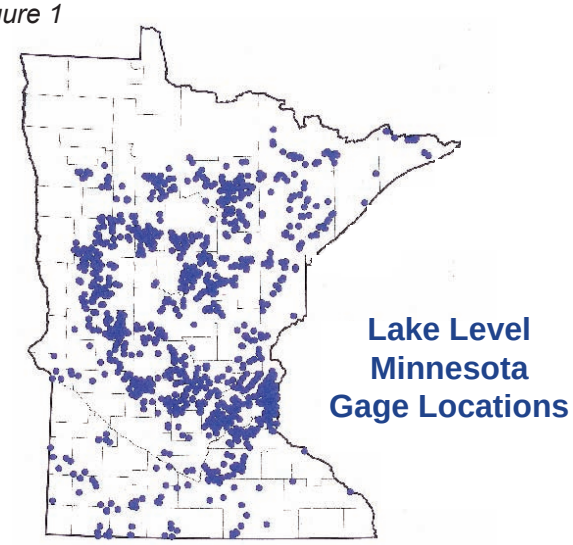
Lake Levels

Introduction

The Lake Hydrology Program exists to support the DNR Waters director and staff by collecting and providing data on lake levels and other lake characteristics that are needed to effectively carry out DNR Waters' statutory responsibilities and management programs.

A key component of the Lake Hydrology Program is the development and maintenance of the Lake Level Minnesota Monitoring Program. The Lake Level monitoring program primarily uses both temporary (movable) and permanent lake gages as indicators for measuring and determining the water surface level of certain lakes. A network of about 1000 lake gages is currently managed (Figure 1). The program relies on over 800 citizen volunteers and local government partners who record lake levels on a regular basis and submit the data to DNR Waters. Approximately 25% of the monitoring sites are managed currently under oral cooperative agreements with governmental units.

Figure 1



Data Uses

Water level data are used by DNR field staff as rationale for decision making in the public waters permit program and appropriations permit program. The records are used as supporting data for establishing ordinary high water levels and historic high water elevations, which are also the foundation for setbacks within the land use management programs. Lake level data support many DNR Waters hydrologic and hydraulic analyses. A consistent record of lake levels provides a long-term indication and understanding of the hydrology of the lake, watershed, and the relation between surface water and ground water. The information is crucial to surface water and ground water interaction studies for appropriations decisions. Long-term records show normal fluctuations, as well as the extreme highs and lows. Data are used to calibrate hydrologic models, especially applications for flood levels and lake outlets.

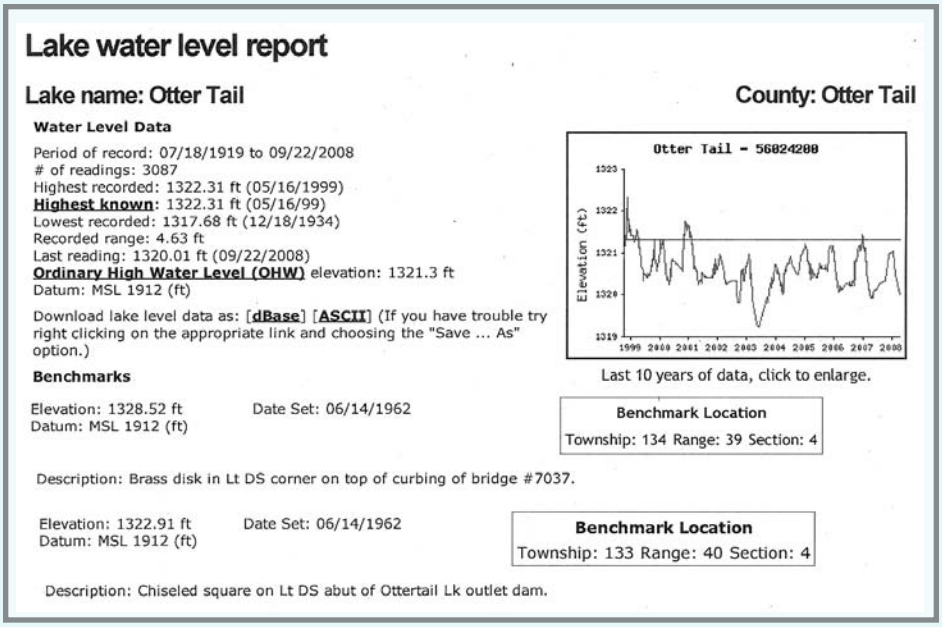
The data are used by local zoning officials for platting, locating structure sites, and for establishing low floor elevations for new construction. Watershed managers and planners use historical lake level data while preparing local water management plans and modeling lake water quality characteristics. Fisheries staff use data as one variable in studying impacts on habitat. Other researchers use the data for climate change studies. Water level data are used for decisions by lakeshore owners on dock location/timing, vegetative shoreline protection, and understanding the natural fluctuations of a lake.

Information Management

All lake level readings received are entered into Lakes-DB©, a database program for storing and retrieving a variety of information on Minnesota's lake basins. Over the last few years, the millions of items of information have been migrated from a stand-alone database to an updated web application.

The DNR Lake Finder web site is the best means for the public to access available data on more than 4,500 Minnesota lakes relating to lake water levels, fisheries information, lake area and maximum depth, depth maps, water quality and clarity, air photos, and topographic maps. After searching by county, lake name, or identification number for a particular lake, a click on the word, "go," below "lake water levels/ruler" displays the Lake Water Level Report page. This report contains information, including:

- reported historical and current lake levels
- period of record and number of readings
- highest recorded lake level
- highest known lake level
- lowest recorded lake level
- recorded range
- ordinary high water level [also shown as the red line on the 10-year graph]
- datum of the majority of elevations
- benchmarks
- most recent 10-year graph [X-axis Year tick mark references mid-year]



Lake water level report

Lake name: Otter Tail **County: Otter Tail**

Water Level Data

Period of record: 07/18/1919 to 09/22/2008
# of readings: 3087
Highest recorded: 1322.31 ft (05/16/1999)
Highest known: 1322.31 ft (05/16/99)
Lowest recorded: 1317.68 ft (12/18/1934)
Recorded range: 4.63 ft
Last reading: 1320.01 ft (09/22/2008)
Ordinary High Water Level (OHW) elevation: 1321.3 ft
Datum: MSL 1912 (ft)

Download lake level data as: [**dBase**] [**ASCII**] (If you have trouble try right clicking on the appropriate link and choosing the "Save ... As" option.)

Last 10 years of data, click to enlarge.

Benchmarks

Elevation: 1328.52 ft
Datum: MSL 1912 (ft)
Date Set: 06/14/1962

Benchmark Location
Township: 134 Range: 39 Section: 4

Description: Brass disk in Lt DS corner on top of curbing of bridge #7037.

Elevation: 1322.91 ft
Datum: MSL 1912 (ft)
Date Set: 06/14/1962

Benchmark Location
Township: 133 Range: 40 Section: 4

Description: Chiseled square on Lt DS abut of Ottertail Lk outlet dam.

Over 1,300 of the lakes have a historical record of more than 100 water level readings. In addition to the summary information, a Lake Finder user can retrieve and view all the reported lake elevations for a specific lake via the download of lake level data as dBase or ASCII from the center of the Lake Water Level report page.

Clicking on ASCII is the most common method used to view the water surface elevations and the date of the readings. The chronological water surface elevation data can then be viewed, saved, or highlighted and copied into a computer software spreadsheet for sorting and graphing. Check out how the levels of a chosen lake compare to other historic drought or wet years or other lakes.

