POTENTIAL FOR LOW FLOWS ON THE UPPER MISSISSIPPI RIVER

The Upper Mississippi River provides the primary water supply for a number of major cities along its banks as well as commerce and recreational activities. The dry weather over the past year has raised concerns over the potential for critical low flow situations over the upcoming summer. This brief article provides a synopsis of what has happened in recent months, the current situation and the prospects for the upcoming summer. For brevity we will focus on St. Cloud and Anoka MN as representative locations.

So what has been happening?:

Figures 1 and 2 clearly show that the Mississippi River flows were well below normal throughout the summer of 2006. The river has returned to near normal levels this spring. The question becomes whether we can expect them to continue near more normal levels.

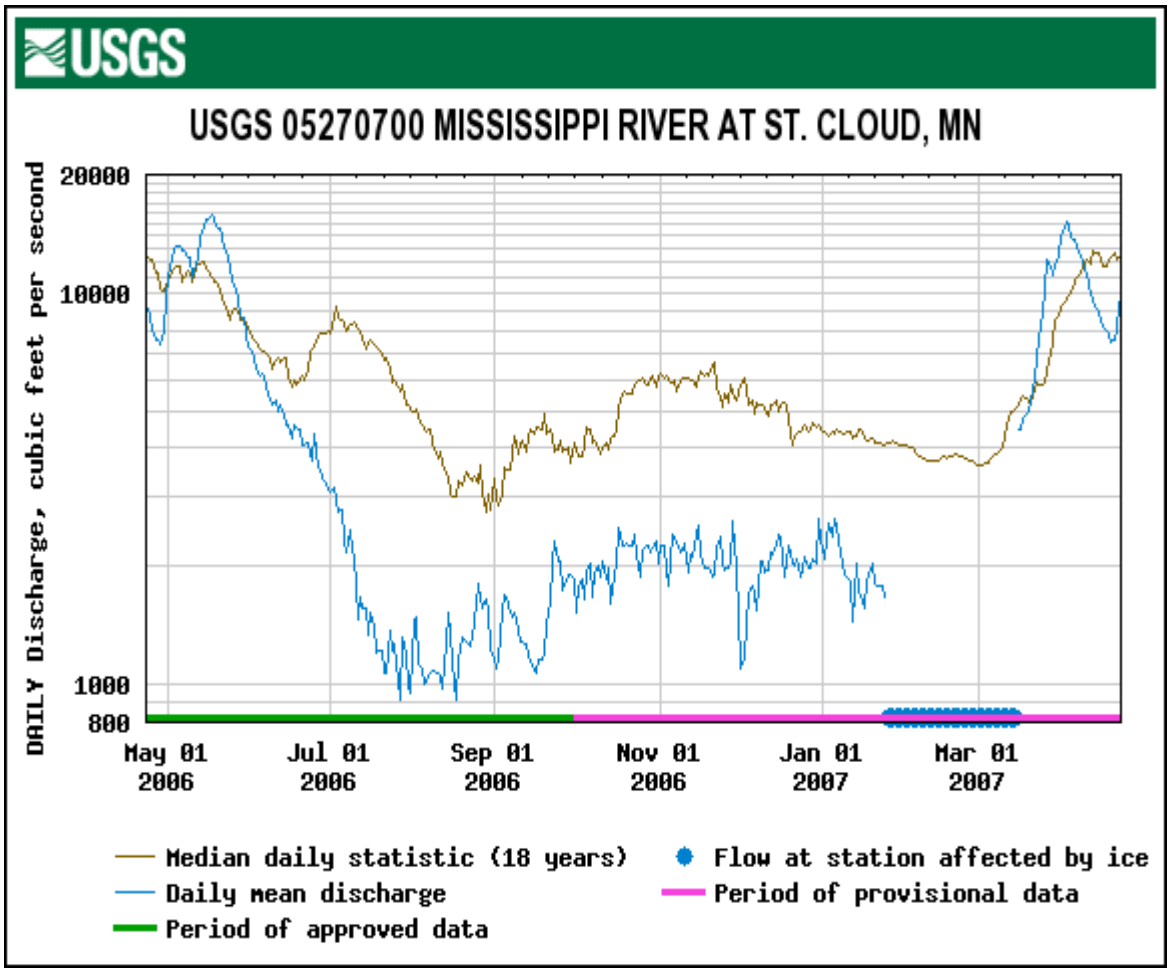


Figure 1: Daily mean flows in the Mississippi River at St. Cloud, MN. (graph courtesy of the USGS. Data for other locations available at http://waterdata.usgs.gov/mn/nwis).

