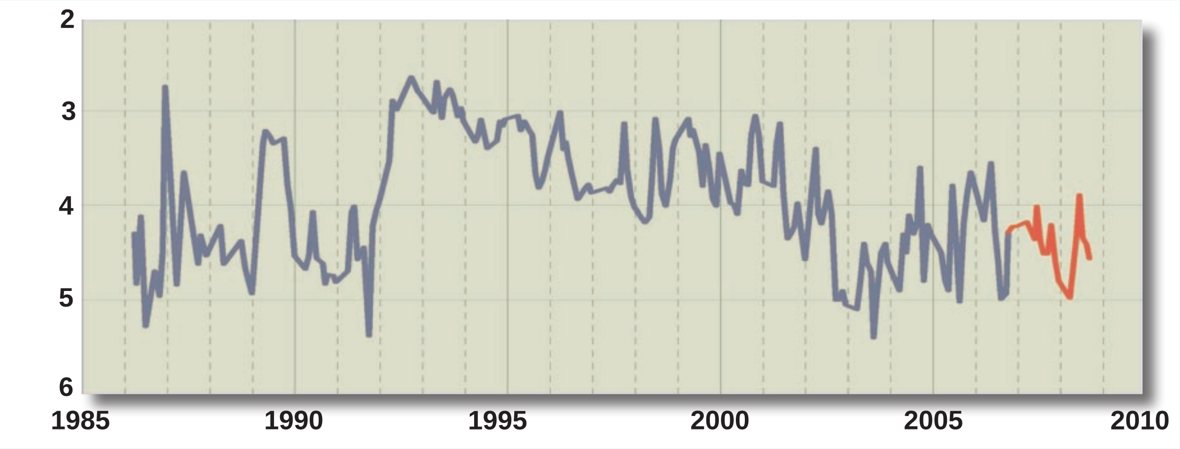


Figure 7E

Hubbard County - Buried Drift #29032

Depth to Water, ft.