Lake Levels

The primary factor that affects water level changes is the quantity and distribution of precipitation. Other factors that contribute to water level changes are soil moisture conditions, runoff, evapotranspiration, outlet conditions, beaver dams, human-made dams, ground water movement, and watershed characteristics and size (Figure 8, page 48).

The water levels of all lakes fluctuate dependent on their unique water budget - some more than others. A water budget is the sum of "incoming" resources minus "outgoing" resources. It is an estimation of the water resources available to "spend" or "save" and must take into account all available ground and surface water. Water enters the lake as precipitation, surface-water inflow, and ground-water inflow. Water leaves the lake as evaporation, surface-water outflow, and ground-water outflow *(see Hydrologic Cycle, page iv)*.

In a prolonged dry cycle, runoff and rain may be absorbed first by the soil and not contribute to lake levels. Knowing, understanding, and accepting the history of water level fluctuations can help lake users deal with expectations and problems associated with the changing levels.

Drought

"Pulled dock out August 28 - lake too low to get boat near."

"Water is 3 feet away from the lake gage."

"I haven't seen the lake this low since 1976."

"Super dry based on my 30 years of volunteer gage reading."

"Funny how we got rain, but it didn't seem to do as much as I thought it would have. No runoff from our watershed went into the lake."

"Think rain!!"

Comments like these from our volunteer readers illustrate the widespread drought in 2007 for the second summer in a row (Figure 2, page 40).

Rainfall totals for the summer were far short of the historical average in some locations in west central and central locales. In response to the lack of precipitation in 2007 and the effects of the drought of 2006, many lakes receded to low water levels. The list of counties with large areas reporting over 150 of their lowest lake levels by the end of Water Year 2007 grew longer and longer: Aitkin, Carlton, Carver, Cass, Hennepin, Kandiyohi, McLeod, Pine, St. Louis, Scott. Over 35 gaged lakes in Washington County reached their all-time lowest reported levels by the end of summer in 2007. Crow Wing and Itasca County lakes had the next highest number of gaged lakes with lowest reported levels in 2007. A number of gages had to be reset one to three times over the summer in deeper locations in order to capture any water level readings.

Water Year 2008 saw a prolonged dry spell for the third summer in a row for southern Minnesota, the Mississippi Headwaters, and parts of the northeast (Figure 3, page 41). Lakes in concentrated areas in Cass, Hubbard, Itasca, Washington, and Martin Counties reached their lowest historic lake level in the summer of 2008.

The 2008 drought areas were lessened by lowered temperatures in the summer, holding evaporation rates close to normal. Remarks by our volunteer readers were few compared to the previous two years of impacts on many gaged lakes. Less than 60 lakes reported their lowest lake level during the summer of 2008, a sharp contrast to the large numbers in 2006 and 2007.

Lake Level Responses

In contrast to the drought and areas of normal precipitation, other areas' significant rainfalls were reflected in lake level increases during the 2007-2008 Water Years (Figure 4, page 42). Rapid snow melt followed by above average precipitation for the first half of 2007 saturated the region in west central and northwestern Minnesota. A dozen lakes in Otter Tail County reported their highest water levels in Spring 2007. Only scattered lakes in the state reached their highest waters during that time, reflecting the effects of the drought. By the end of August 2007, many locations in the southern third of the state set all-time monthly rainfall records which helped restore low lake levels. One Twin Cities gage reader wrote, "Water, water everywhere! What happened to the drought?"

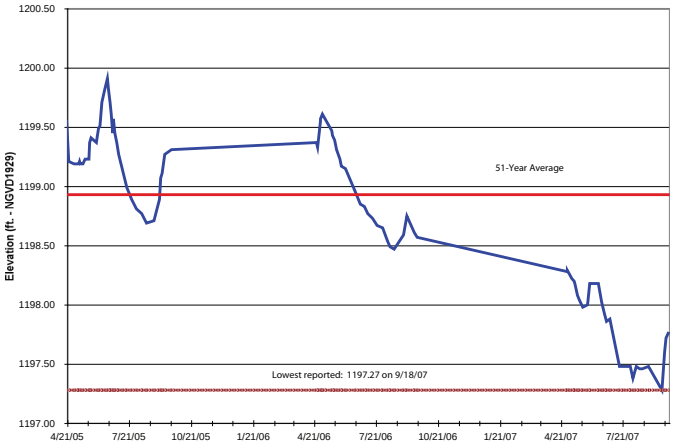
A strong weather system in early September 2007 dropped over six to nine inches of rain in the Arrowhead region, tripling historical averages for the month. Many of these same locations in the northeastern counties also had one of their wettest Octobers ever with similar precipitation totals. These cumulative rain events spiked lake levels to a number of highest reported levels in St. Louis County. A volunteer reported, "My dock is under water, and the lake is still rising."

(photo at left: Poplar Lake, Rockwood Lodge & Canoe Outfitters)

One of the most interesting fluctuations over a year came from our volunteer readers on Poplar Lake in Cook County. In May 2007, they apologized [without need!]for missing taking a gage reading during the Ham Lake fire. Early May had brought weather conditions that were highly conducive to dry conditions and spreading wildfire potential. There was some June recharge of their lake, but the lake levels quickly dropped below the gage by the end of August. The lake then received the double impact from historic rainfalls in both September and October as seen in the hydrograph in Figure 4 (page 42).

The influence of the Fall 2007 rains carried over into high lake levels for many St. Louis County lakes in Spring and Summer 2008. Climatology Office maps showed this area with more than 175% of normal precipitation through mid-June 2008. Lakes were kept high as that trend continued with close to 100% precipitation by the end of the summer.

Long Lake (77-0027), Todd County



Gilbert Lake (18-0320), Crow Wing County

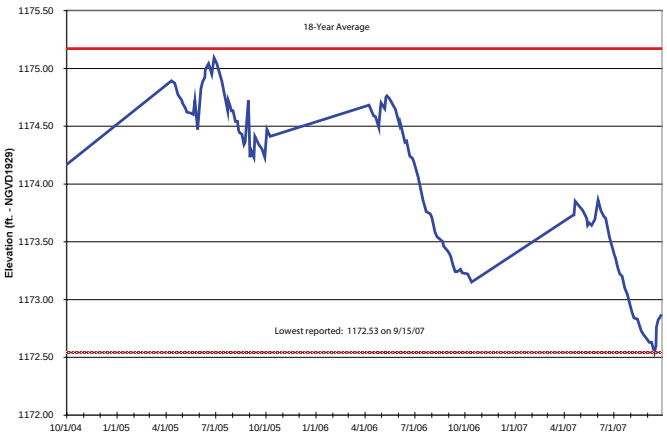
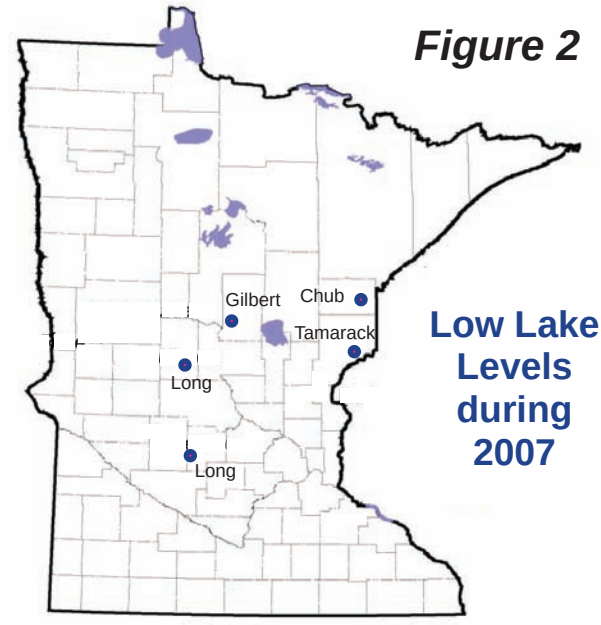
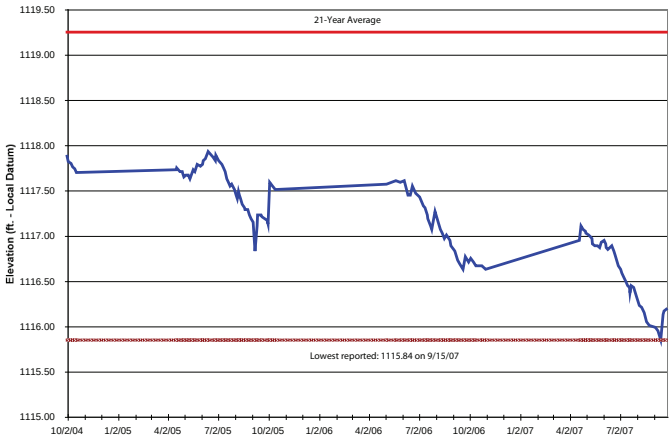