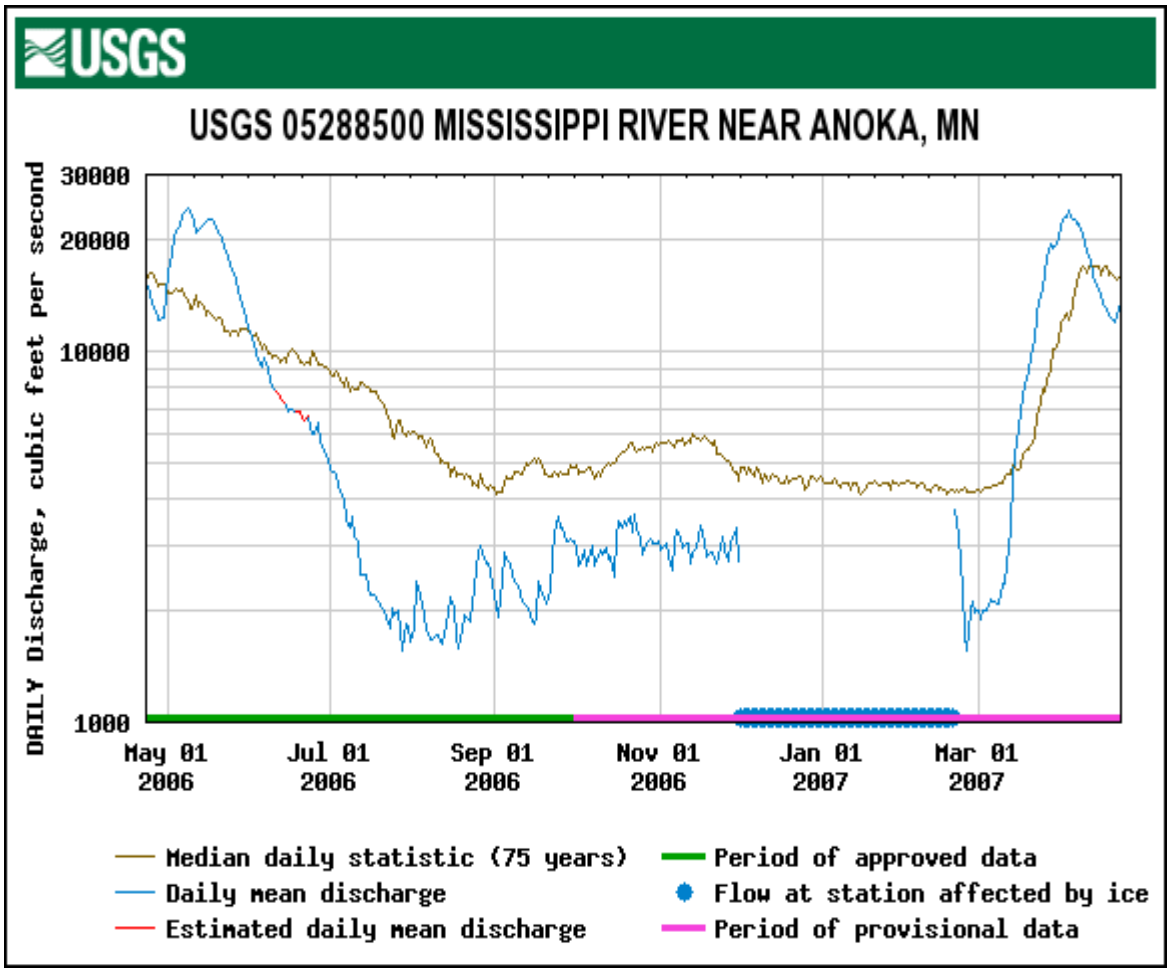


Figure 2: Daily mean flows in the Mississippi River at Anoka, MN (graph courtesy of the USGS. Data for other locations available at http://waterdata.usgs.gov/mn/nwis).