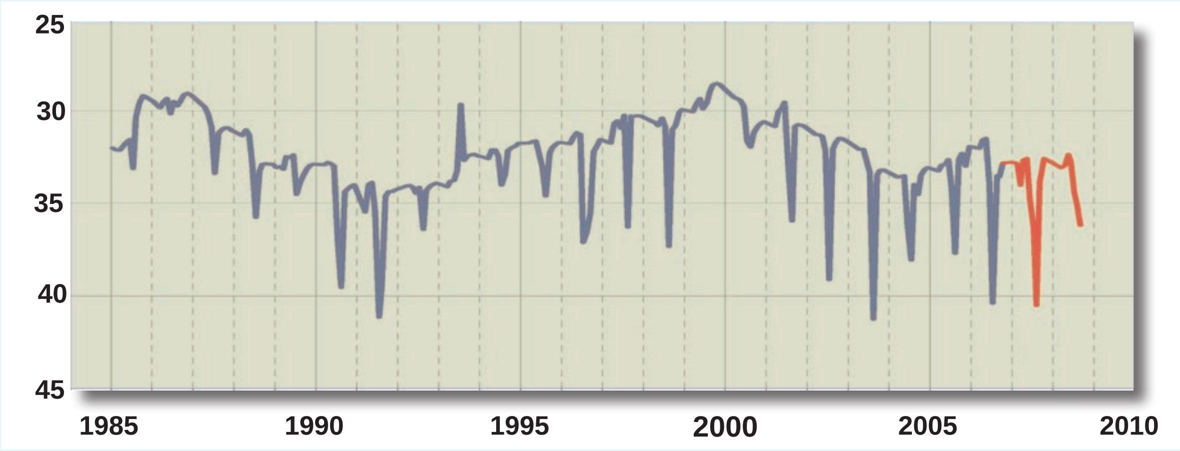


Figure 7F

Jackson County - Buried Drift #32003

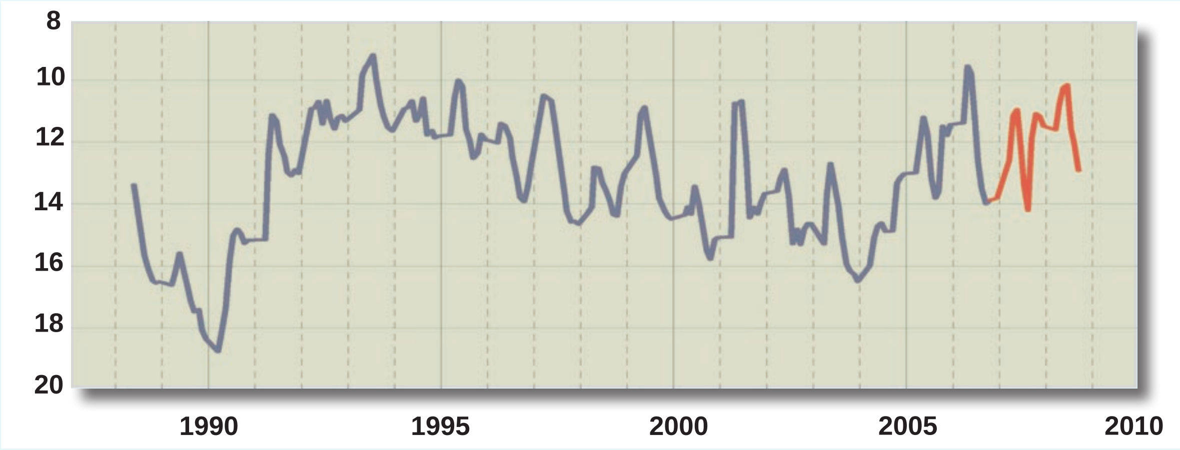


Figure 7G

Marshall County - Buried Drift #45000

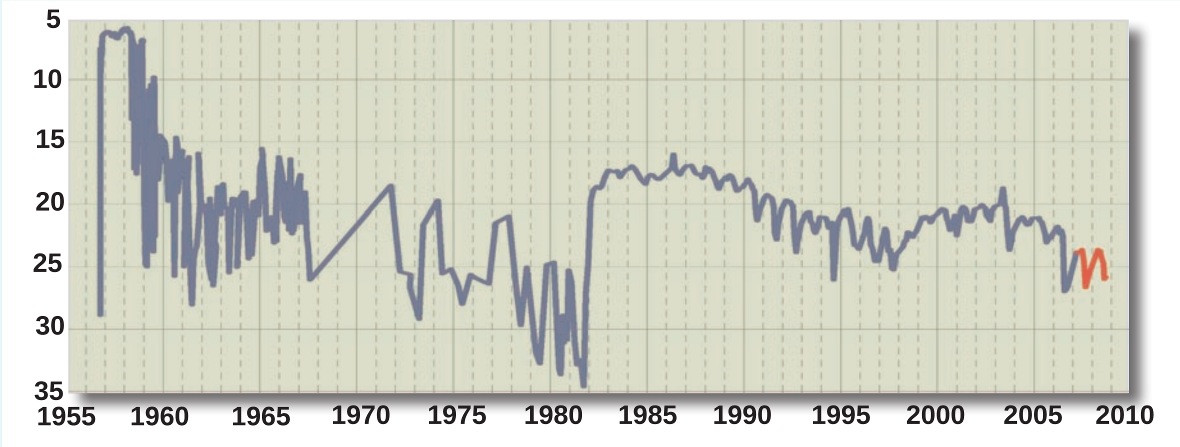


Figure 7H

Meeker County - Buried Drift #47007

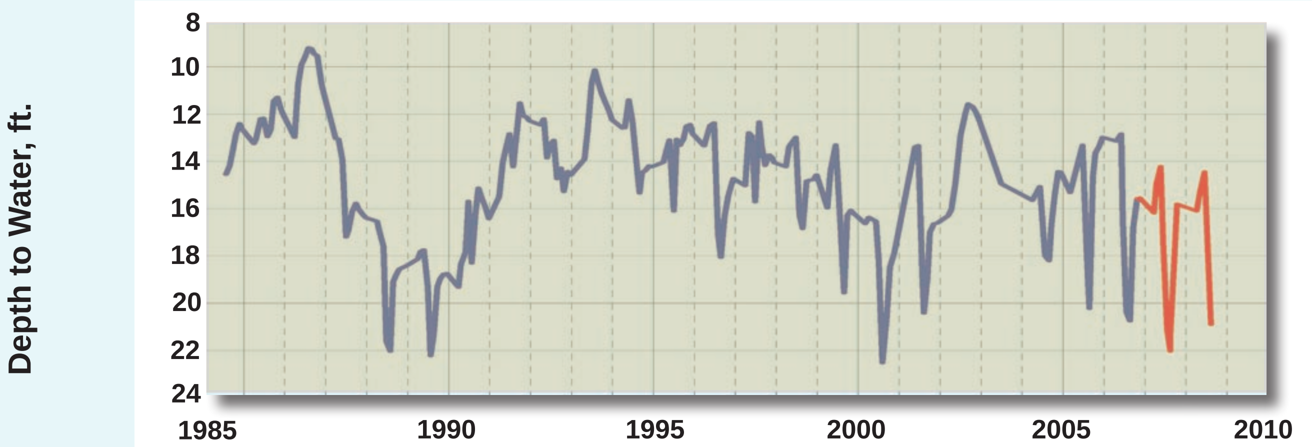


