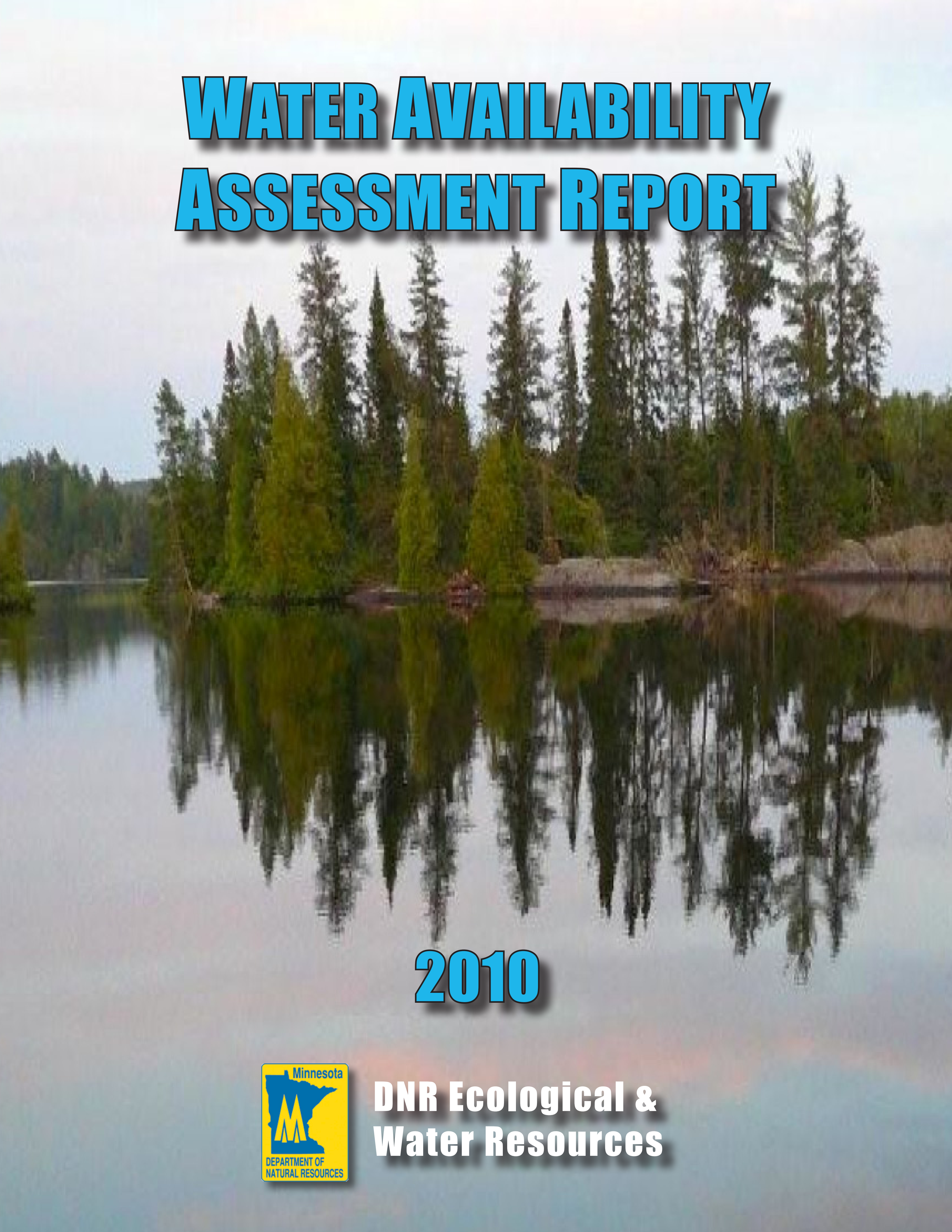
Water Availability Assessment Report



2010

DNR Ecological & Water Resources

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Water Availability Assessment Report 2010

by DNR Ecological & Water Resources
Hydrogeologists and Hydrologists

St. Paul, Minnesota

August 2010

Minnesota
Department of Natural Resources
Ecological & Water Resources

"Healthy Watersheds across Minnesota"

Introduction

The availability of water to meet the state's needs is determined by three basic factors; climate and global weather patterns, human changes to flow pathways and water use, and human changes to water quality[1]. In Minnesota, we have little ability to affect climate and global weather patterns, but we have great ability to affect how we change flow pathways and water use, and our land use choices that can affect water quality.

In order to address the long-term sustainability and availability of our water and natural resources, the Department of Natural Resources (DNR) must necessarily engage in long-term thinking and planning efforts. Minnesota Statutes, 103G.265 requires the DNR to provide for an assurance of water supply as follows: "The commissioner shall develop and manage water resources to assure an adequate supply to meet long-range seasonal requirements for domestic, municipal, industrial, agricultural, fish and wildlife, recreational, power, navigation, and quality control purposes from waters of the state."

The greatest threat to having sufficient water to assure our many and varied needs comes from how we have manipulated the landscape without due consideration of its impacts on our water quantity, water quality and the ecosystem. The ecosystem functions of natural plant communities that slow water down and remove nutrients and other compounds can reduce the problems we create if we better plan for and make landscape management choices that retain these essential functions. Looking forward, we must become much wiser about how we are managing the lands and waters of Minnesota if we hope to have the desired availability and quality of water to provide the quality of life we desire.

This report provides a review of the current state of our water resources relative to the quantities and trends of our water supplies. The necessary background for reading and understanding this report lies in a DNR Information Paper entitled "Minnesota's Water Supply: Natural Conditions and Human Impacts". Its reference is found in the Appendix to this report and is available on our web page in the following location: mndnr.gov/waters

Minnesota's Water Budget and Human Impacts

The following charts, maps, diagrams and narratives provide information to evaluate the trends of our climate, surface waters, groundwater systems and water use over the last ten years as well as in relation to long-term historic trends.

[1] Waters that become impaired by contaminants are still available for use, however the cost of removing contaminants may be so expensive that they become undesirable and not considered as waters that are available for use.

The Ten Year Water Availability Trends for Planning Purposes

The following information is provided for general trend evaluation purposes. The reader must recognize that the historical period of record for each of the indicator resources examined is not the same and the average conditions for each of these resources is a reflection of these dissimilar time periods. However, for examining general trends and changes over time these data provide a reasonable assessment of the resources.

A ten year average for water levels, flows and precipitation from 2000-2010 was calculated using data from indicator sites in the state's monitoring networks. These indicator locations are those presented in the DNR's monthly Hydrologic Conditions Report (web link) and represent a cross section of monitoring sites throughout the state. At a minimum these sites have at least 20 years data.

Precipitation (2000-2009)

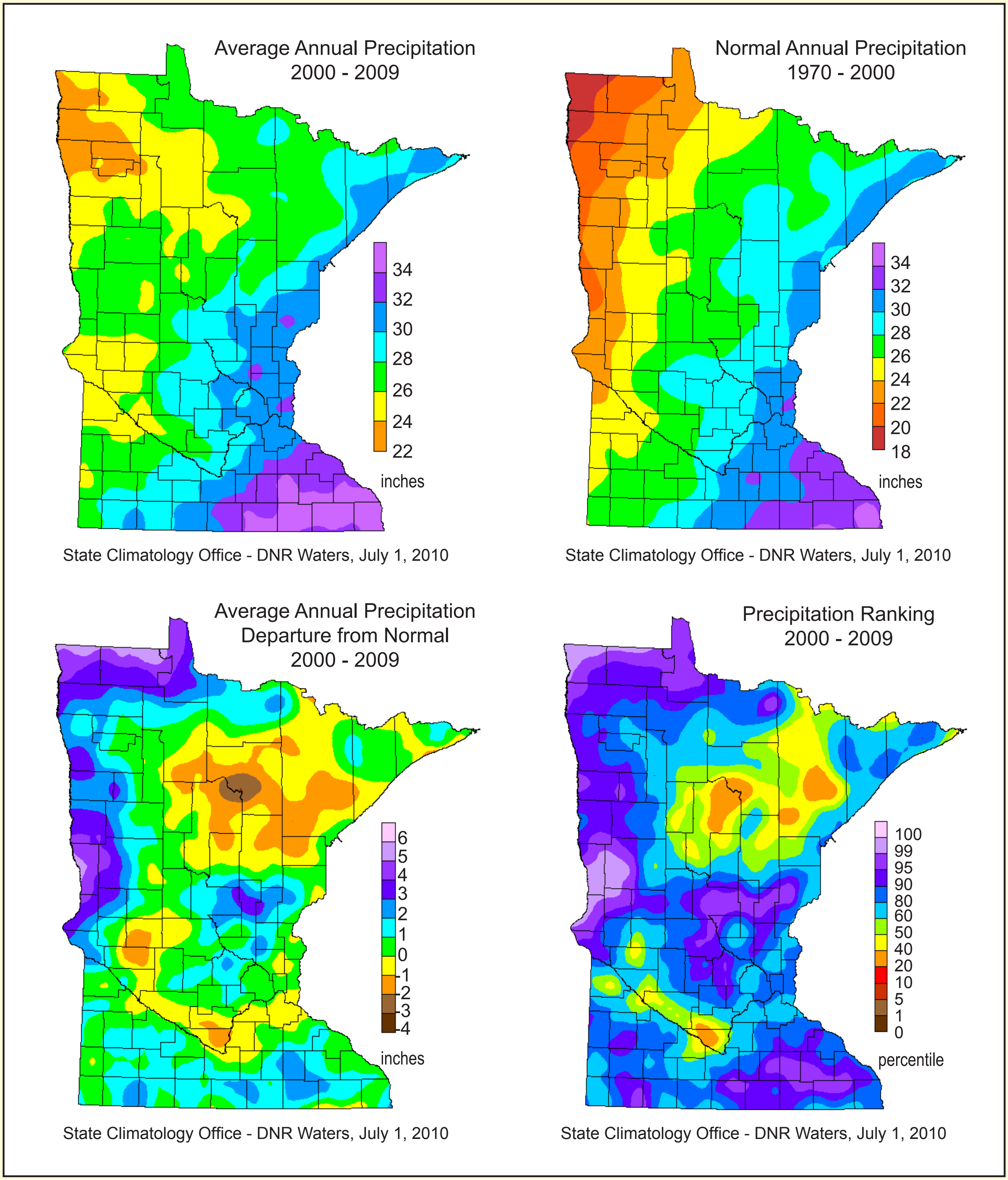
Caution must be used when making generalized statements concerning climate trends for a state the size of Minnesota. Large spatial variations can and do occur from one end of the state to another. Nonetheless, it can be informative to look at the state climate data set as a collective. The figure titled "Minnesota State-Averaged Annual Precipitation" offers a precipitation time-series using data from across Minnesota. Items of note from this graphic:

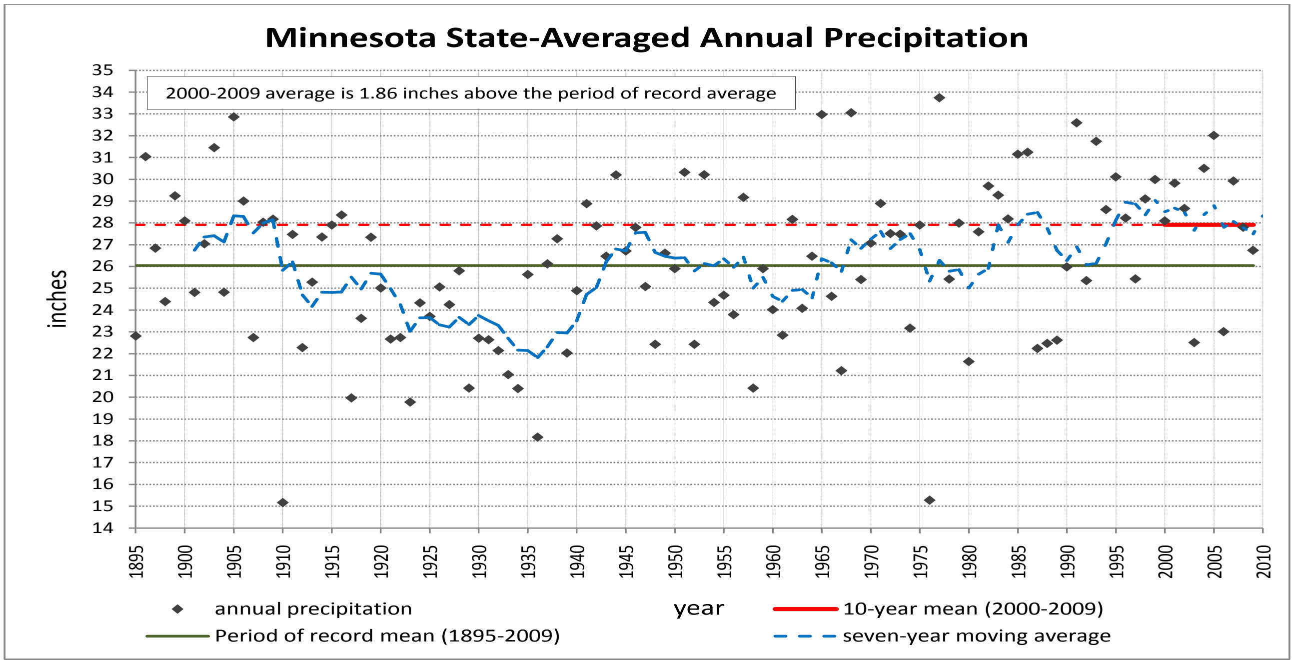
- Precipitation trends in Minnesota reached a plateau during the past decade, halting the upward push evident during the end of the 20th century. However, the 2000-2009 decadal precipitation average remained high relative to the full period of record.

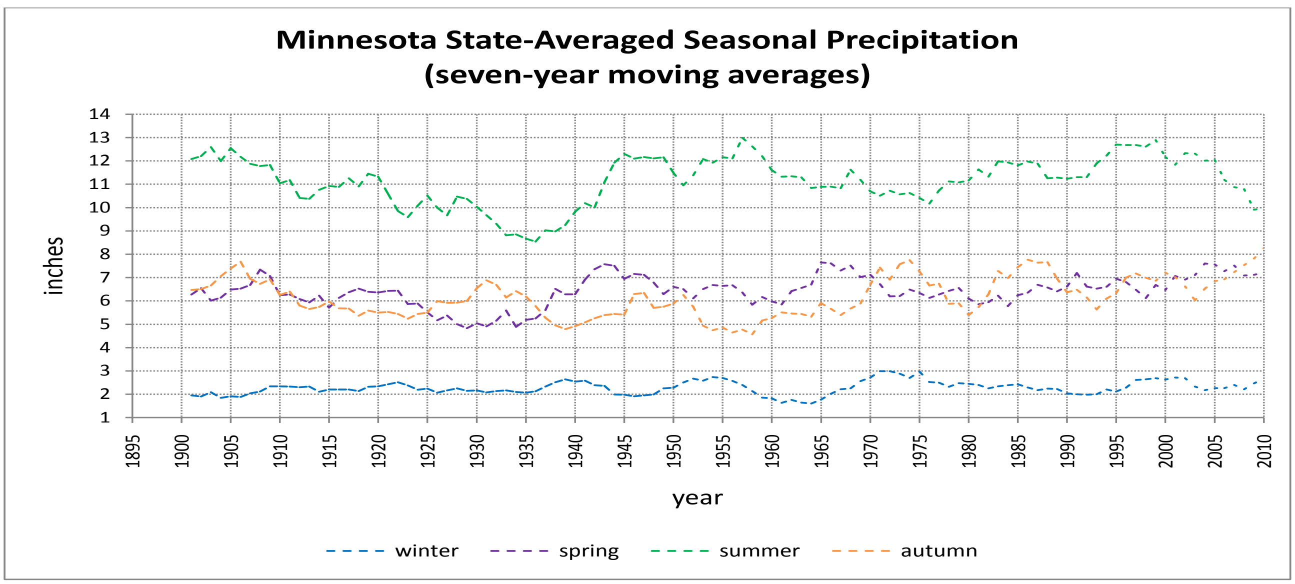
- The past decade produced two years that ranked in the drier range of the historical distribution (2003, 2006). This comes on the heels of the 1990s when dry years were nonexistent and drought was seldom an issue.

Although the annual precipitation trend leveled off during the first decade of the 21st century, this was NOT the case for seasonal precipitation. As shown in the graphic titled "Minnesota State-Averaged Seasonal Precipitation", summer precipitation totals showed an appreciable dip over the past 10 years. The summer dryness was offset by increases in autumn precipitation, and to a lesser extent, spring precipitation.

The decadal precipitation departure from normal and precipitation ranking maps demonstrate the ongoing precipitation anomaly impacting hydrology and agriculture in west central and northwestern Minnesota. This extraordinary wet spell dates back to 1991 and is responsible for high water level problems experienced in the those counties as well as the Devils Lake crisis in neighboring North Dakota. The suggestion of relative dryness depicted in north central and northeastern Minnesota may have impacted forest health issues such as drought-stress and pest infestations.


Average Annual Precipitation
2000 - 2009
34
32
30
28
26
24
22
inches
State Climatology Office - DNR Waters, July 1, 2010
Normal Annual Precipitation
1970 - 2000
34
32
30
28
26
24
22
20
18
inches
State Climatology Office - DNR Waters, July 1, 2010
Average Annual Precipitation
Departure from Normal
2000 - 2009
6
5
4
3
2
1
0
-1
-2
-3
-4
inches
State Climatology Office - DNR Waters, July 1, 2010
Precipitation Ranking
2000 - 2009
100
99
95
90
80
60
50
40
20
10
5
1
0
percentile
State Climatology Office - DNR Waters, July 1, 2010


Minnesota State-Averaged Annual Precipitation
2000-2009 average is 1.86 inches above the period of record average
inches
year
annual precipitation
10-year mean (2000-2009)
Period of record mean (1895-2009)
seven-year moving average

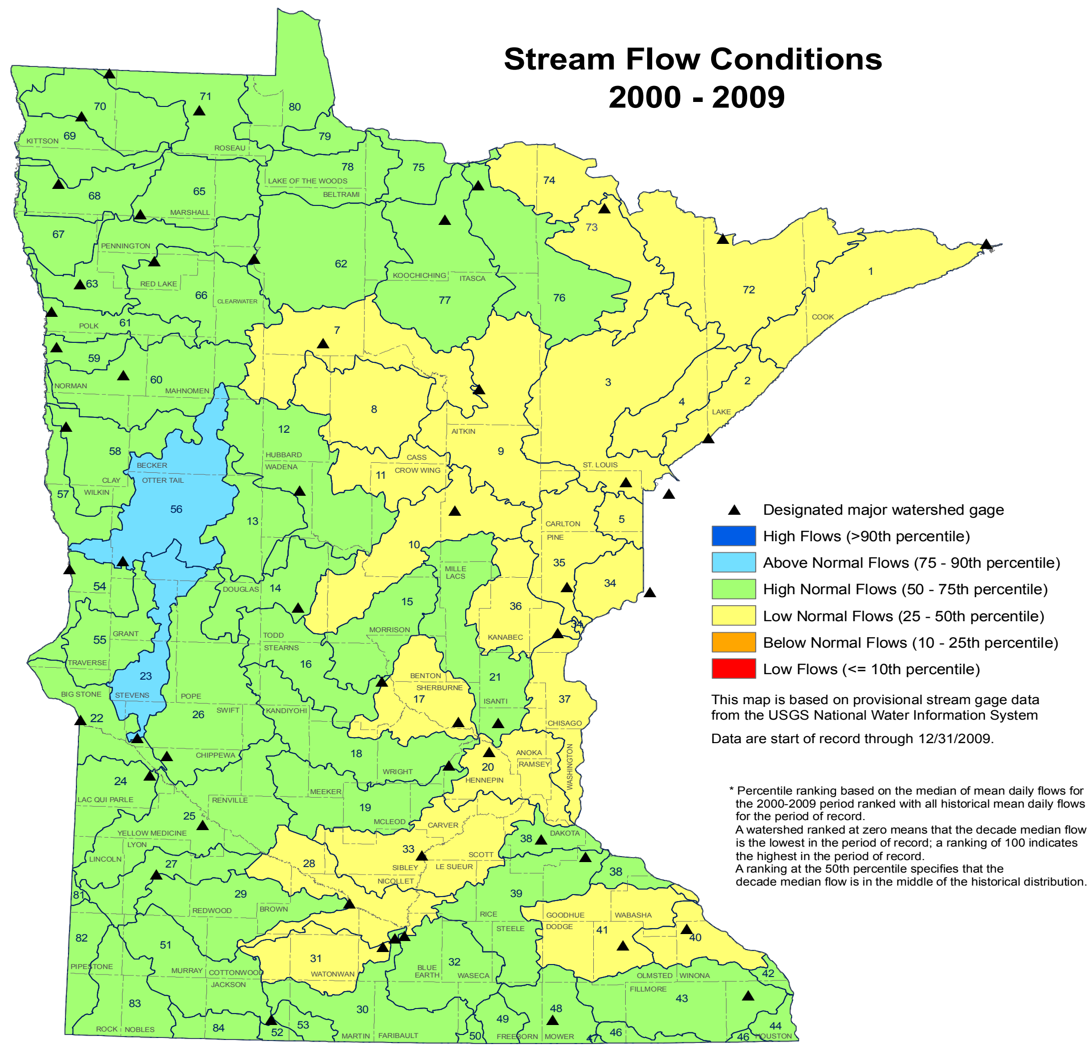

Minnesota State-Averaged Seasonal Precipitation
(seven-year moving averages)
inches
year
winter
spring
summer
autumn

Stream Flows (2000-2009)

For much of Minnesota, stream flows at indicator gages for each major watershed were in the normal range with the eastern and northeastern watersheds low normal (25-50th percentile) and western watersheds high normal (50-75th percentile). The exceptions to this include the Pomme de Terre River (Major Watershed 23) and Otter Tail River (Major Watershed 56). These watersheds rank above normal (75-90th percentile).