Figure 2

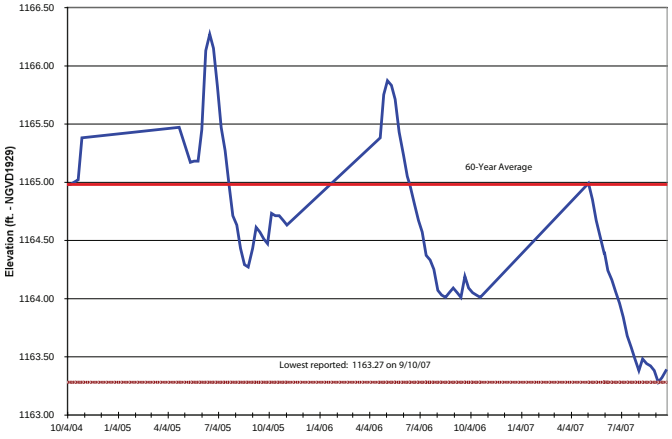


Low Lake Levels during 2007

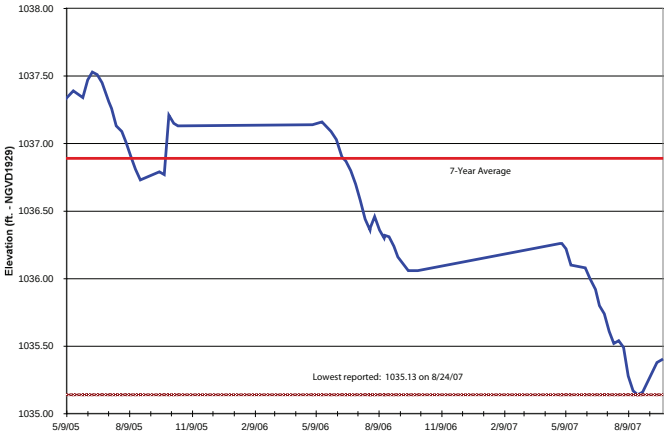
Chub Lake (09-0008), Carlton County



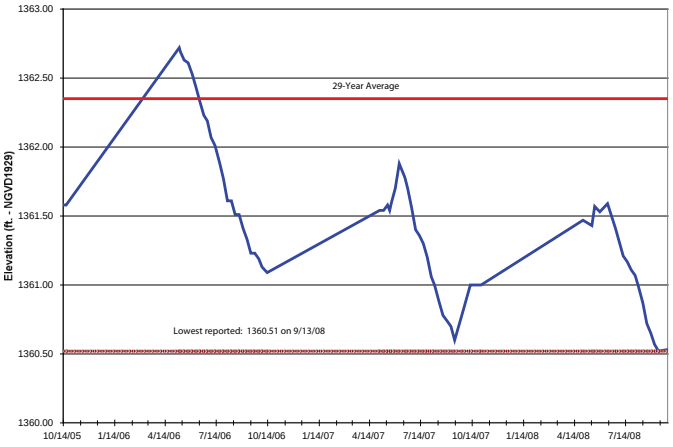
Long Lake (47-0177), Meeker County



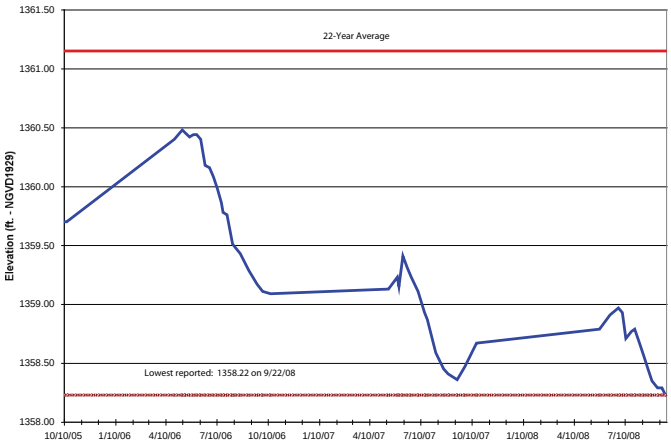
Tamarack Lake (58-0024), Pine County

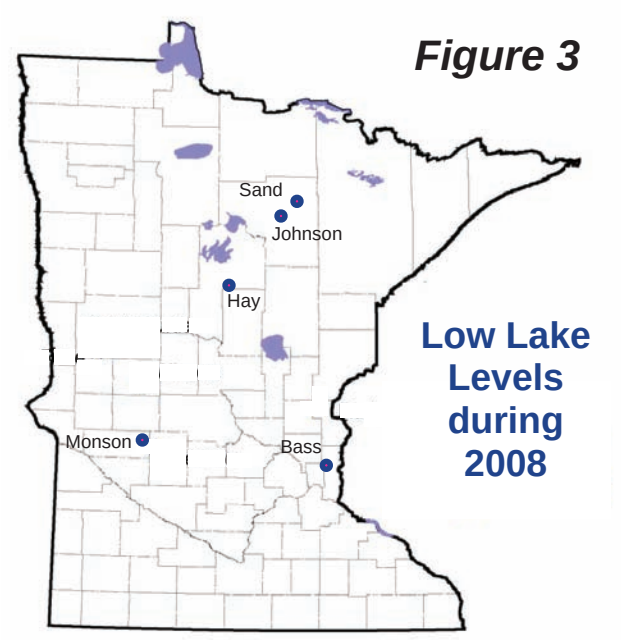


Johnson Lake (31-0586), Itasca County

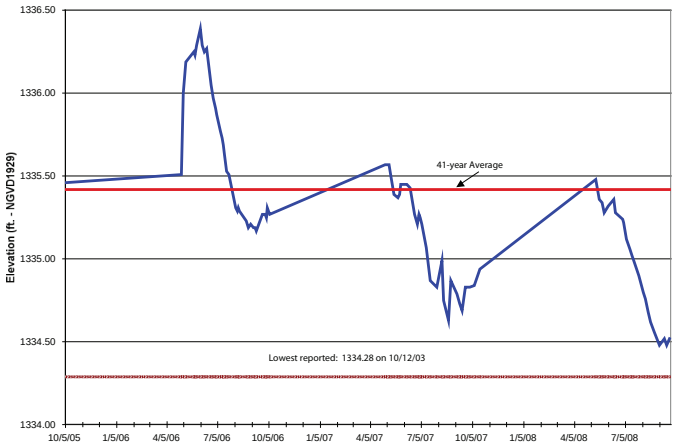


Sand Lake (31-0438), Itasca County

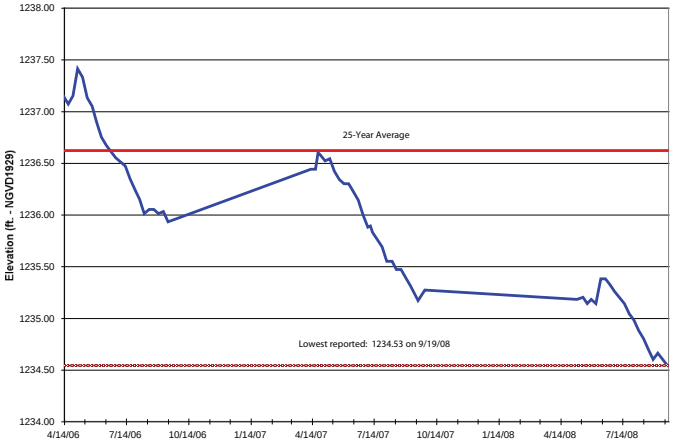




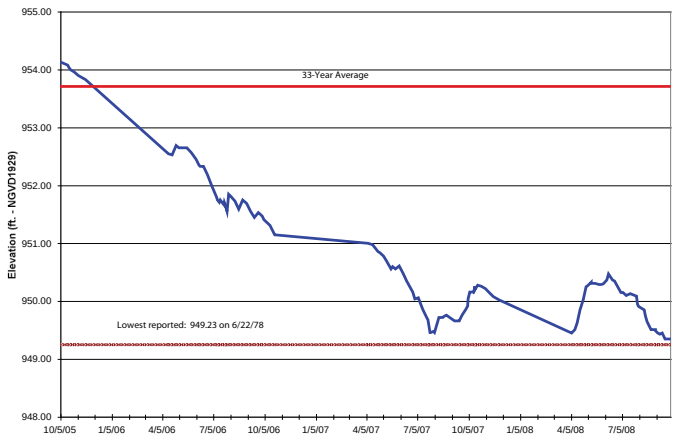
Hay Lake (11-0199), Cass County



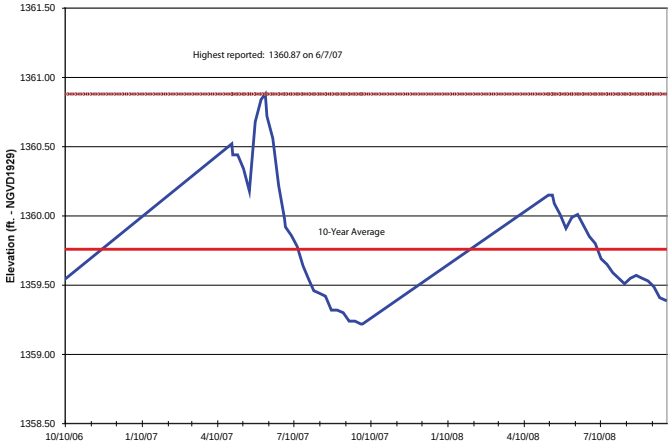
Monson Lake (76-0033), Swift County



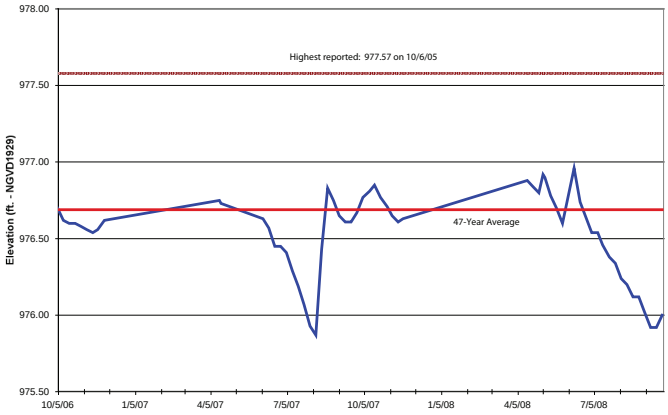
Bass Lake (82-0123), Washington County

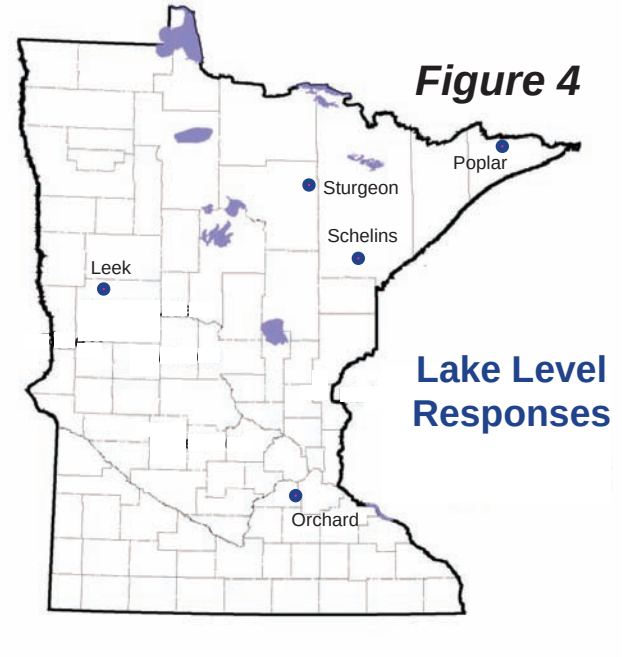


Leek (Trowbridge) Lake (56-0532), Otter Tail County
Spring 2007

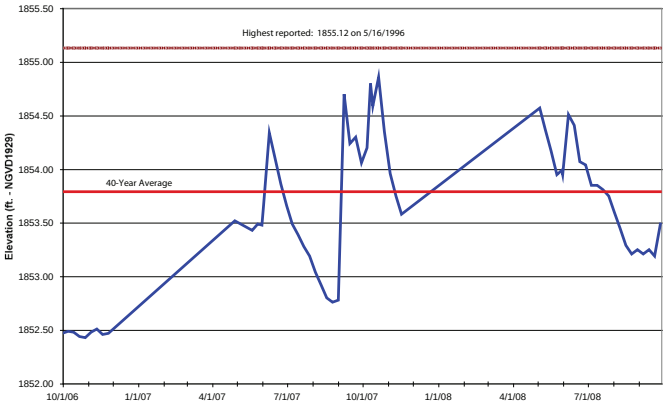


Orchard Lake (19-0031), Dakota County
Summer 2007

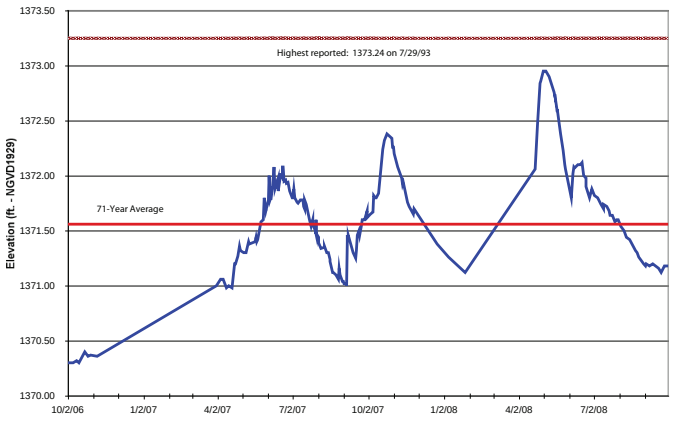




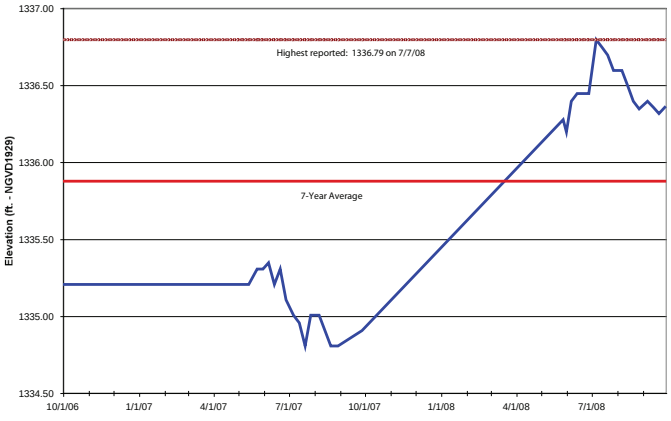
Poplar Lake (16-0239), Cook County
Fall 2007



Sturgeon Lake (69-0939), St. Louis County
Spring 2008

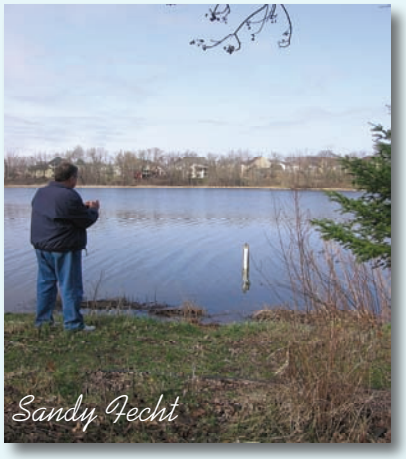


Schelins Lake (69-0624), St. Louis County
Summer 2008



Ten-Year Trends

Information has been collected and reported over a period of more than ten years for many of the lakes that are currently monitored. A ten-year average may be used as a point of reference when comparing water year data to a shorter or longer time period, or a ten-year climate cycle. It may be useful in discerning trends for an individual basin.