Figure 7i

North St. Louis County - Buried Drift #69050

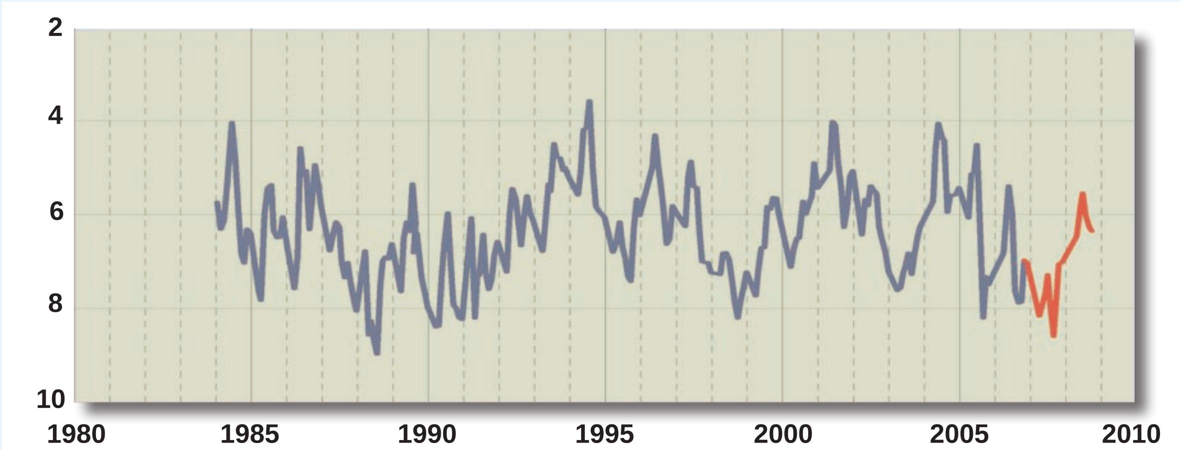


Figure 7J

Todd County - Buried Drift #77034

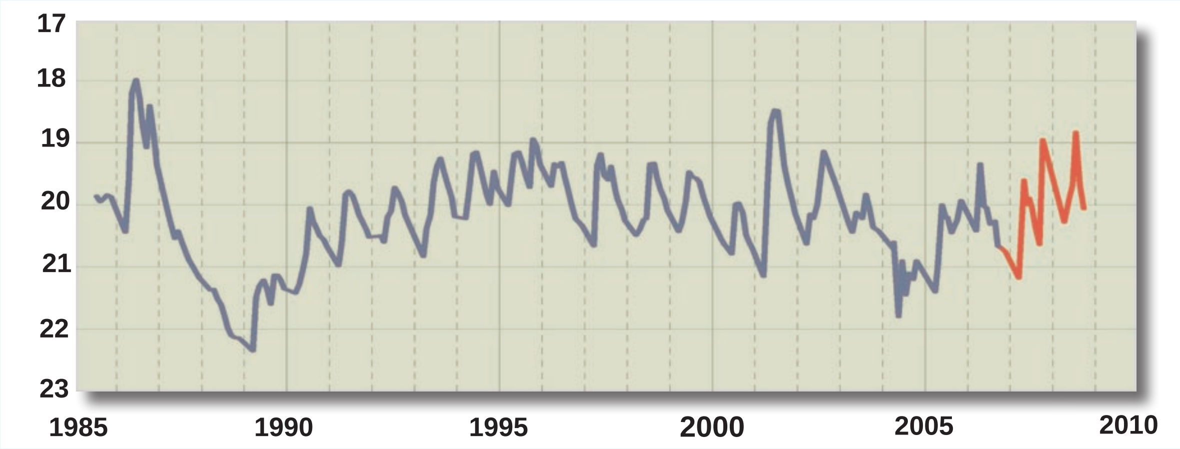


Figure 7K

Wadena County - Buried Drift #80029

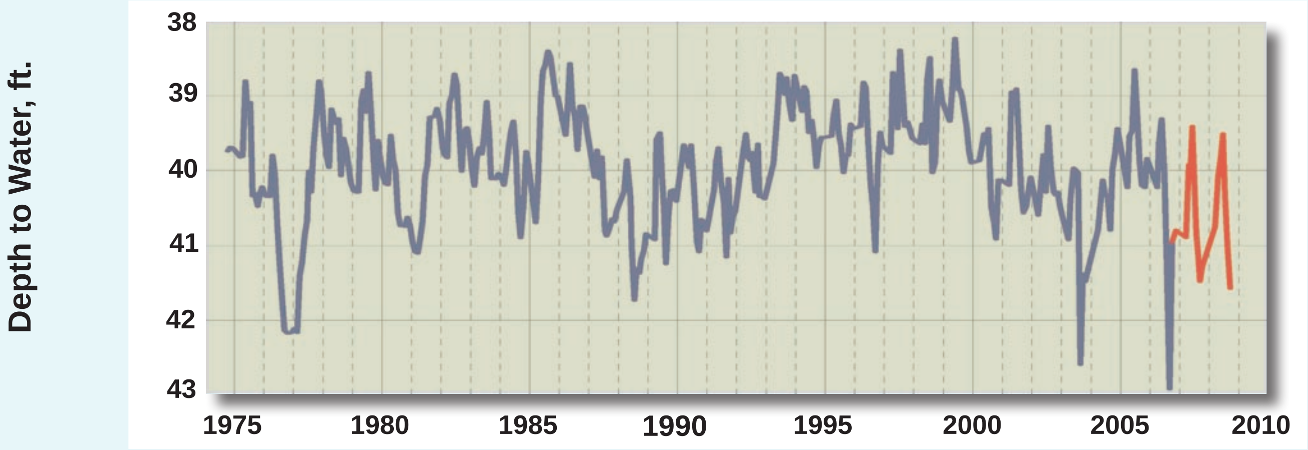
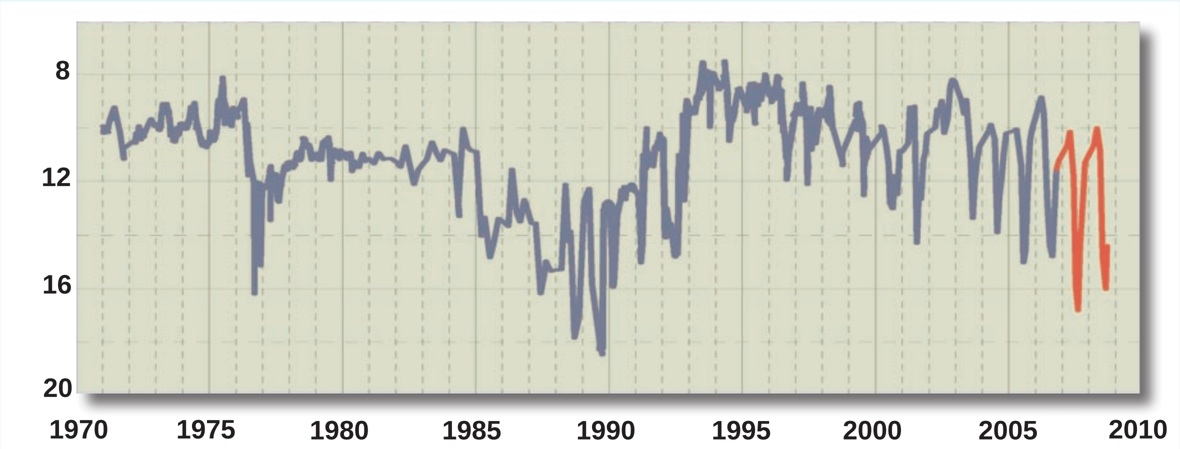