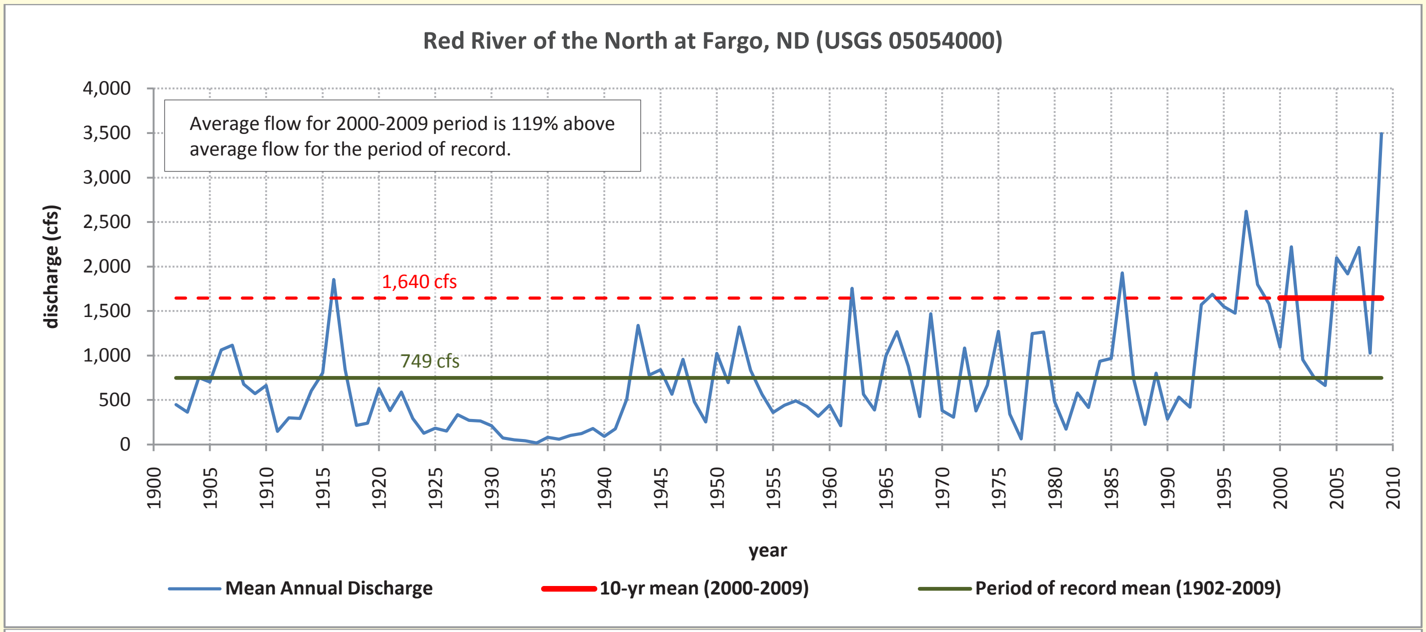
Three gages on major rivers with long-term records were also selected to compare average mean daily flow from the ten-year period 2000-2009 to the average mean daily flow for the entire period of record. The Mississippi River at St. Paul and the Minnesota River at Mankato show slightly higher average flows for the ten-year period. The mean annual flow for these locations masks seasonal variations in flow during the past decade where severe drought was followed by extremely wet periods. The mean annual flow ends up being fairly close to the period of record mean as opposed to other years when persistent trends in flow (dry in the 1930s, wet years in 1986 and 1993) show a greater deviation from the long term mean. The Red River of the North at Fargo, however, showed a much different pattern in the last decade. Mean annual flow was significantly higher over the last ten years when compared to the full period of record. This condition was seen all across the Red River Basin in eastern North Dakota and northwestern Minnesota and began this wetter trend beginning in the early 1990s. In the last decade, even the driest years at Fargo are still above or at the period of record mean flow.

Surface Water: Stream Flow

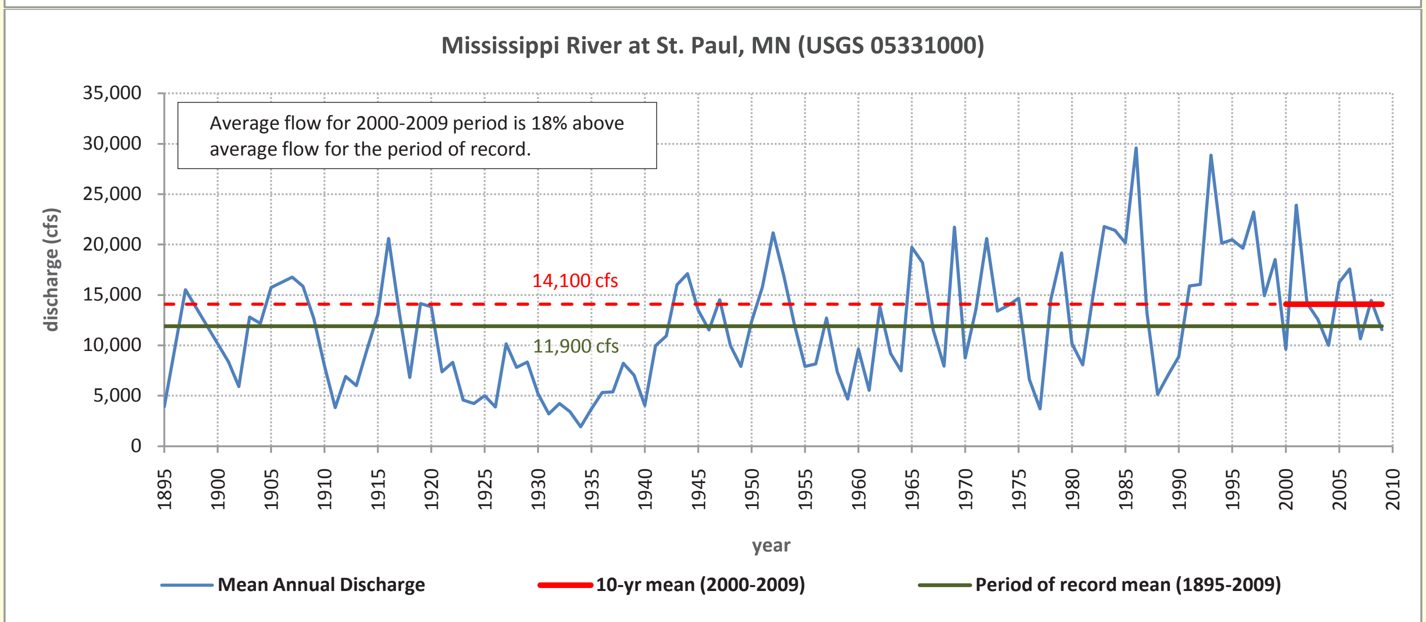


DNR Major Watershed (HUC 08 id)

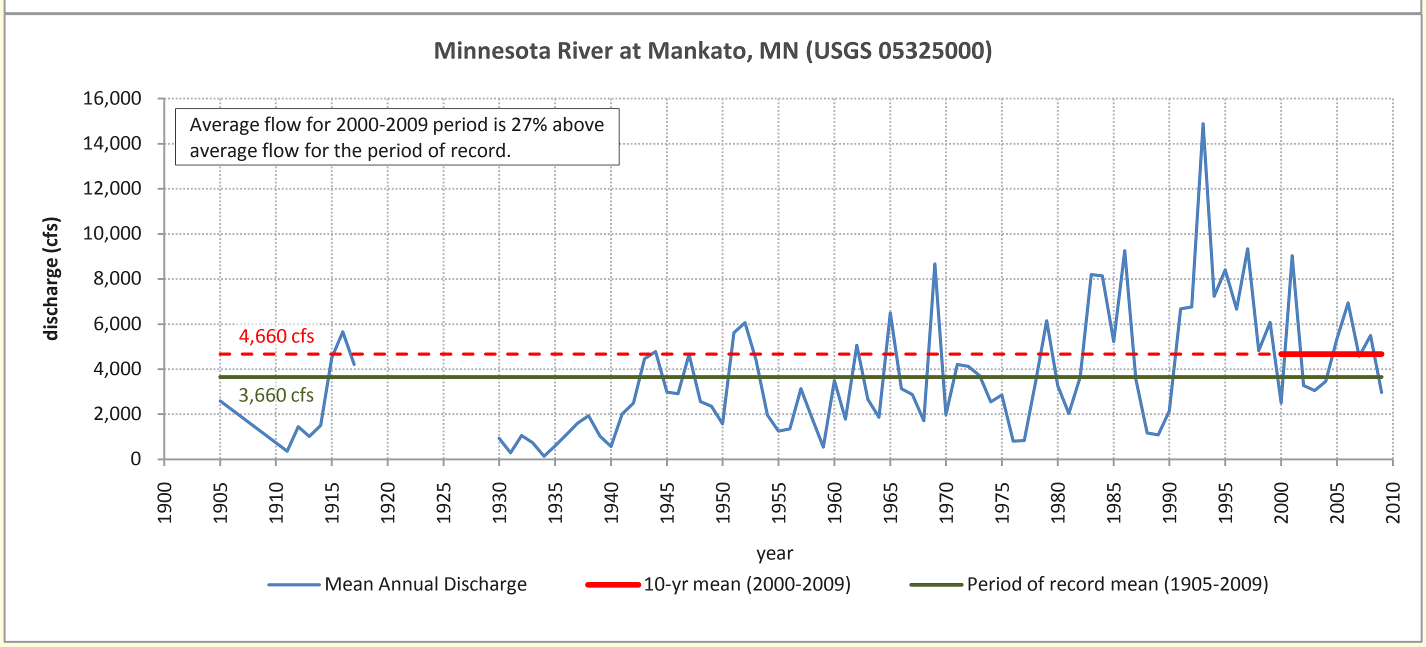
1. Lake Superior - North (04010101)
2. Lake Superior - South (04010102)
3. St. Louis River (04010201)
4. Cloquet River (04010202)
5. Nemadji River (04010301)
6. (none)
7. Mississippi River - Headwaters (07010101)
8. Leech Lake River (07010102)
9. Mississippi River - Grand Rapids (07010103)
10. Mississippi River - Brainerd (07010104)
11. Pine River (07010105)
12. Crow Wing River (07010106)
13. Redeye River (07010107)
14. Long Prairie River (07010108)
15. Mississippi River - Sartell (07010201)
16. Sauk River (07010202)
17. Mississippi River - St. Cloud (07010203)
18. North Fork Crow River (07010204)
19. South Fork Crow River (07010205)
20. Mississippi River - Twin Cities (07010206)
21. Rum River (07010207)
22. Minnesota River - Headwaters (07020001)
23. Pomme de Terre River (07020002)
24. Lac Qui Parle River (07020003)
25. Minnesota - Yellow Medicine Rivers (07020004)
26. Chippewa River (07020005)
27. Redwood River (07020006)
28. Minnesota River - Mankato (07020007)
29. Cottonwood River (07020008)
30. Blue Earth River (07020009)
31. Watonwan River (07020010)
32. Le Sueur River (07020011)
33. Lower Minnesota River (07020012)
34. Upper St. Croix River (07030001)
35. Kettle River (07030003)
36. Snake River (07030004)
37. Lower St. Croix River (07030005)
38. Mississippi River - Lake Pepin (07040001)
39. Cannon River (07040002)
40. Mississippi River - Winona (07040003)
41. Zumbro River (07040004)
42. Mississippi River - La Crescent (07040006)
43. Root River (07040008)
44. Mississippi River - Reno (07060001)
45. (none)
46. Upper Iowa River (07060002)
47. Upper Wapsipinicon River (07080102)
48. Cedar River (07080201)
49. Shell Rock River (07080202)
50. Winnebago River (07080203)
51. Des Moines River - Headwaters (07100001)
52. Lower Des Moines River (07100002)
53. East Fork Des Moines River (07100003)
54. Bois de Sioux River (09020101)
55. Mustinka River (09020102)
56. Otter Tail River (09020103)
57. Upper Red River of the North (09020104)
58. Buffalo River (09020106)
59. Red River of the North - Marsh River (09020107)
60. Wild Rice River (09020108)
61. Red River of the North - Sandhill River (09020301)
62. Upper/Lower Red Lake (09020302)
63. Red Lake River (09020303)
64. (none)
65. Thief River (09020304)
66. Clearwater River (09020305)
67. Red River of the North - Grand Marais Creek (09020306)
68. Snake River (09020309)
69. Red River of the North - Tamarac River (09020311)
70. Two Rivers (09020312)
71. Roseau River (09020314)
72. Rainy River - Headwaters (09030001)
73. Vermilion River (09030002)
74. Rainy River - Rainy Lake (09030003)
75. Rainy River - Black River (09030004)
76. Little Fork River (09030005)
77. Big Fork River (09030006)
78. Rapid River (09030007)
79. Rainy River - Baudette (09030008)
80. Lake of the Woods (09030009)
81. Upper Big Sioux River (10170201)
82. Lower Big Sioux River (10170203)
83. Rock River (10170204)
84. Little Sioux River (10230003)