Sandy Fecht

A selection of lakes is shown in Figures 5 (page 45) and 6 (page 46). Lake Vermilion reflected the high precipitation for the Northeast in Fall 2007 and Spring 2008. Reported lake levels in May 2008 were some of the highest reported for Vermilion in our 58 years of records. Comparable spring levels can only be found in 1970 and 2001.

For these selected lakes, one lake remained below average during Water Year 2007 and most of Water Year 2008. Three of the lakes remained below their average throughout both Water Years 2007 and 2008. In Fall 2008, White Bear Lake reported its lowest level for the last 17 years. For more information from a past study of lake-ground water interaction at White Bear Lake following a drought, see this link.

Landlocked Basins

A landlocked lake has no regularly-functioning surface outlet channel, and usually a small watershed. These types of lakes typically experience large, long-term water level fluctuations. The importance of ground water contributions to a landlocked lake can make the lake a good indicator of local ground water levels and movement. Examples of landlocked basins are shown in Figure 7 (page 47). Some of these lakes also reflect responses to the dry conditions of 2007 and 2008.


Velma Wesloh

Annual Lake Level Fluctuation

Minnesota lakes typically fluctuate one to two vertical feet in a given year, but historical fluctuations have been recorded in excess of ten feet. Assessing the annual fluctuation can be done by looking at the changes from one Water Year to the next. Another primary evaluation tool is the "starting point," i.e. the elevation of the lake in spring, and how that compares to the end of the open water season and how that year compares to the "starting point," "end point," and pattern of other years. The lake levels and their patterns can then be evaluated in the context of historic climate data.

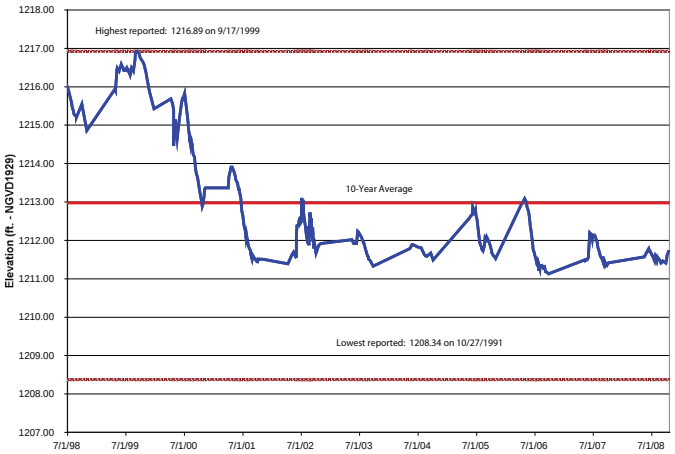
The statewide average fluctuation for Water Year 2007 was 1.24 feet, but decreased to 1.14 feet for the statewide average during Water Year 2008. Average fluctuations for the past ten Water Years are shown in the table on the next page. Link here to tables which display fluctuations, spring and fall elevations, ranges, reported highest and lowest lake levels and their dates, and averages for selected lakes grouped by county.

Additional summary information, ten-year trend graphs, and a comprehensive list of all reported lake levels for an individual lake may be found on the DNR Lake Finder web site.

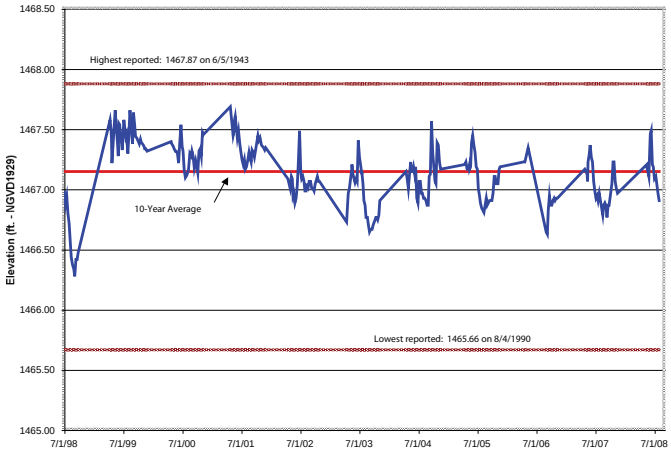
Water Year	Average Fluctuation Statewide (ft.)
1999	1.24
2000	1.05
2001	1.97
2002	1.33
2003	1.42
2004	1.24
2005	1.07
2006	1.29
2007	1.24
2008	1.14