Figure 8A

Anoka County - Jordan #2012



Depth to Water, ft.

Figure 8B

Hennepin County - Jordan #27001

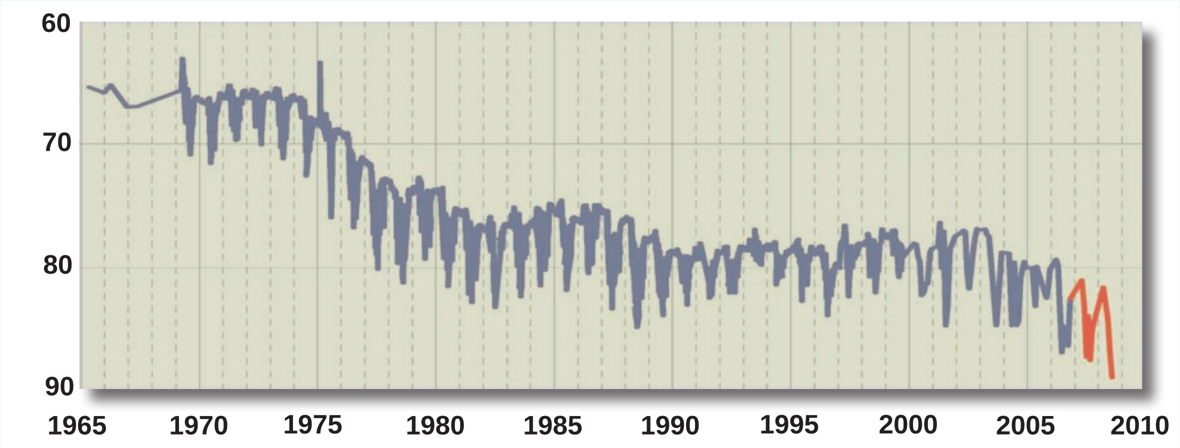


Figure 8C

Hennepin County - Jordan #27011

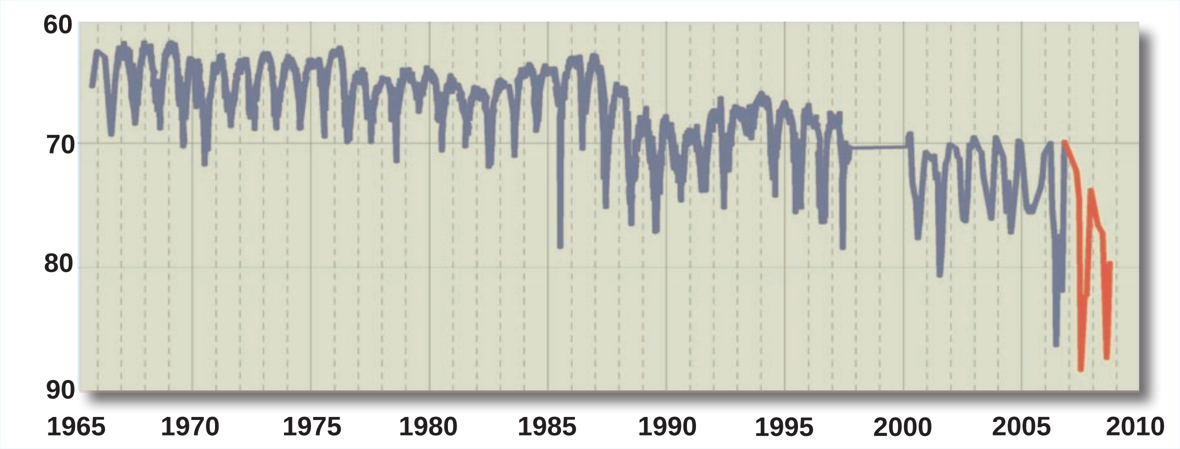


Figure 8D

Olmsted County - Jordan #55000

Depth to Water, ft.