Red River of the North at Fargo, ND (USGS 05054000)
Average flow for 2000-2009 period is 119% above average flow for the period of record.
1,640 cfs
749 cfs
discharge (cfs)
year
Mean Annual Discharge
10-yr mean (2000-2009)
Period of record mean (1902-2009)

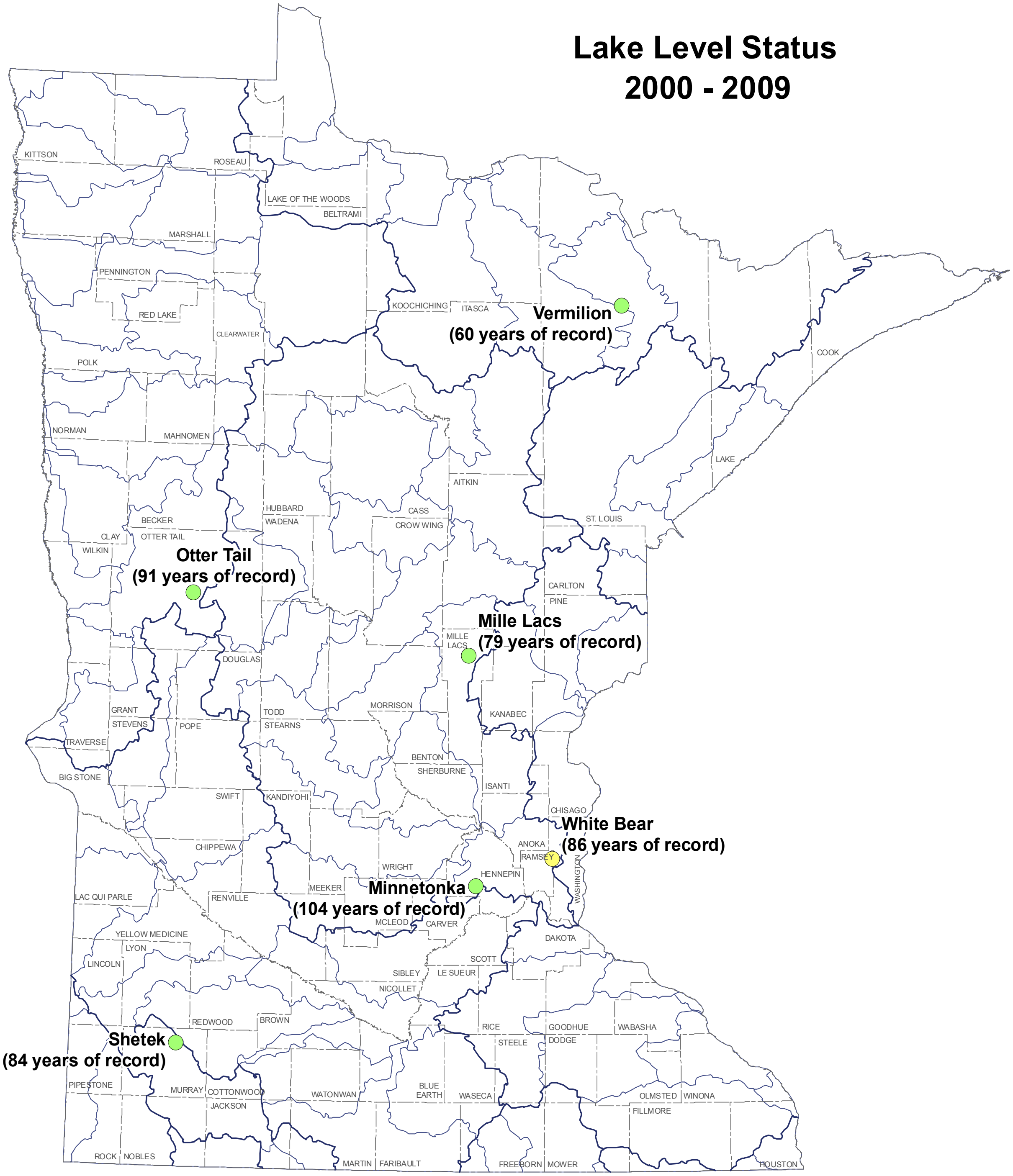


Mississippi River at St. Paul, MN (USGS 05331000)
Average flow for 2000-2009 period is 18% above average flow for the period of record.
14,100 cfs
11,900 cfs
discharge (cfs)
year
Mean Annual Discharge
10-yr mean (2000-2009)
Period of record mean (1895-2009)



Minnesota River at Mankato, MN (USGS 05325000)
Average flow for 2000-2009 period is 27% above average flow for the period of record.
4,660 cfs
3,660 cfs
discharge (cfs)
year
Mean Annual Discharge
10-yr mean (2000-2009)
Period of record mean (1905-2009)

Surface Water: Lake Levels



Percentile *

- High Water Levels (>90th percentile)
- Above Normal Water Levels (75 - 90th percentile)
- High Normal Water Levels (50 - 75th percentile)
- Low Normal Water Levels (25 - 50th percentile)
- Below Normal Water Levels (10 - 25th percentile)
- Low Water Levels (<= 10th percentile)
- Level 2 Hydrologic Unit
- DNR Major Watershed

* Percentile ranking based on the median of lake levels for the 2000-2009 period ranked with all historical reported levels. A lake ranked at zero means that the decade median is the lowest in the period of record; a ranking of 100 indicates the highest in the period of record. A ranking at the 50th percentile specifies that the decade median lake level is in the middle of the historical distribution.

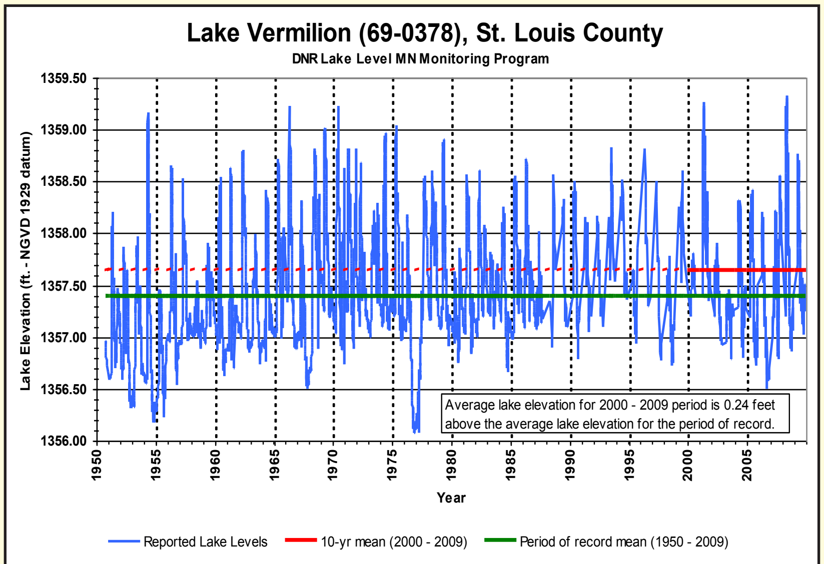
Source data from: MN DNR Waters Lake Level Minnesota Monitoring Program

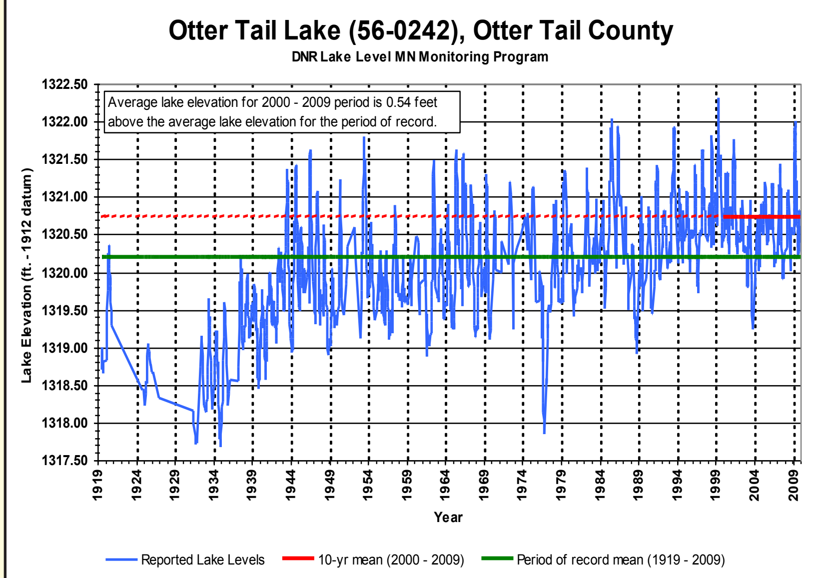
Lake Levels (2000-2009)

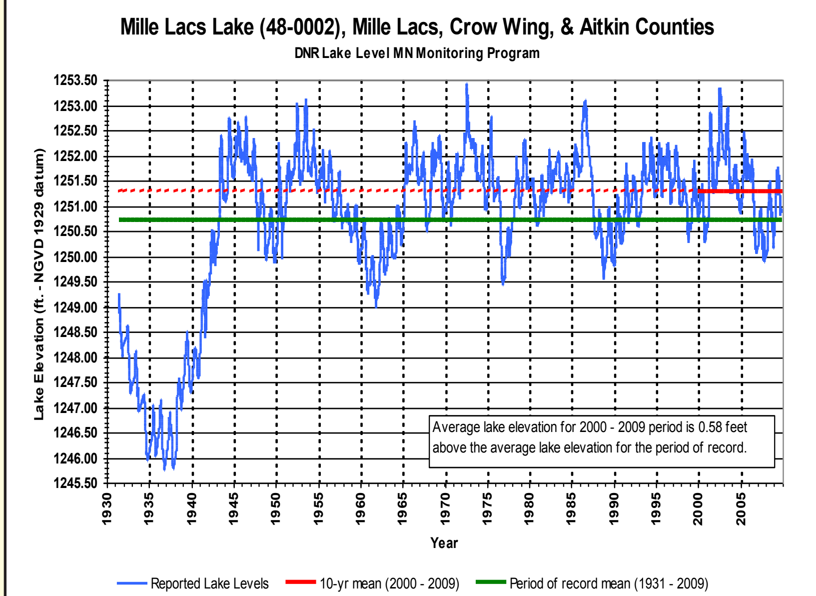
On **Lake Vermilion**, Minnesota's fifth largest lake, the last half of the 2000 - 2009 decade has seen large annual lake level fluctuations between spring and fall, a common pattern in a majority of the years of lake records. Years of little annual lake fluctuation, such as 2000 and 2003, are relatively uncommon.