Sandy Fecht

Union Lake (60-0217), Polk County



Lake Itasca (15-0016), Clearwater County



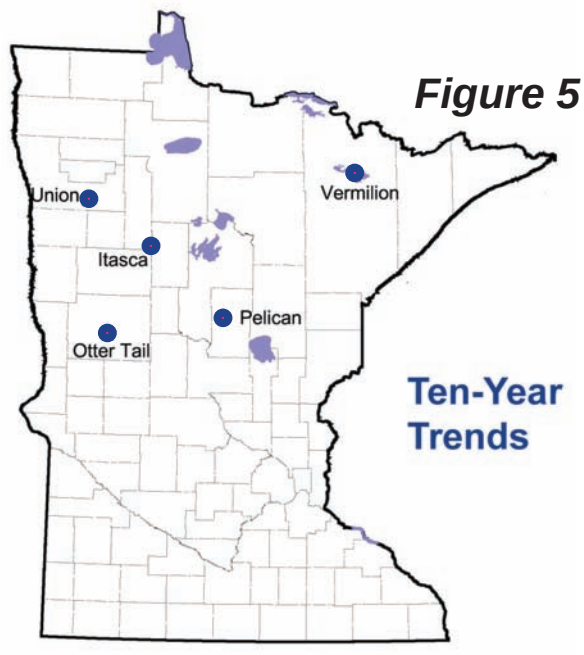
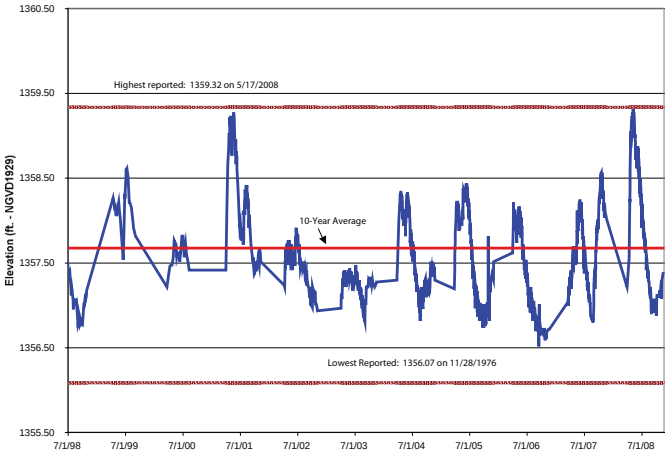
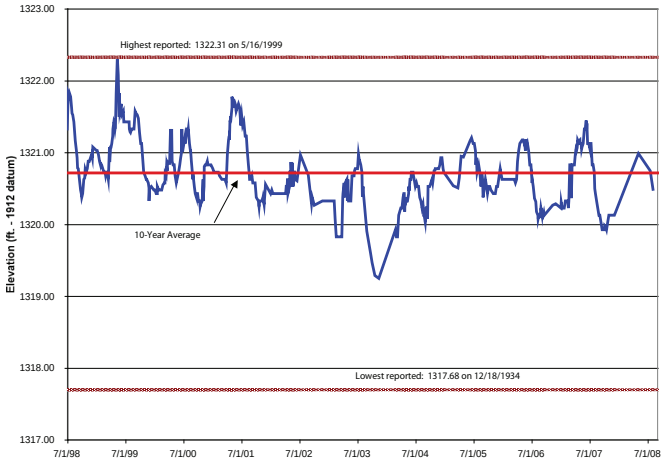


Figure 5

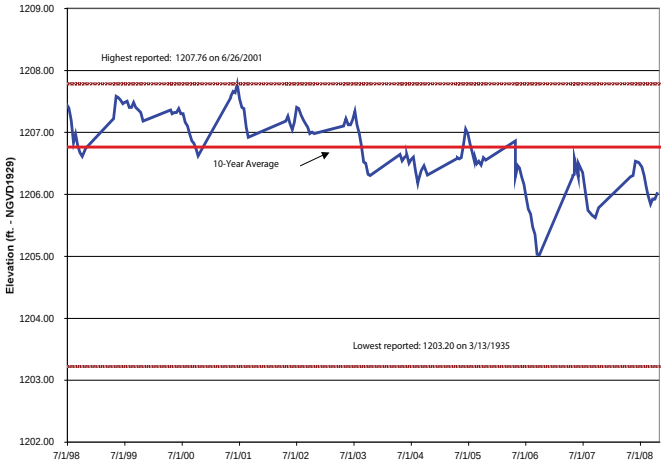
Vermilion Lake (69-0378), St. Louis County



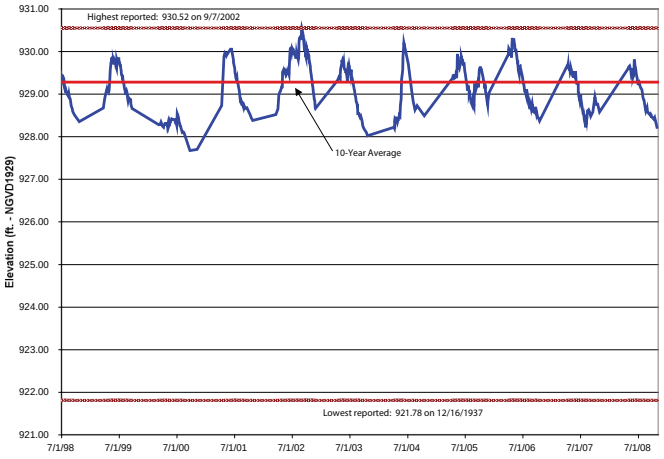
Otter Tail Lake (56-0242), Otter Tail County



Pelican Lake (18-0308), Crow Wing County



Lake Minnetonka (27-0133), Hennepin County



White Bear Lake (82-0167), Washington County

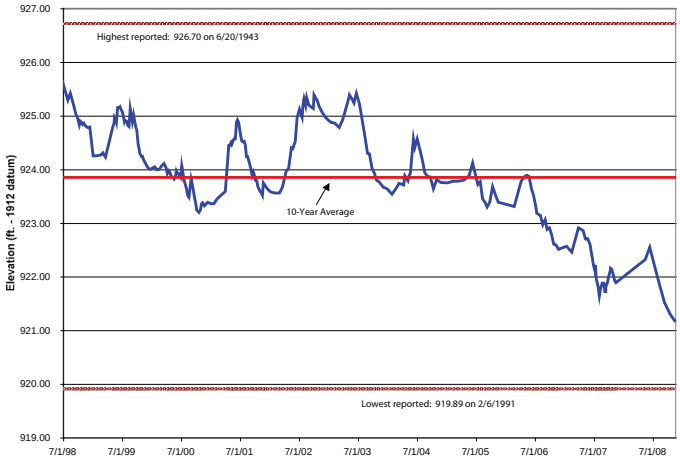
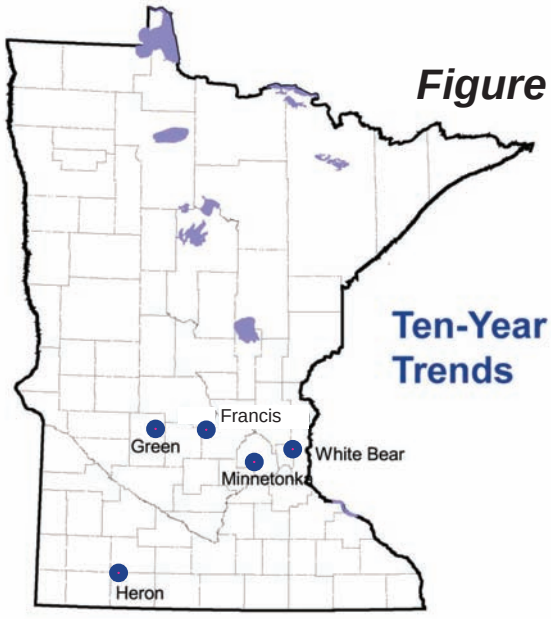
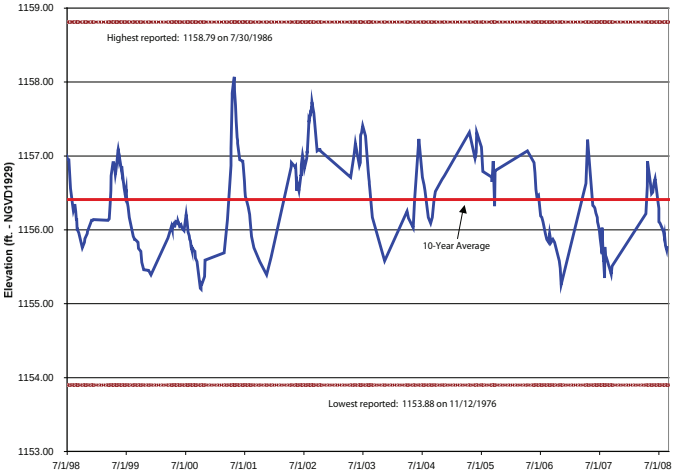