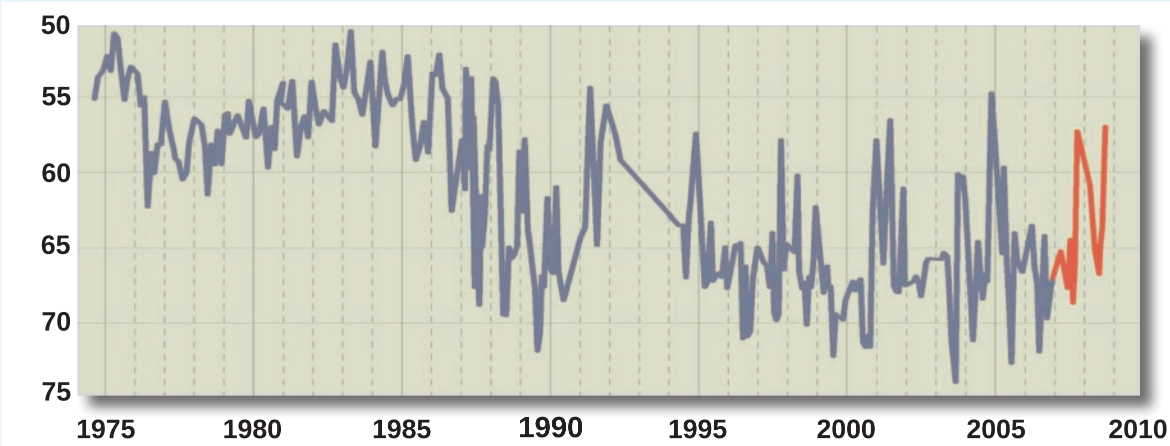


Figure 8E

Ramsey County - Jordan #62030

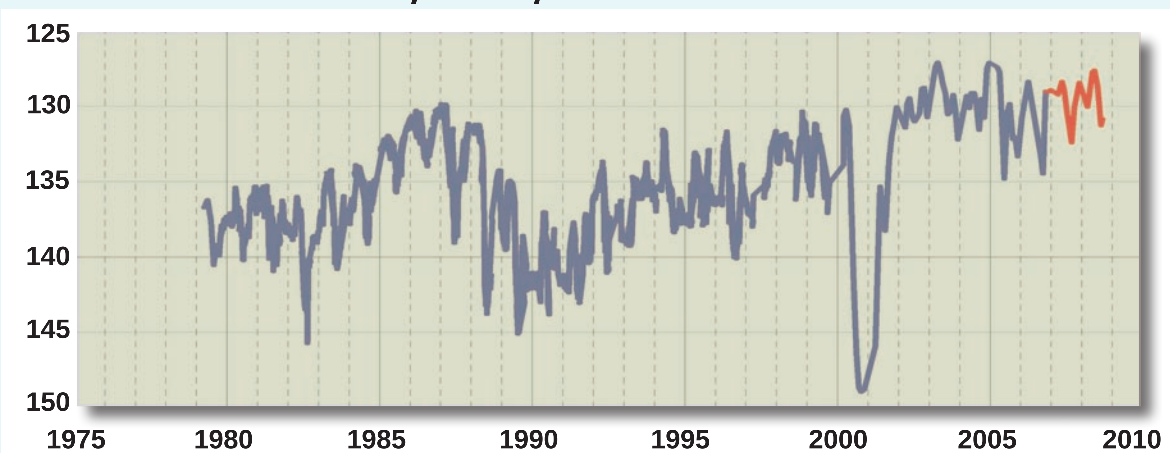


Figure 8F

Rice County - Jordan #66015

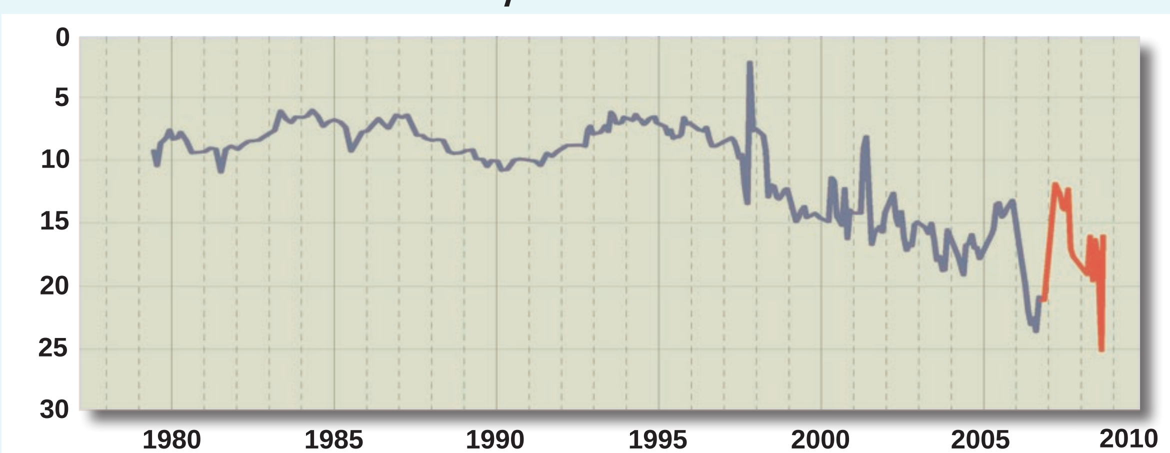


Figure 8G

Washington County - Jordan #82031

Figure 9A

Dakota County - Prairie du Chien #19005

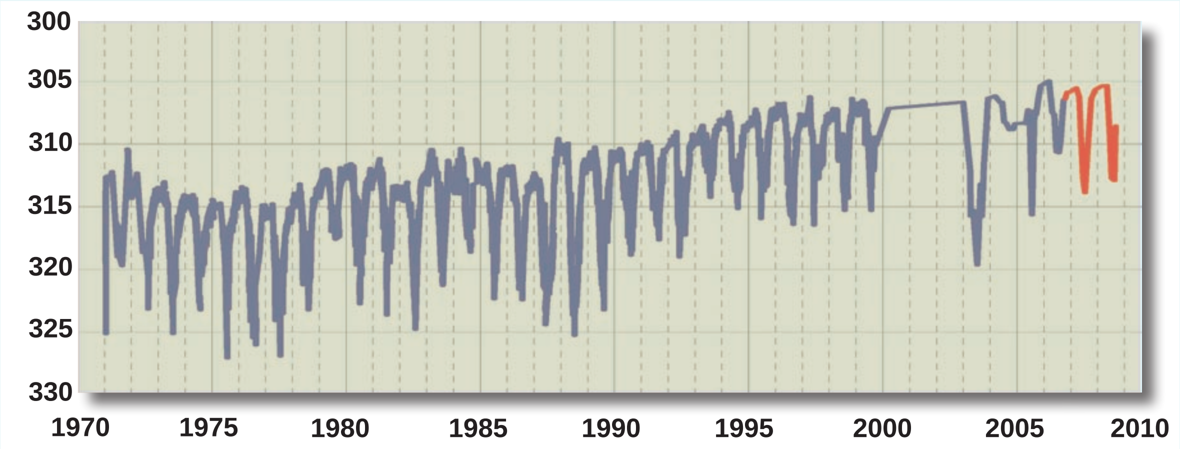


Figure 9B

Dakota County - Prairie du Chien #19007

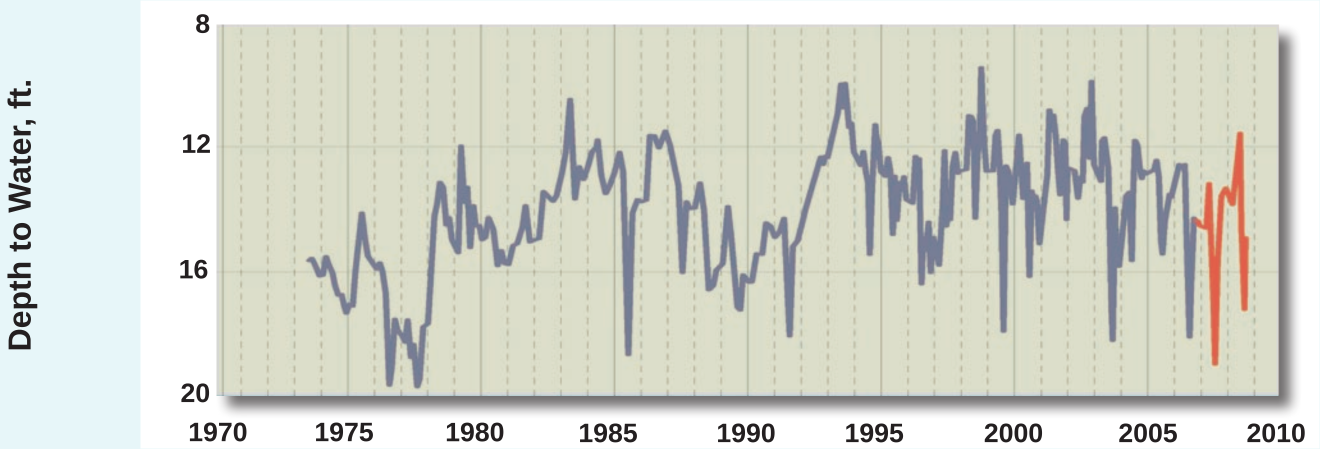


Figure 9C

Dakota County - Prairie du Chien #19008