Otter Tail Lake, the largest lake in Otter Tail County, is part of the Otter Tail River chain of lakes. Although the lake has a maximum depth of 120 feet, over 50% of the lake is less than 15 feet in depth. In response to the high precipitation as seen in the climate maps, the lake experienced very high and sustained levels in 2009, well above the 10-year and total record averages. This is also reflected in the stream flow map.

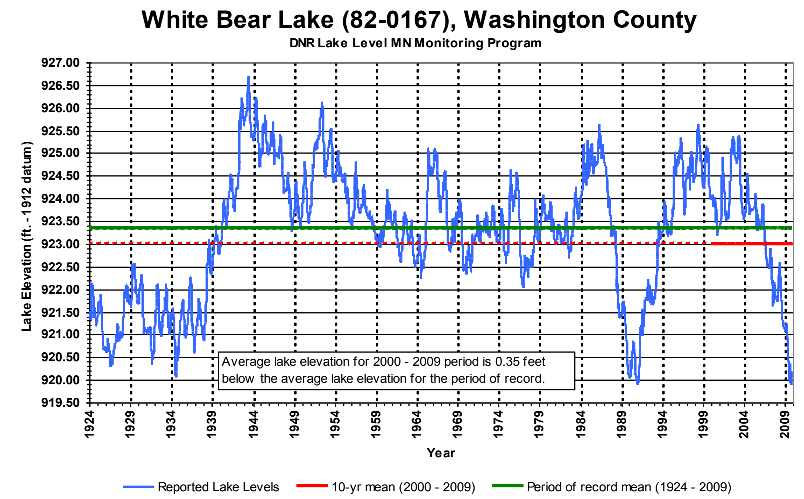
Although most changes in water level in **Lake Mille Lacs** are influenced by usual weather patterns, the lake is also affected by a 1953 fixed-crest spillway and fluctuations caused by seiches, which are large waves or storm surges. For this decade, the maximum level was in 2002 affected by seiche action, and the lowest levels were during the droughts of 2007 and 2008. The dry 1930's era broke all records for low levels.



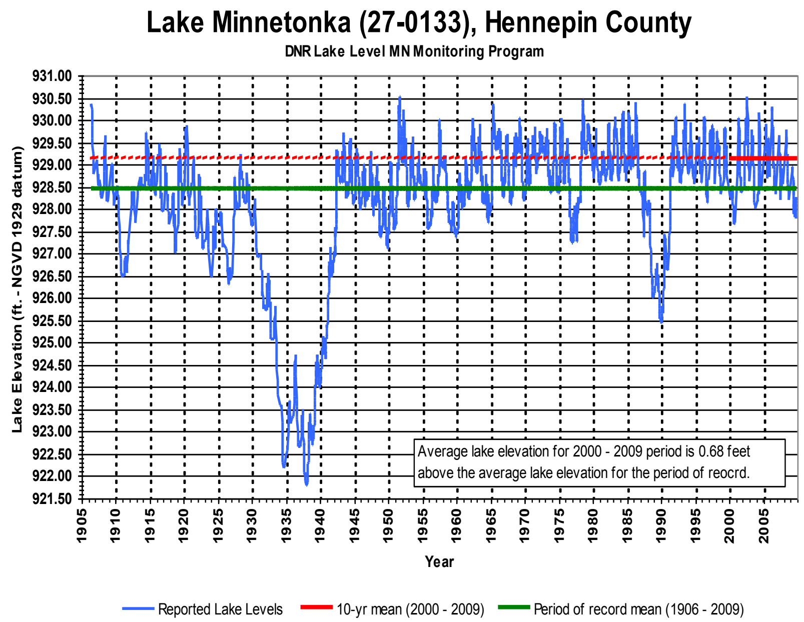




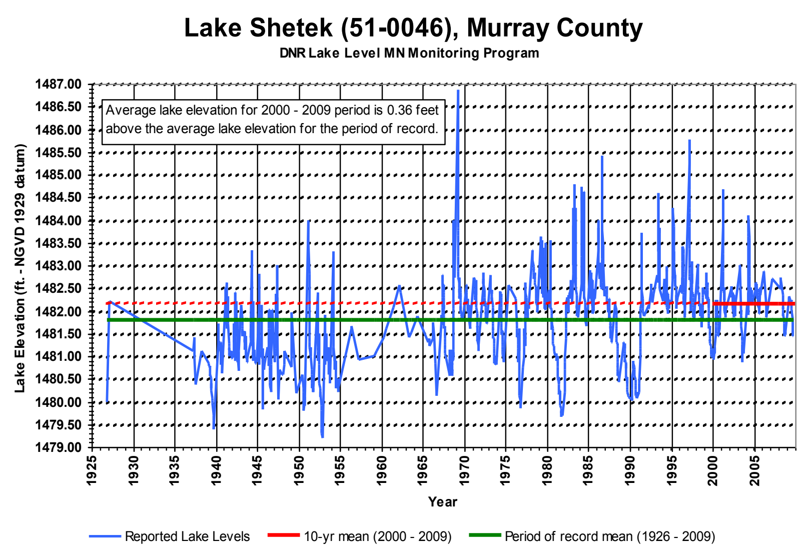
After high lake levels in the first few years of this decade, **White Bear Lake** has dropped almost 5.5 feet from Spring 2003 to Fall 2009. This area has experienced abnormally dry to severe drought conditions off and on during those seven years, according to the National Drought Mitigation Center. The decline resulted in the 10-year mean falling below the total record average. This is similar to the time when the lake dropped 5.6 feet from Spring 1986 to Fall 1990. Note that it took three years until 1993 for the lake to rise over 3 feet to a more average level. Over the long term, White Bear Lake levels are controlled principally by the region's groundwater level fluctuations, and in the short term by precipitation and runoff from a small watershed.



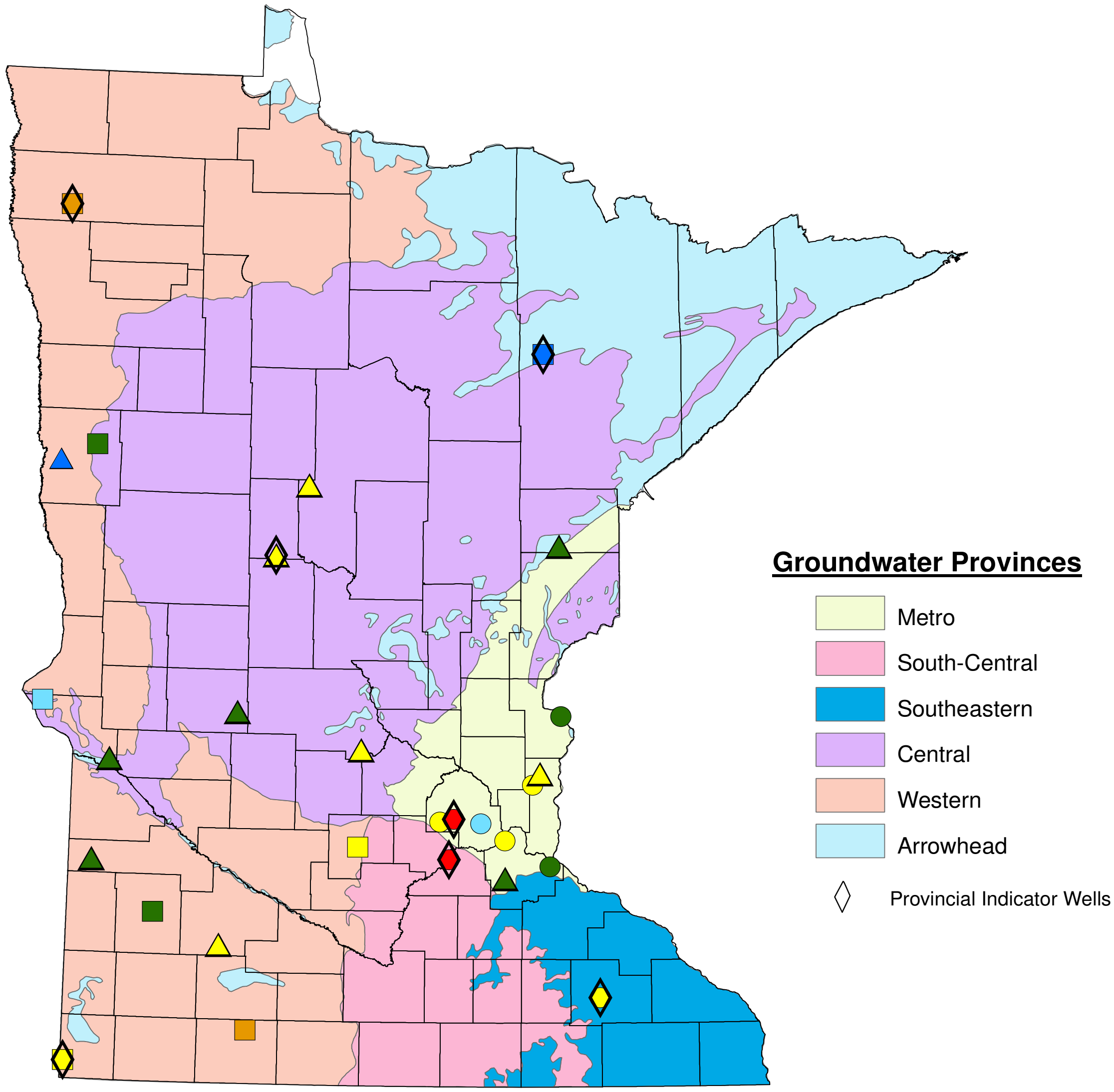
Lake levels and discharge have been controlled on **Lake Minnetonka** since 1897. In order to reduce flooding on downstream waters, water is stored from April to mid-June, and then released at a controlled uniform rate during summer and fall. The dam closes when the lake level is at 928.6 feet and below, as it did during the droughts of 2008 and 2009. Lake levels are affected by precipitation and runoff entering the lake, as seen by the last half of this decade during the dry seasons, as well as evaporation and controlled discharge leaving the lake.