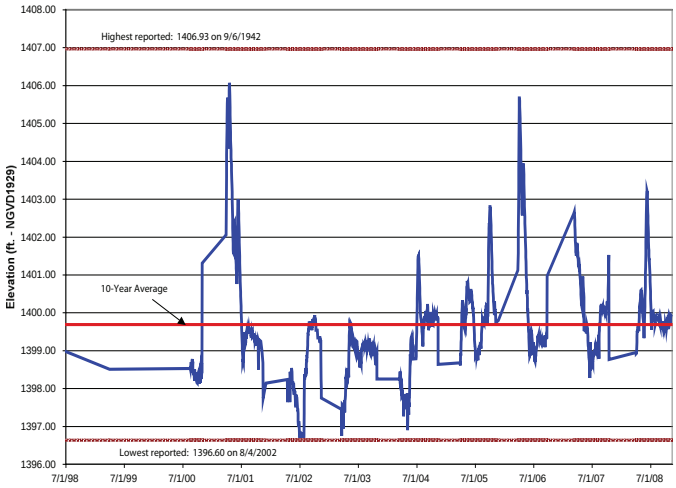
Figure 6



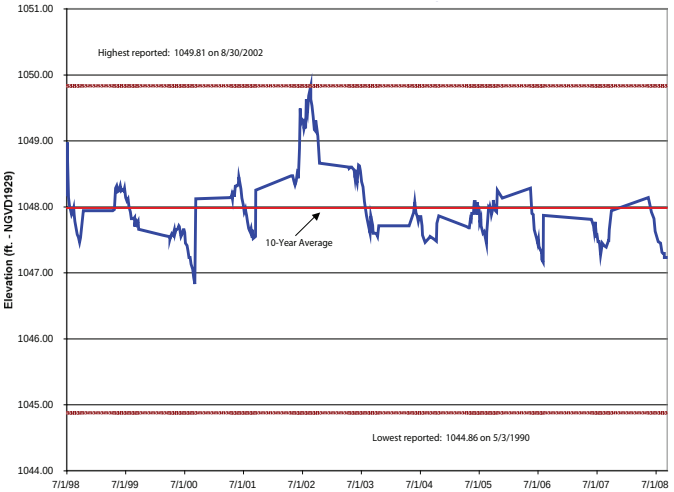
Green Lake (34-0079), Kandiyohi County



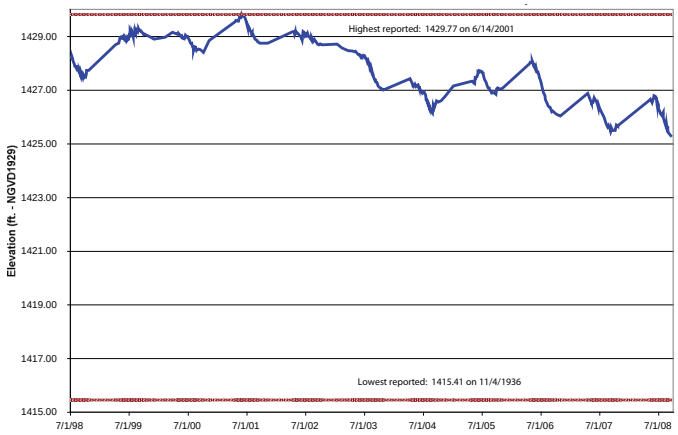
Heron Lake (32-0057-01), Jackson County



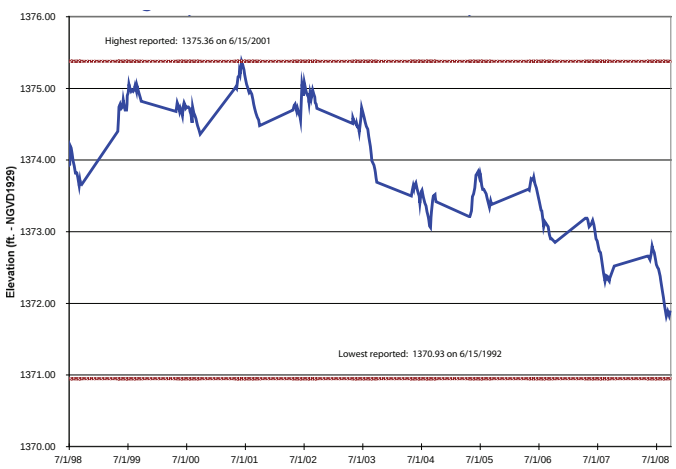
Francis Lake (47-0002), Meeker/Wright Cos.