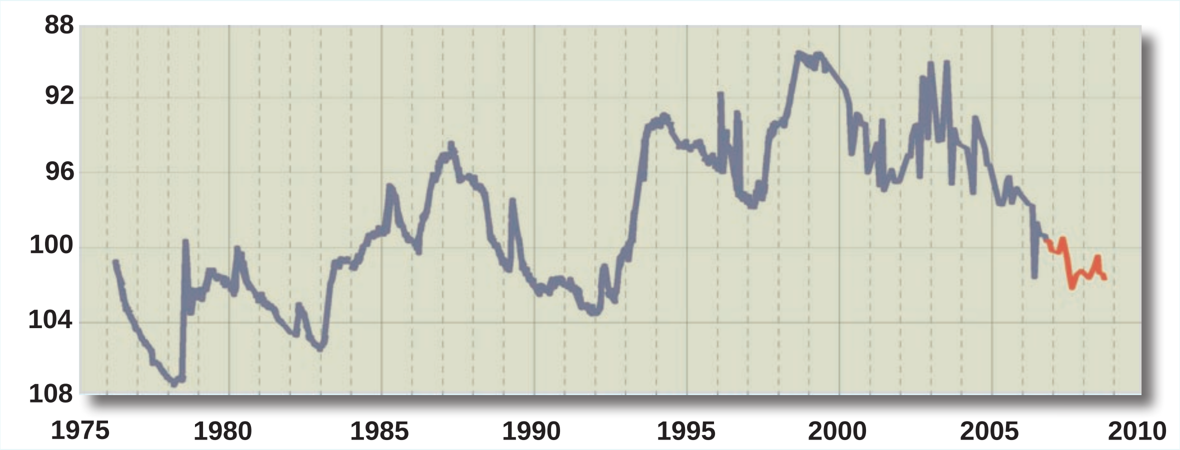


Figure 9D

Dakota County - Prairie du Chien #19029

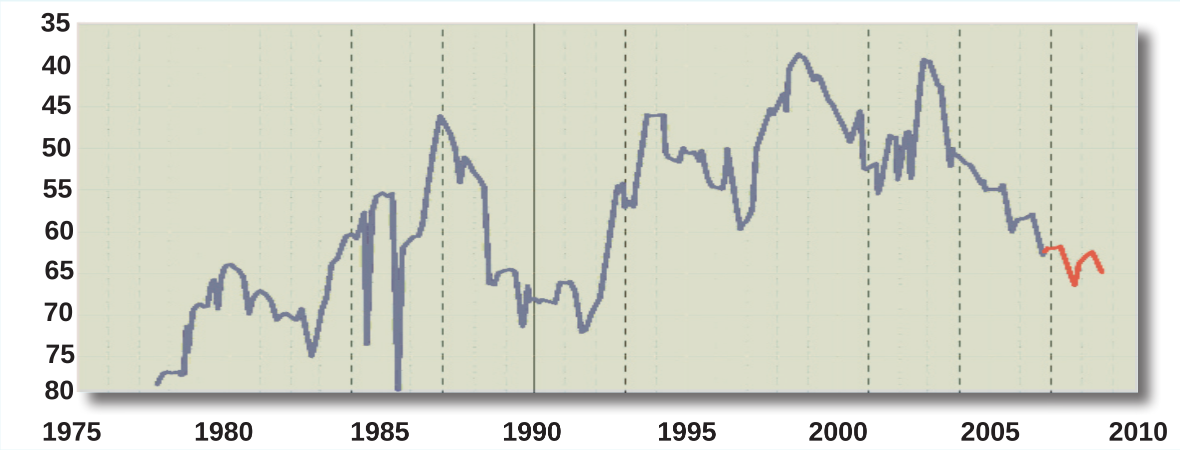


Figure 9E

Hennepin County - Prairie du Chien #27036

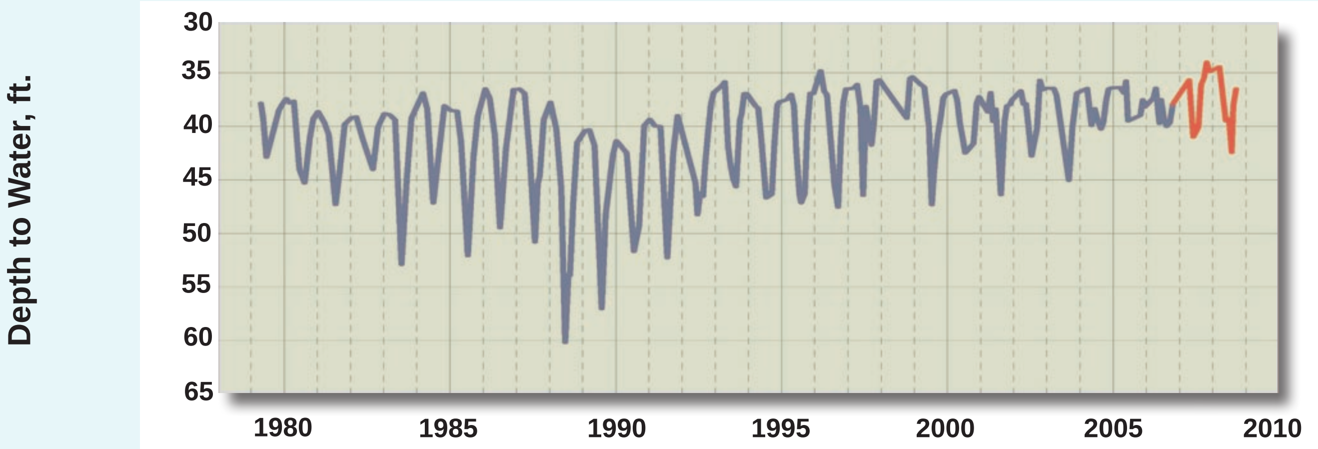


Figure 9F

Rice County - Prairie du Chien #66016

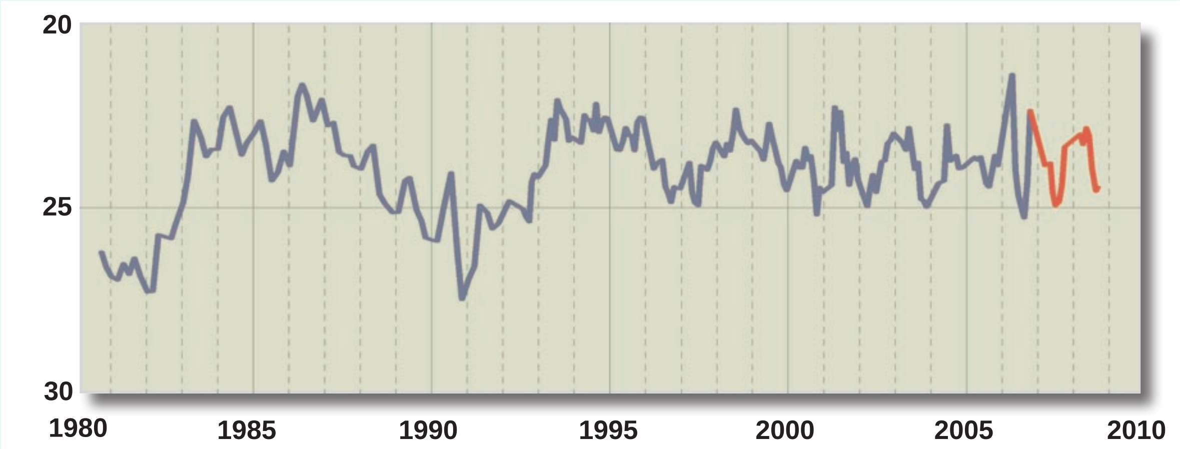


Figure 9G

Rice County - Prairie du Chien #66017

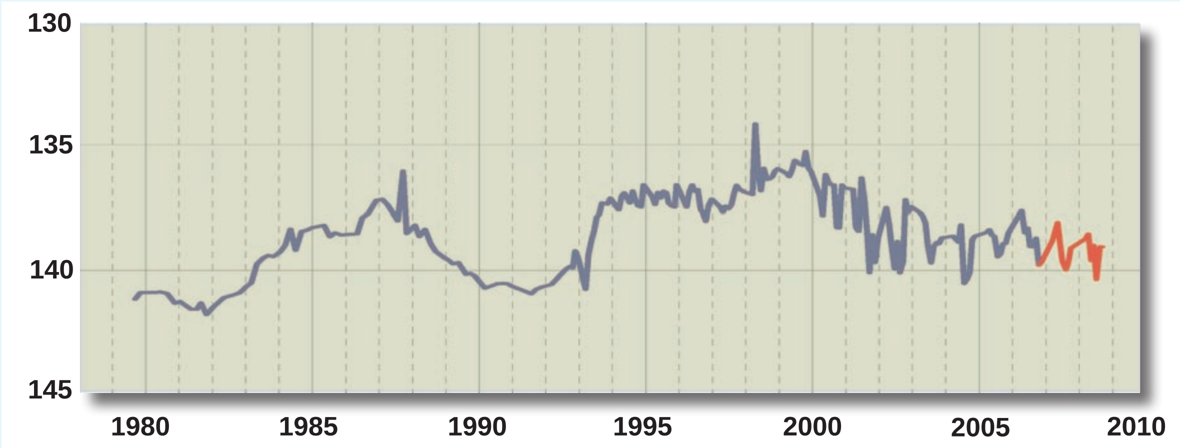


Figure 9H

Scott County - Prairie du Chien #70008

Depth to Water, ft.