With an average maximum depth of 10 feet, **Lake Shetek** is one of the largest lakes in southwestern Minnesota and the headwaters of the Des Moines River. The last half of this decade has shown a normal pattern around the average, with more extreme high bounces in the first part of the decade.



Groundwater



Aquifer

- △ Water Table
- □ Buried Artesian
- ○ Bedrock

Water Level

- High Water Levels (> 90% percentile)
- Above Normal Water Levels (75% - 90% percentile)
- Normal Water Levels (50% - 75% percentile)
- Normal Water Levels (25% - 50% percentile)
- Below Normal Water Levels (10% - 25% percentile)
- Low Water Levels (< 10% percentile)

* Percentile ranking based on last reported reading for the current month compared to all historical reported levels for that month. A water level ranked at zero means that the present reported level is the lowest in the period of record; a ranking of 100 indicates the highest in the period of record. A ranking at the 50th percentile (median) specifies that the present-month reported water level level is in the middle of the historical distribution.

Source data from: MN DNR Ground Water Level Monitoring Program

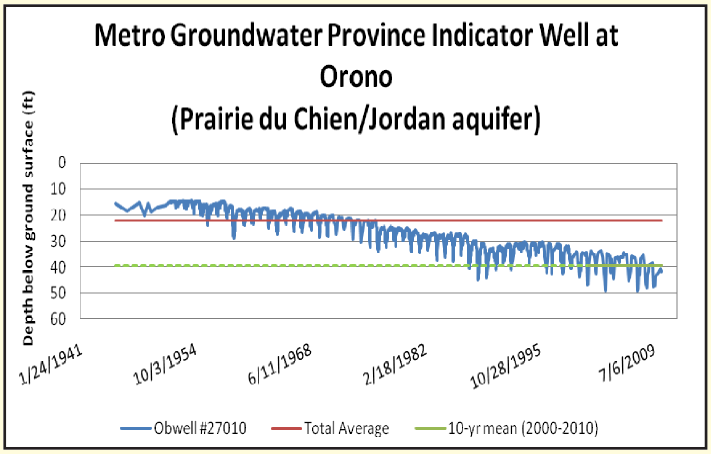
Groundwater Levels (2000-2009)

The ten year average water level was compared to the entire length of record for the well. A high value indicates that the average water level compared to the highest 90% of water levels measured in the well. A low value indicated that the average water level compared to the lowest 10% of water levels measured in the well. A map showing the wells and their water levels is presented in Figure X. Most of the wells show that the ten year average falls within normal water levels for the well which are levels between 25% and 75% of all of the water levels measured in the well.

Seven of the wells were selected as representatives of the six groundwater provinces in the state and hydrographs were produced for each well. The groundwater provinces are defined by the bedrock and glacial geology which control the availability of groundwater in each of the areas. These provinces are presented on the Figure below.

Province 1 – Metro Province

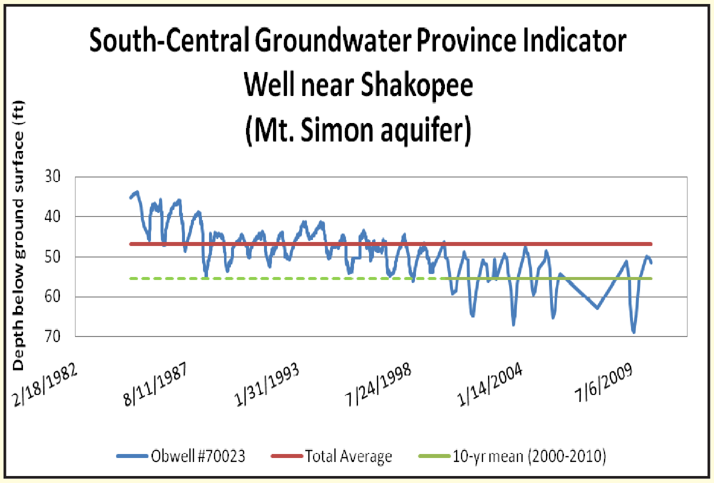
Water levels in the Prairie du Chien/Jordan aquifer, a major water supply aquifer showed an overall downward trend in water levels. The hydrograph also shows the cyclical change between the high summer water use and lower winter water use. In the past ten years, the swing between the high water levels of winter and the low water levels of summer has increased and appears to be greater than any time except for the 1988 drought.



Province 1 – Metro Province

Province 2 – South-Central Province

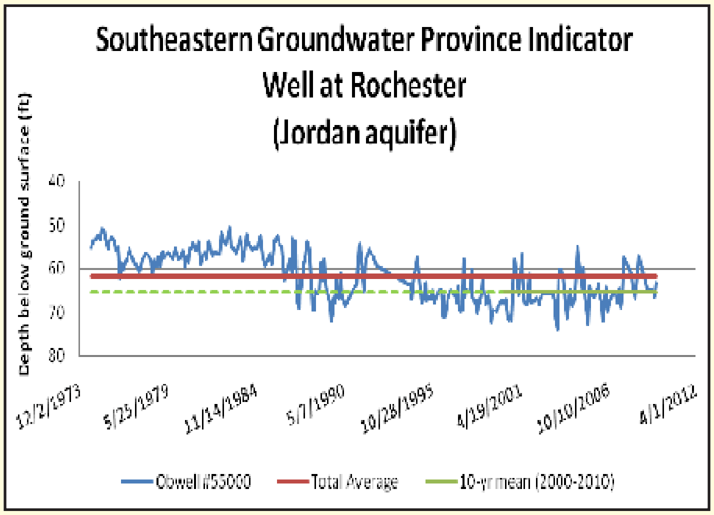
The indicator well in the Mount Simon, typically the deepest aquifer in the state and a water supply aquifer for a number of communities shows a continued decline in the water levels. The size of the seasonal cyclic changes in water levels continues to increase between summer and winter water levels.



Province 2 – South-Central Province

Province 3 - Southeastern Province

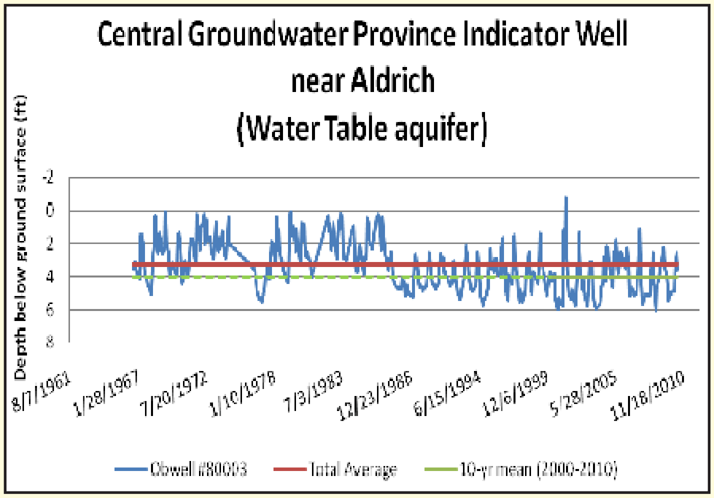
The indicator well in the Jordan aquifer also shows a slight downward trend in water levels since measurements began in the 1970s, although the water levels appear to have leveled in the past ten years. The past ten years also show winter/summer water level cycles similar in size to those in previous years.



Province 3 – Southeastern Province

Province 4 - Central Province

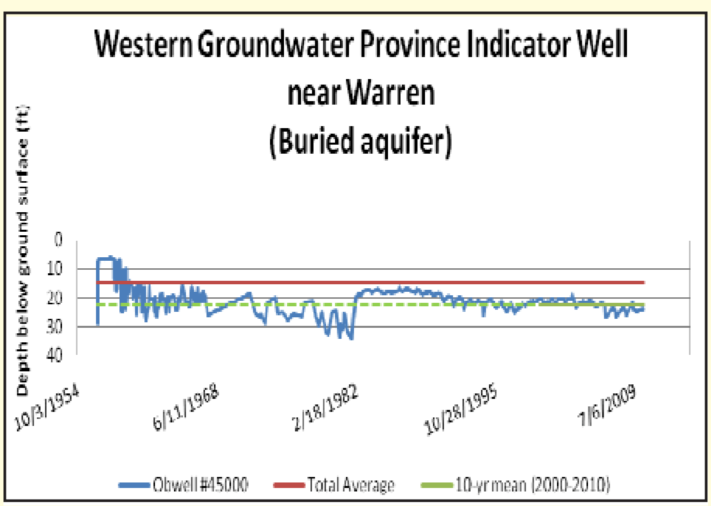
The water table aquifer in the Central Province is a major water supply for this part of the state. This area has a large number of irrigation systems which also use this aquifer. The water level in this aquifer has decreased since measurement began in the 1960s but appears to have leveled off in the past 20 years. However, the changes between winter and summer water levels have increased over the past ten years.



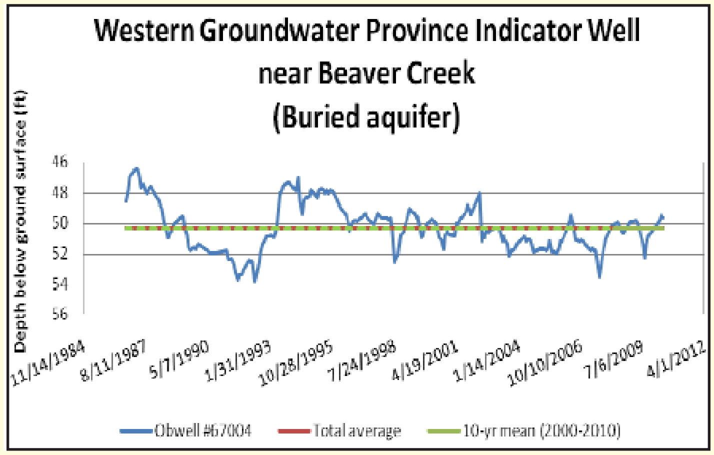
Province 4 - Central Province

Province 5 - Western Province

Two wells in the Western groundwater province were selected to provide a representative presentation of the province because of its size. These two wells are both buried aquifer wells. The northern of the two wells shows a downward trend in water level from the 1950s through the early 1980s when the water levels rose and stabilized. The past ten years has seen a slow downward trend in water levels, but not to the extent of what was seen in the past. The southern well shows a small downward trend in water levels. The past ten years does not appear to show any change in general water levels and there is no regularity in size or timing of the changes between summer and winter water levels.