The low flows during the Summer and Fall of 2006 resulted from well below normal precipitation throughout much of the year. This is shown in Figure 3 entitled "Total Precipitation Percent of Mean from May 1, 2006 to December 31, 2006." Precipitation averaged 50 to 75 percent of normal over a major portion of northern Minnesota including the entire Mississippi River drainage area above Anoka. Below Anoka, precipitation was 75 percent of normal to near normal. The was also reflected over the Middle Mississippi River reaches over the winter months where low flows were a serious problem in many areas.

As noted earlier, there has been some improvement in river flows since the first of the year. The upper reaches of the Mississippi River basin have experienced well above normal precipitation since January 1st with the heaviest storms occurring in March and April. Figure 4 shows graphically that precipitation levels have been running 125 to 175 percent of normal, resulting in the return of flow levels in the river to near normal levels.

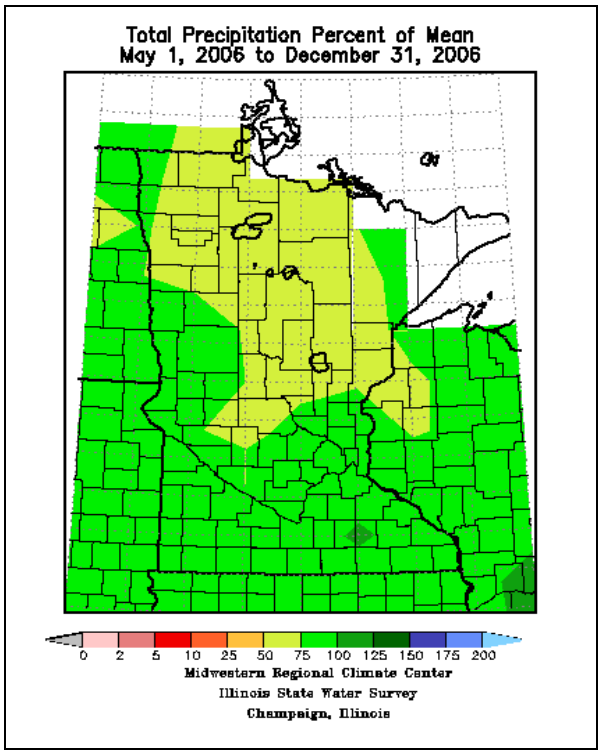


Figure3: Precipitation as a percent of the mean from May through December, 2006 and January through April 23rd, 2007. Image courtesy of the Midwestern Regional Climate Center.

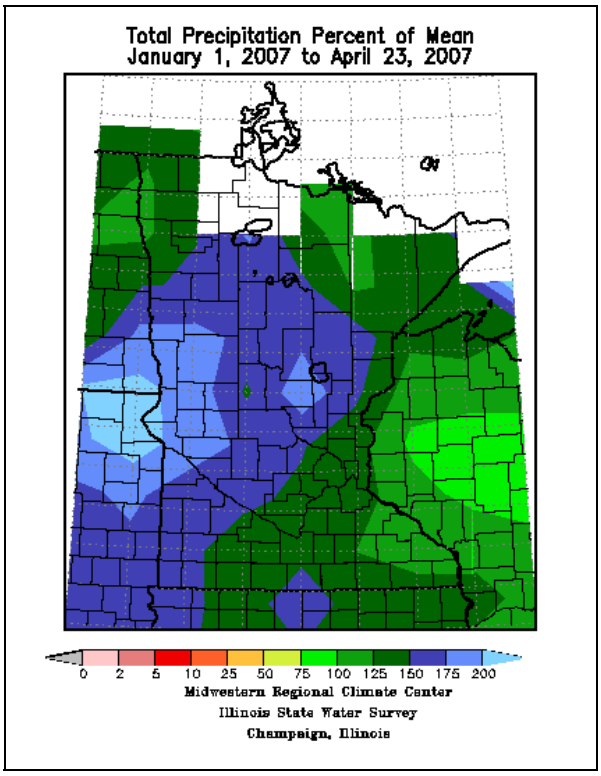


Figure 4: Precipitation as a percent of the mean from January through April 23rd, 2007. Image courtesy of the Midwestern Regional Climate Center.