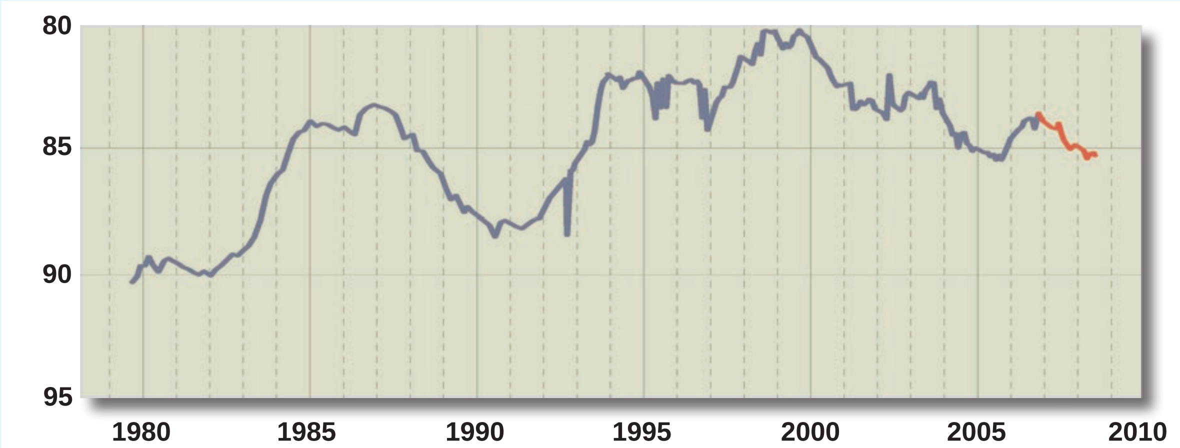


Figure 9i

Washington County - Prairie du Chien #82029

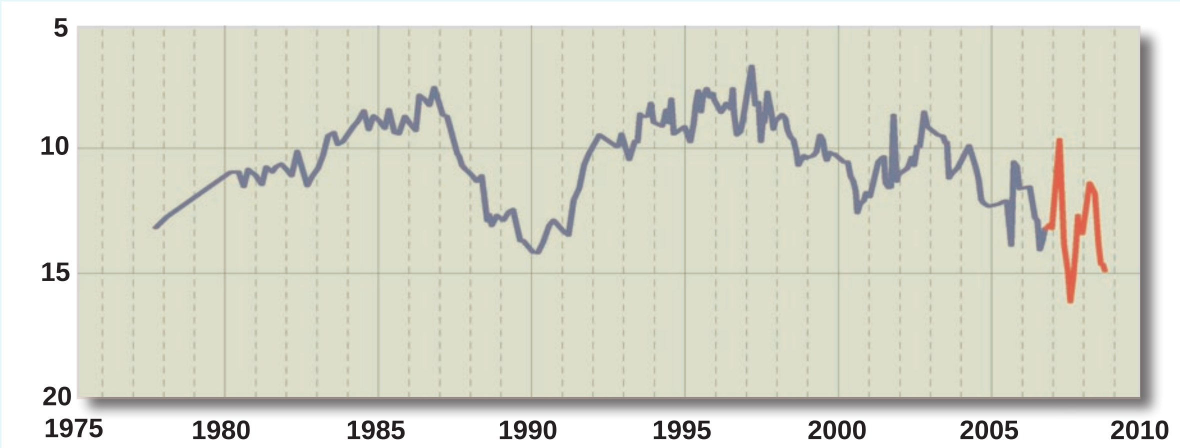


Figure 9J

Washington County - Prairie du Chien #82033

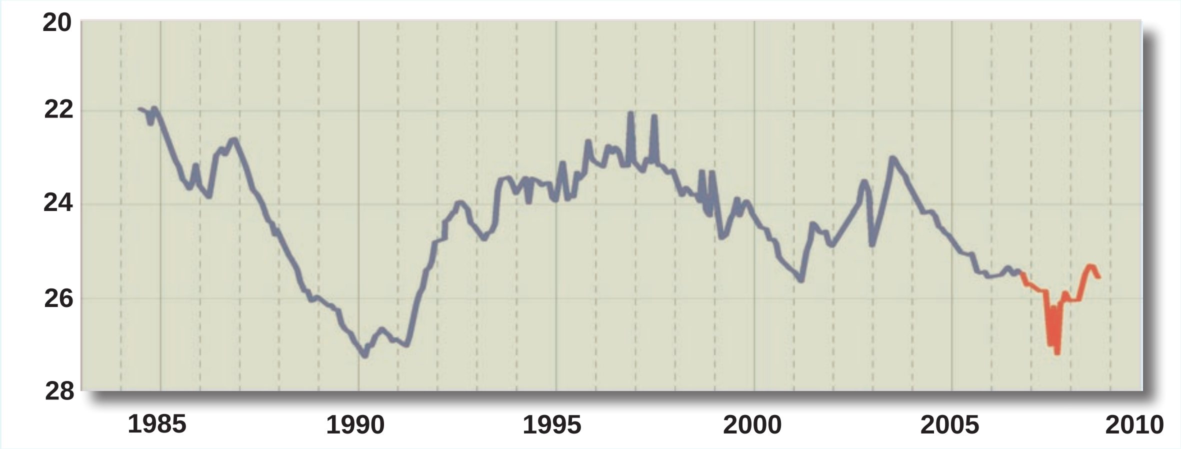


Figure 9K

Dakota County - Prairie du Chien/Jordan #19046

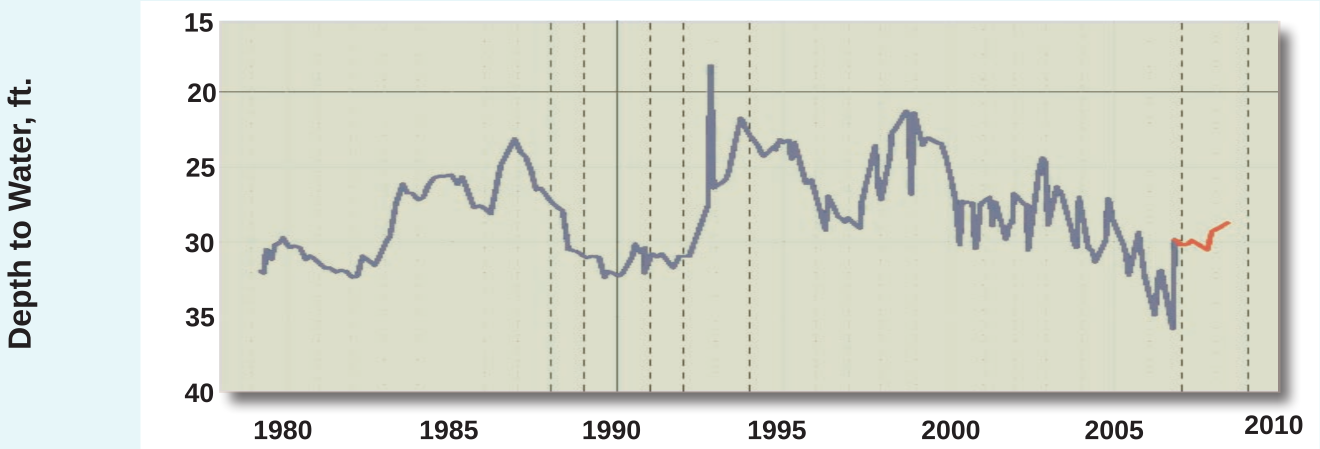


Figure 10A

Anoka County - Mt. Simon #2028

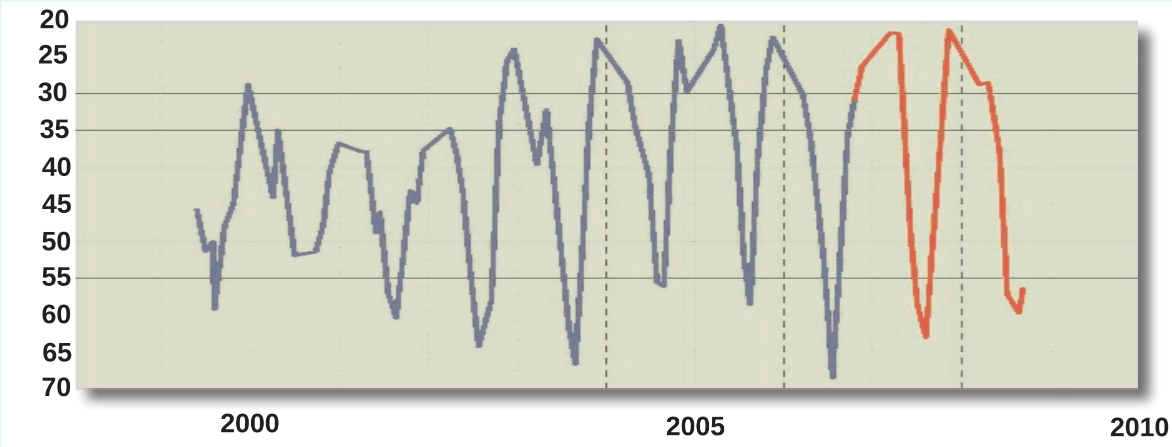


Figure 10B

Chisago County - Mt. Simon #13006

Depth to Water, ft.