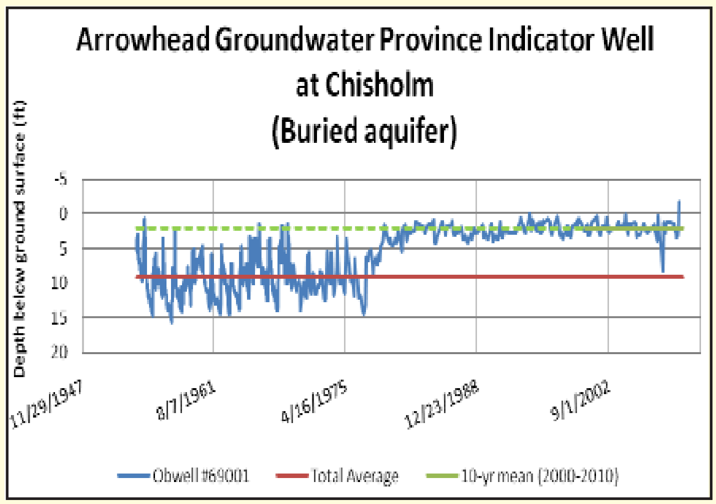
Province 5 - Western Province



Province 5 - Western Province

Province 6 - Arrowhead Province

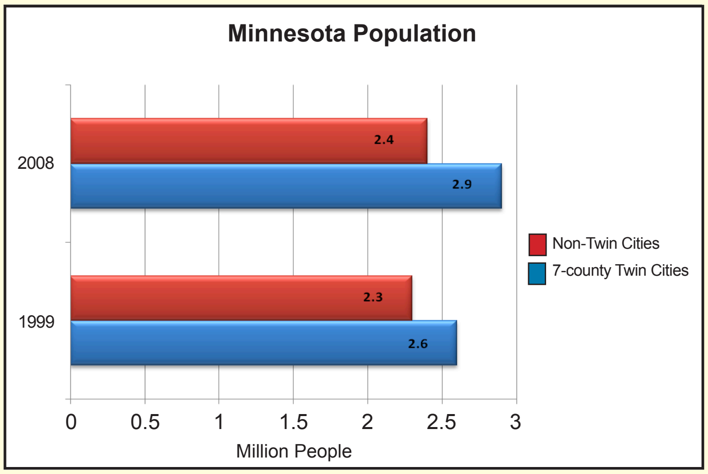
This well is a buried aquifer well on the border of the Arrowhead and Central Provinces. The well had large cyclical changes until about 1977 when the water level rose and leveled. In the past ten years, there has been little change in the general water levels or the seasonal changes measured in the well.



Province 6 - Arrowhead Province

Water Use

Minnesota DNR regulates water use to protect the long-term viability of the water resource for people and the environment. Water use permits are required from appropriators of more than 10,000 gallons per day or one million gallons per year. On an annual basis, monthly water use data is collected from these permit holders. This information is analyzed and compared with data from stream flow measurements, lake water levels, groundwater levels, and precipitation to give Minnesotans a picture of what is going on with the water resources of this state.

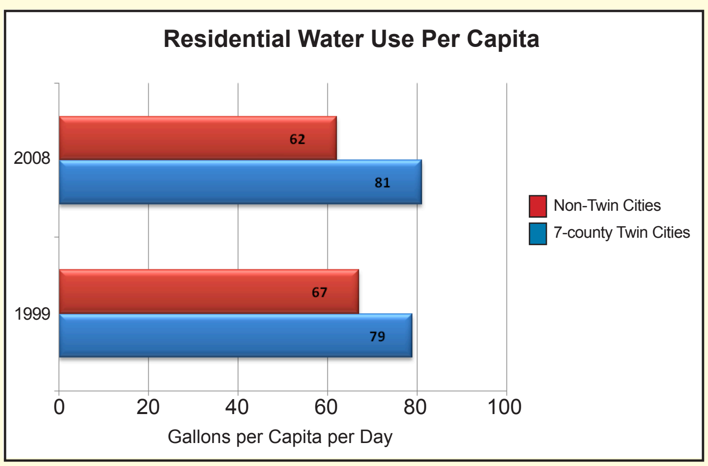


Minnesota Population. *Source: Estimates from the Minnesota State Demographic Center*

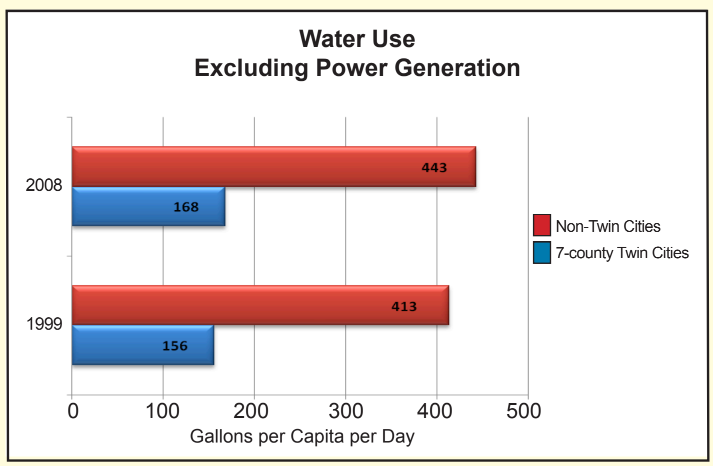
Overall, Minnesota saw water use increase by 77.6 billion gallons per year from 1999 through 2008 (excluding water used for power generation). Residential water use accounted for about 4.8 BGY, or 6%, of the increase.

The 3 figures on this page illustrate population and water use comparisons between the 7-county metro area and greater Minnesota. Minnesota's population increased slightly during the 10-year period from 1999 through 2008, mainly in the Twin-Cities area. Public water suppliers report the volume of water used in their communities for household purposes (residential water use). Comparisons of these volumes to reported population served are shown in Figure "Residential Water Use Per Capita". Residential per capita water use* increased in the 7-county Twin-Cities area and decreased slightly outside of Twin Cities area. When all water uses ("all uses" includes industrial processing, irrigation, public water supply, and other uses except power generation) are distributed across Minnesota's population, the per-capita water use increased by 6% from 1999 to 2008.

* Residential water use volume does not include separate water uses below the regulatory threshold of 10,000 gallons per day or one million gallons per year such as is typical for private residential wells.



Minnesota Residential Water Use. *Source: Supplemental Inventory forms required by public water suppliers which tally total water use by customer category and population served. Output is the averaging of all suppliers (large & small). Note the quality of this information varies. Values are from averaging all reported information.*



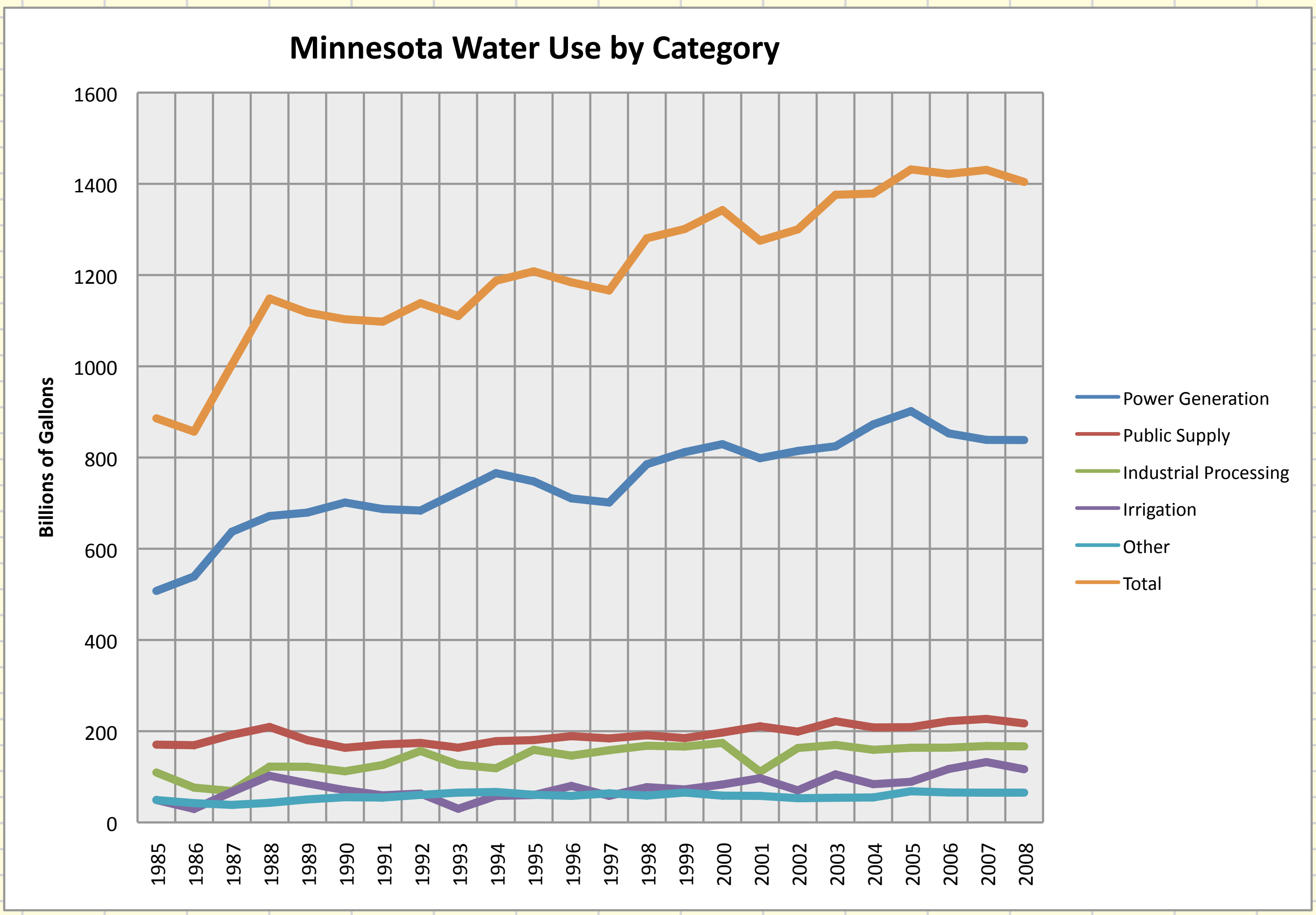
Water Use Excluding Power Generation. *Source: DNR Water Appropriation Permit Program water use reports maintained in the State Water Use Data System (SWUDS).*

Overall water use has risen from about 850 billion gallons per year in the mid 1980s when electronic water use data tracking began to about 1400 billion gallons per year in 2008. Over the 1999-2008 period water use increased by 103 billion gallons per year. The largest portion of water use is for power generation from surface water sources. This use is mostly non-consumptive, meaning that the water is returned to its source immediately after use. Public Water Supply and Industrial processing account for 68% of the non-power generation water use. Irrigation water use has increased over time with more acres regularly irrigated. Annual precipitation drives changes to irrigation demand on a yearly basis. Industrial processing water demand changes with the financial climate and the need to move water in the iron-mining areas of Minnesota.