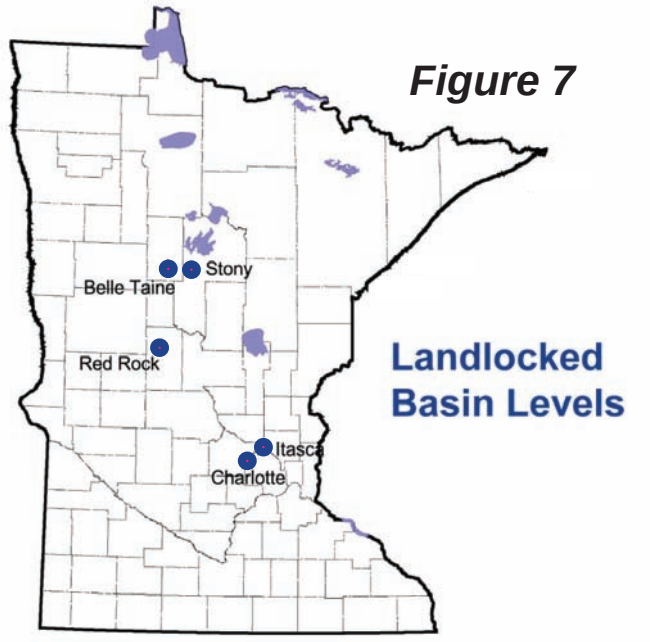


Belle Taine Lake (29-0146), Hubbard County

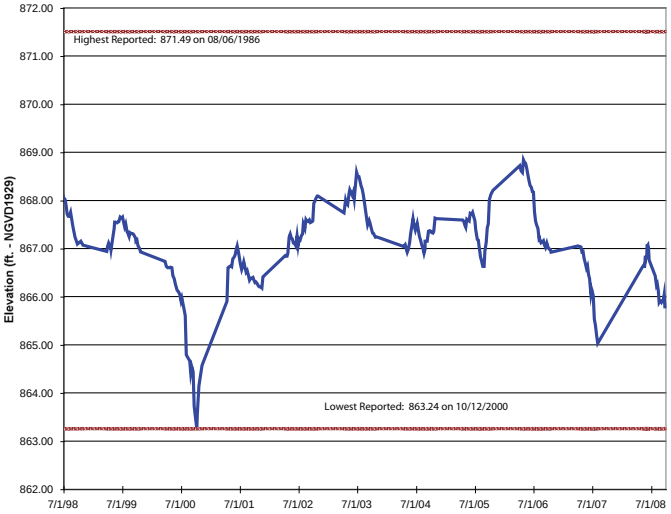


Stony Lake (11-0371), Cass County

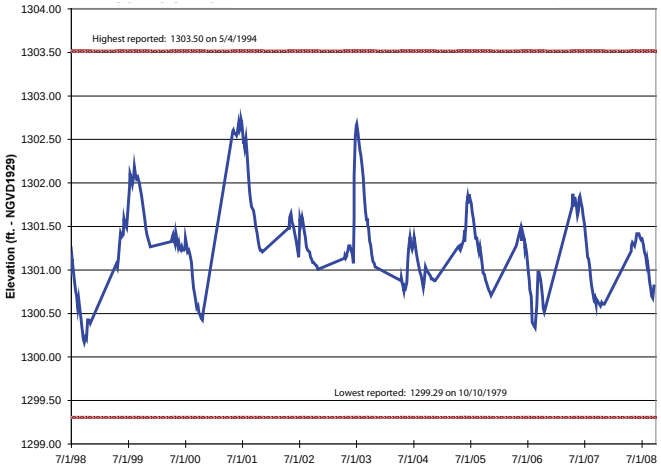




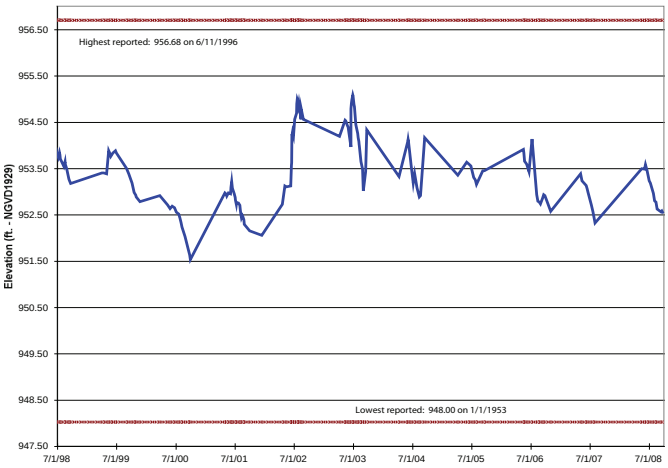
Itasca Lake (02-0110), Anoka County



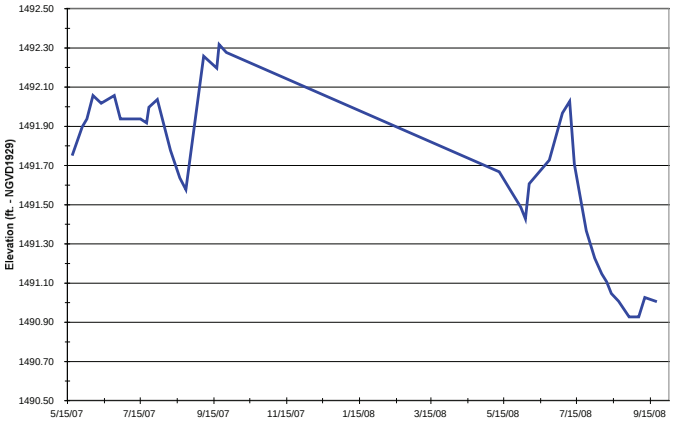
Red Rock Lake (21-0291), Douglas County

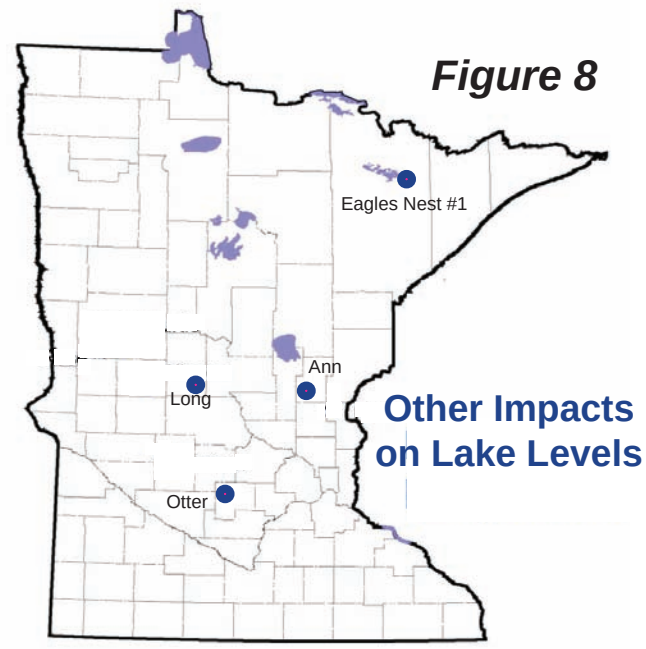


Charlotte Lake (86-0011), Wright County

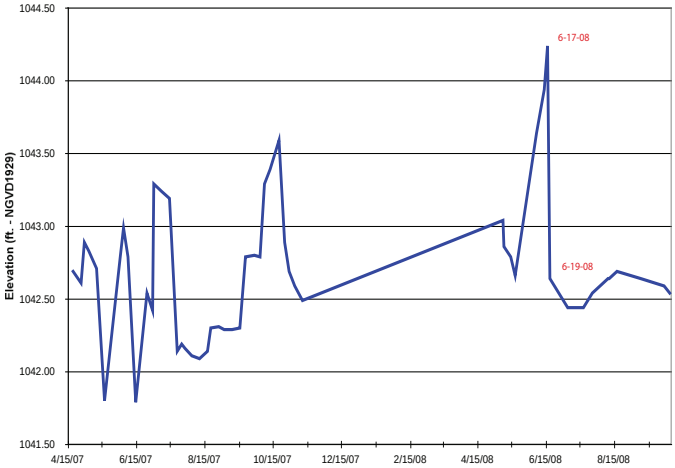


Eagles Nest #1 Lake (69-0285-01), St. Louis County
Beaver dams removed mid-July 2008

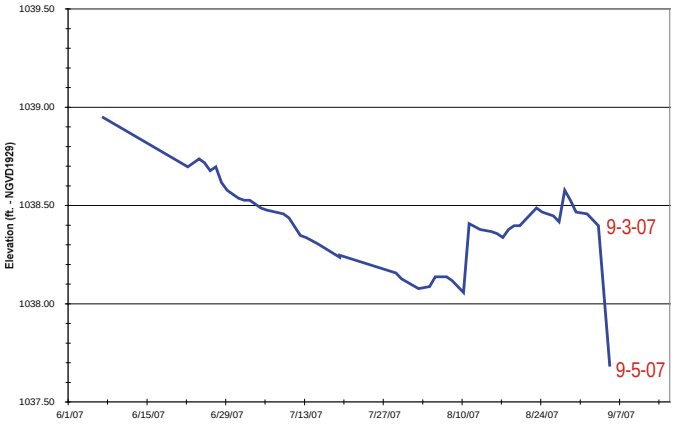




Ann Lake (33-0040), Kanabec County
Bog removed June 2008



Otter Lake (43-0085), McLeod County
Dam opened September 4, 2007 at noon



Long Lake (77-0027), Todd County
Heavy Rains during Fall 2007 & Outlet Plugged