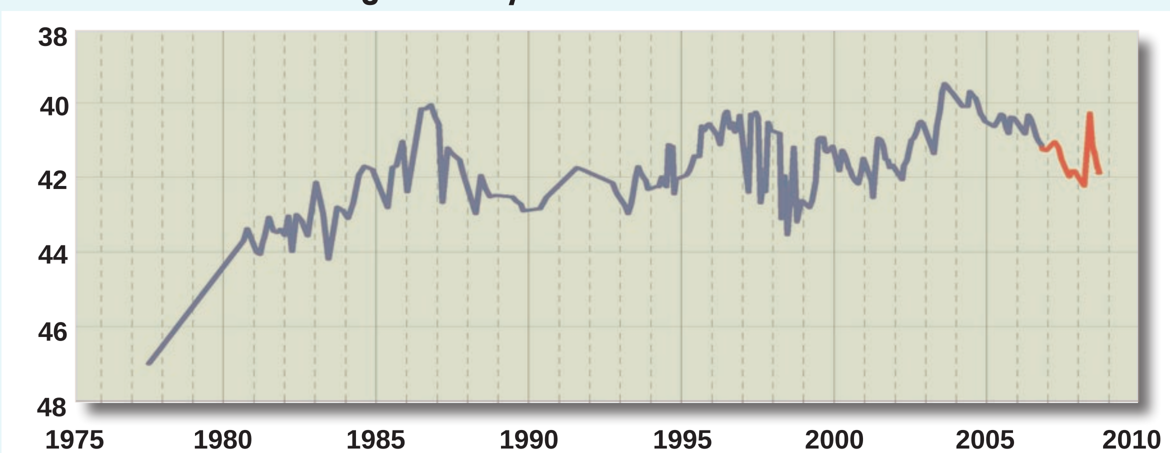


Figure 10C

Hennepin County - Mt. Simon #27004/27048

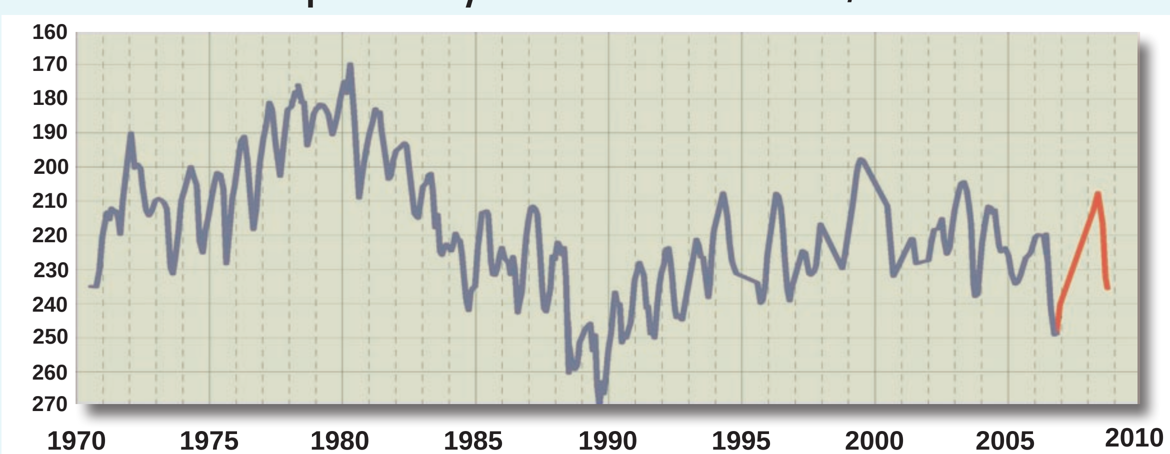


Figure 10D

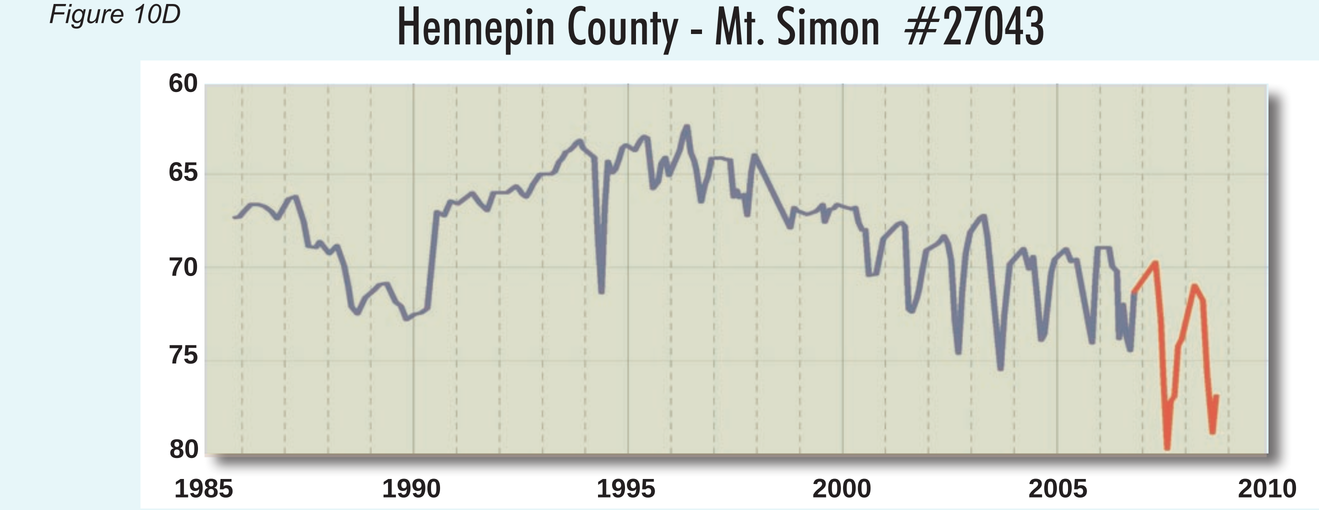


Figure 10E

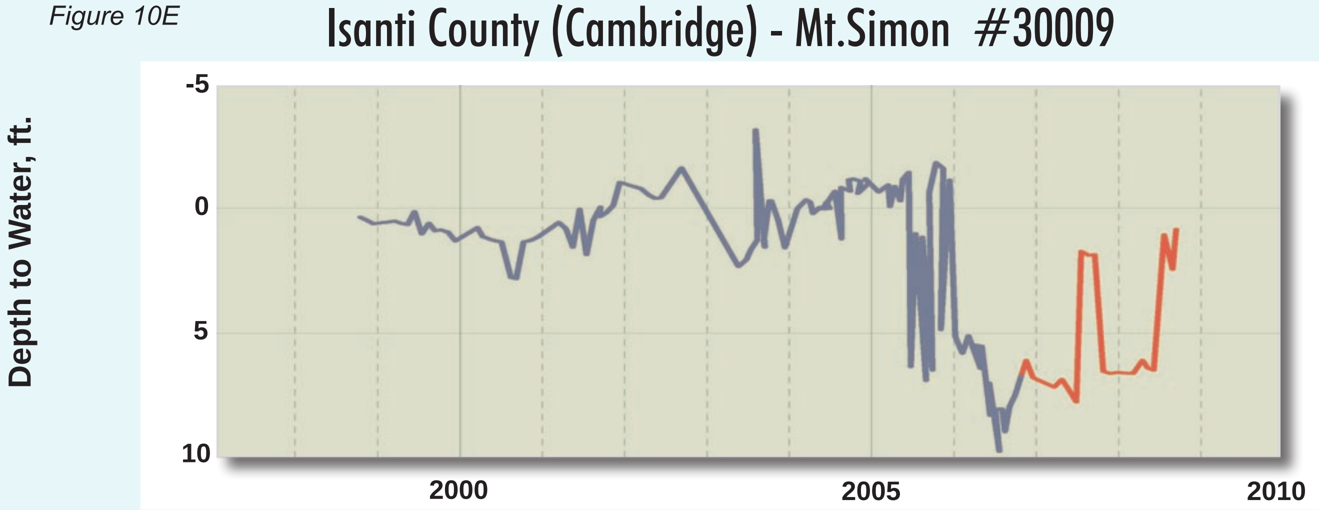


Figure 10F

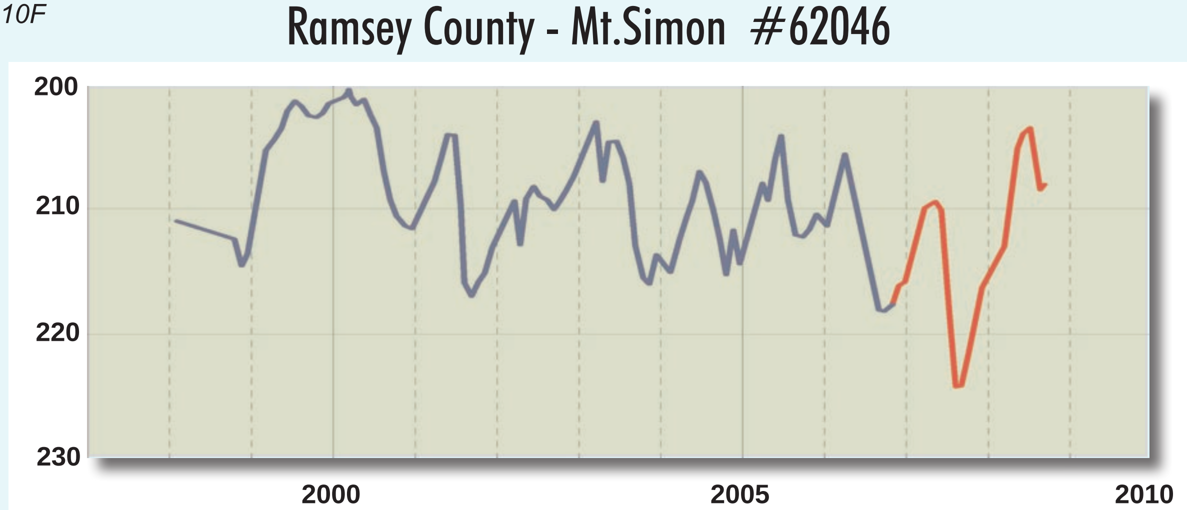


Figure 10G

Scott County (Savage) - Mt.Simon #70002/70030

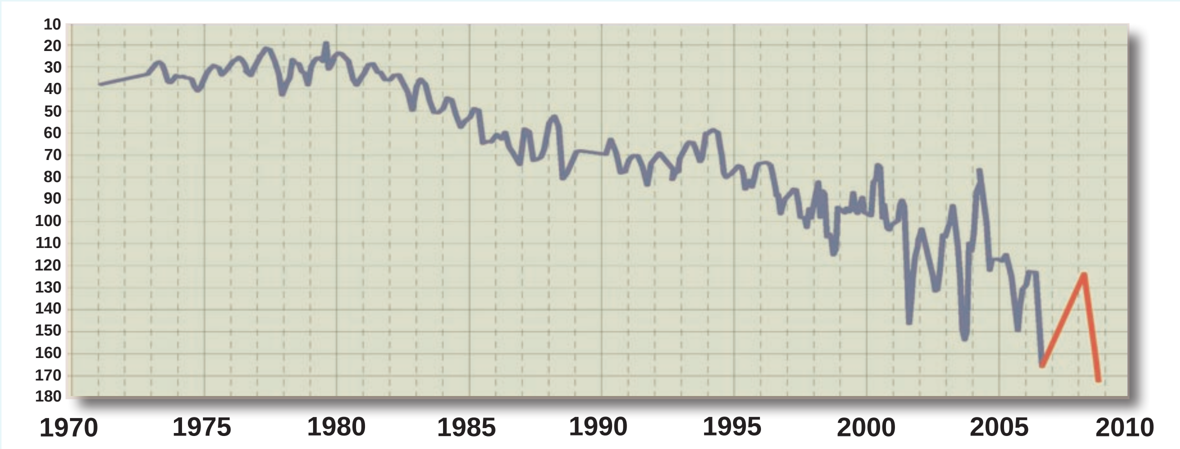


Figure 10H

Washington County - Mt.Simon #82046

Depth to Water, ft.

Figure 10i

Wright County - Mt.Simon #86001