Minnesota Reported Water Use in Billion Gallons

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Power Generation	508	539	637	672	679	701	687	684	725	766	748	710
Public Supply	171	169	192	209	180	164	171	174	164	178	181	189
Industrial Processing	109	76	69	122	122	112	126	157	127	119	159	146
Irrigation	49	30	67	102	86	71	59	63	30	58	60	80
Other	49	42	38	43	50	55	55	60	65	67	61	58
Total	886	857	1003	1148	1118	1103	1098	1138	1110	1187	1208	1184

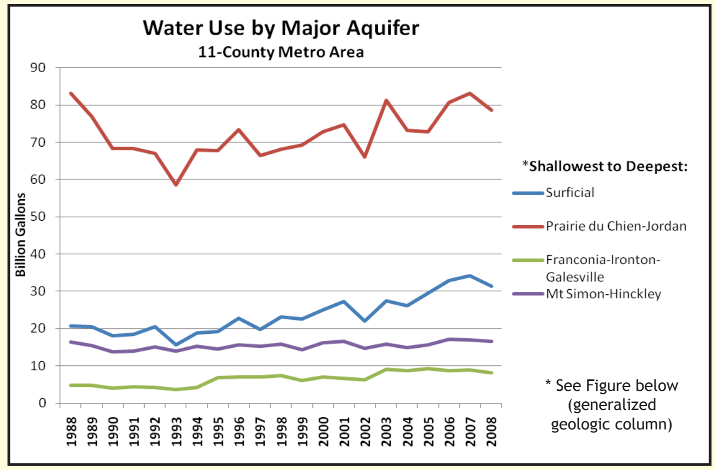
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Power Generation	701	785	812	829	798	814	825	873	902	853	839	838
Public Supply	184	191	185	197	211	199	222	208	209	222	227	217
Industrial Processing	158	168	166	174	111	163	170	159	164	164	168	167
Irrigation	58	77	72	83	97	70	105	84	89	117	132	117
Other	64	59	66	59	58	53	54	55	68	66	65	65
Total	1166	1281	1301	1342	1275	1300	1376	1379	1432	1422	1431	1404



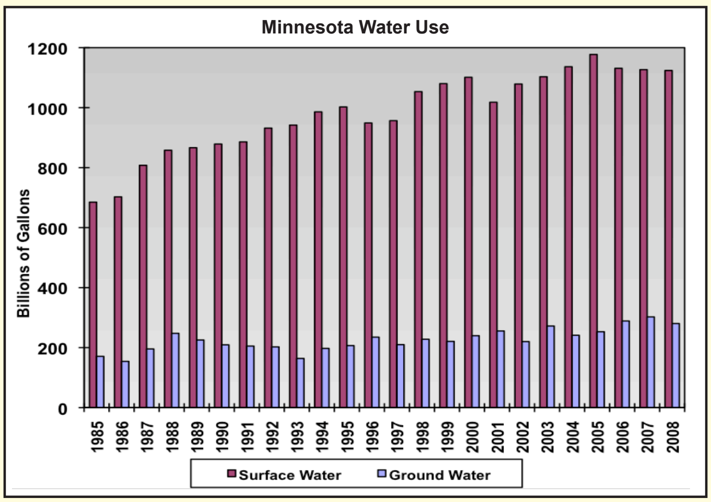
Minnesota Water Use by Category 1985-2008. Source: DNR Water Appropriation Permit Program water use reports maintained in the State Water Use Data System (SWUDS)

Surface water use has risen from 700 billion gallons per year in 1985 to 1100 billion gallons per year in 2008. Groundwater use has risen from 170 billion gallons in 1985 to 280 billion gallons in 2008.

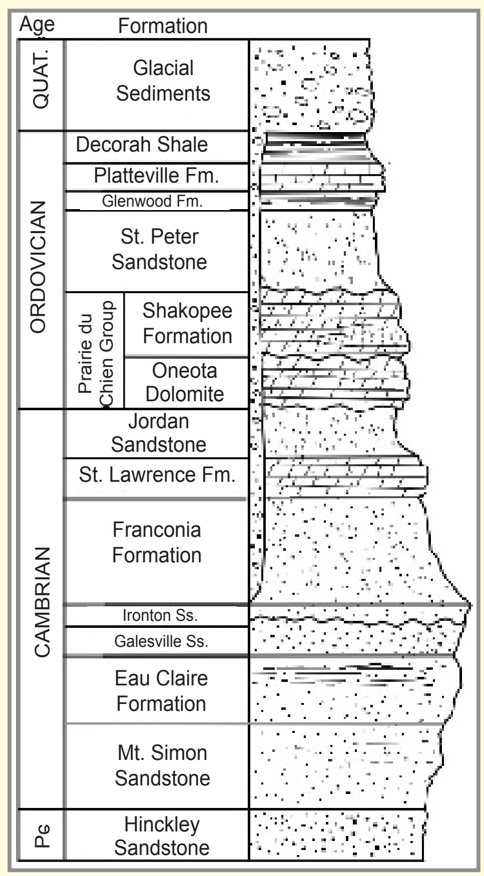
In the 11-county metro area, 4 principle aquifers account for 98% of groundwater use. The Prairie du Chien-Jordan aquifer is used for an average of 61% of the groundwater demand over the last 20 years. The surficial aquifers averaged 20% of the total groundwater use. The remaining water used came from the Franconia-Ironton-Galesville and Mt Simon-Hinckley aquifers. The largest increase in use over the 20-year time period was from the Prairie du Chien-Jordan and surficial aquifers.



Water Use by Major Aquifer. *Source: DNR Water Appropriation Permit Program water use reports maintained in the State Water Use Data System (SWUDS). Multi-aquifer wells were evaluated and water use assigned to individual major aquifer by the method described in US Geological Survey Water-Resources Investigations Report 83-4033. Two percent of known water use was either from an unknown aquifer source or other minor sources omitted from the graphic.*



Minnesota Water Use: Surface Water and Ground Water.
Source: DNR Water Appropriation Permit Program water use reports maintained in the State Water Use Data System (SWUDS).



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

Water Resource Summary

- Over all the average precipitation was higher over the last ten years when compared to the historical average and markedly higher in areas of the northwest part of the state.

- Generally, indicator lakes and rivers responded to climatic conditions and reflect those conditions over the past ten years.

- Stream flows were higher than the historical average in the western half of the state and slightly below average in the east.

- Indicator lakes across the state were slightly higher than the historical average with the exception of White Bear Lake, a groundwater influenced lake.

- Generally groundwater levels in water table and buried artesian indicator wells are in the normal range when compared to historical average.

- Seasonal fluctuations in some indicator wells were greater in recent years when compared to historical fluctuations indicating seasonal use of the resource is increasing.

- Deeper aquifers in metropolitan areas used for water supply continue to decline over time.

- In some areas the reliability of deep aquifers for water supply in the future may be limited if the declining trend continues.

Previous Reports & Strategies for Water Management

The concerns, strategies and conclusions found in "Minnesota's Water Supply: Natural Conditions and Human Impacts" remain relevant today and are incorporated into this report by reference. The DNR has also laid out strategies to provide for the long-term protection of our surface and groundwater resources that can be found in our report found at:
http://files.dnr.state.mn.us/publications/waters/long-term_protection_surface_ground_water_201001.pdf.

The two reports referenced above and the table below were shaped and guided by present and past inter-agency input processes and reports, and through years of ongoing coordination and discussions with our many partners in water supply management. More recent reports, such as the Metropolitan Council's Master Water Supply Plan, EQB reports on Water Sustainability, and past reports on water availability required under Minnesota Statutes 103A.43 have continued to shape the direction DNR has taken with its responsibilities.

Previously Identified Strategies

Minnesota's Water Supply: Natural Conditions and Human Impacts (September 2000)	Long-term Protection of the State's Surface Water and Groundwater Resources (January 2010)
Water Supply Assessment	Enhance Data Collection and Sharing and Simplify Access to Data
	Answer Key Questions and Meet Key Information Needs
Partnership in Study and Protection	Deliver Up-To-Date Protection Tools and Recommended Best Management Practices
	Adopt Long-term Focus for Monitoring and Prevention Activities
Conservation and Restoration	Approach Groundwater and Surface Water Management and Protection as a Comprehensive System
	Provide Adequate Financial Resources
Regulation and shared responsibility	Encourage and Influence Local Engagement in Management, Prevention, and Demonstration Efforts

Conclusions and Recommendations

An increasing number of places in Minnesota are experiencing water supply problems related to inadequate supplies, unacceptable quality or both. Our past management systems were designed around managing the impacts of an individual project to prevent it from creating unacceptable impacts to our natural resource systems. We have been largely successful in this endeavor. The challenge for all levels of government, as we move forward, will be adapting to understand and manage the impacts from the collective actions of all land use and water supply management decisions on the public, economic and environmental health.

In some places we are seeing water availability problems. We are using water faster than it can be replenished by diverting water from natural discharge zones or lowering water levels in aquifers. In some areas our land use choices are contaminating our water supplies, and we have so greatly changed the natural landscape that the ecosystem that remains is no longer able to provide its essential cleansing and recharge functions.

Minnesota's climate, on average, provides us with an ample supply of water. We are improving our networks for understanding precipitation patterns, lake levels, and stream flow that enable us to manage surface water systems. We know far less about our groundwater system, and since approximately 75% of Minnesotans depend on groundwater systems and dependence is increasing, we will need to know more about these systems in the future. Additionally, we will need to have a better understanding of the surface and groundwater relationships to the health of our ecosystems. To begin to eliminate current problems and avoid future water availability problems, we must improve our understanding and the quality of management decisions in the following areas:

1) We need to significantly increase our understanding of how water moves into, through and out of the earth beneath us.

2) We need to learn to reduce our withdrawal of water and promote the understanding that water captured by pumping has been diverted from discharge areas (springs, streams, lakes and wetlands) and taken from storage as evidenced by declining groundwater levels. We need to learn how much humans can take away from discharge areas without impairing ecosystem function and we also need to learn how to manage pumping water levels to reduce competition and conflict among water users.

3) We will need to manage land uses to ensure that water recharging our groundwater systems has had sufficient time or treatment to remove contaminants before entering subsurface flow pathways.

4) And finally, we will need to learn more about how our surface waters are dependent on groundwater systems for supply throughout the year so we can prevent undesirable impacts in lakes and wetlands, rivers and streams, and in natural and rare plant communities that all provide important functions toward the quality of life we have enjoyed in Minnesota.

In summary, industry, agriculture, housing, manufacturing, power generation, and well-managed public water supply systems are all necessary elements to nurture and sustain communities. To maintain all the natural resource features that contribute to Minnesota's attractive quality of life, including fish and wildlife habitat and recreational opportunities, each growth and development decision needs to include consideration of its effect on the water supply and associated water resources. Careful consideration of the effect each use may have on the available water supply is essential for the sustainability of the water supply and the water supply's ability to be recharged for future growth, development, and enjoyment.

In order to ensure the future of our water supply, thoughtful water supply management, including conservation, restoration, study, and protection must be practiced. Only in this manner will Minnesotans continue to wisely control their water resource destiny.