The National Drought Mitigation Center's Drought Monitor Products also suggest that conditions are improving. Figure 5 shows that there has been a 2 to 3 class improvement over the past seven months.

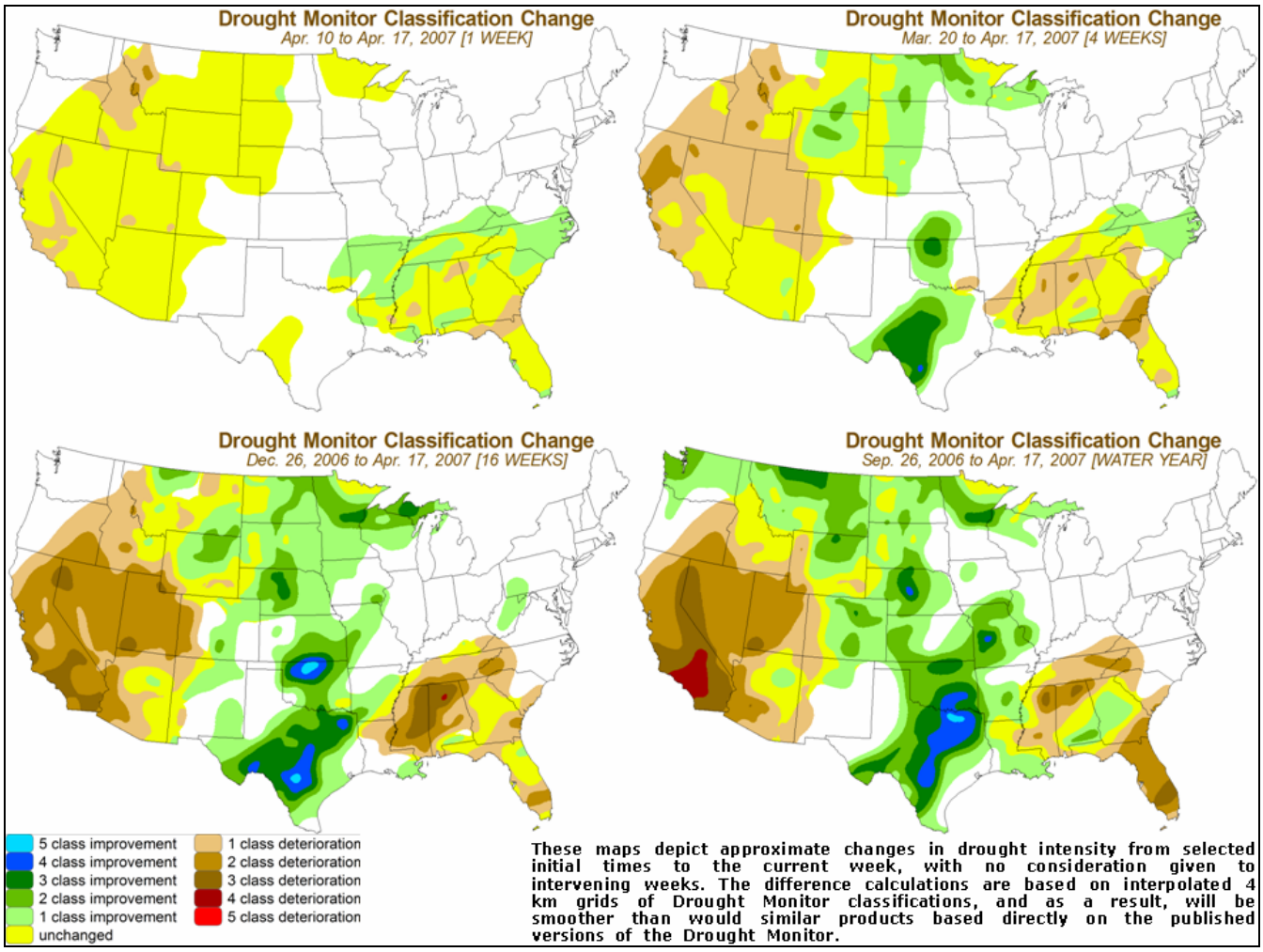
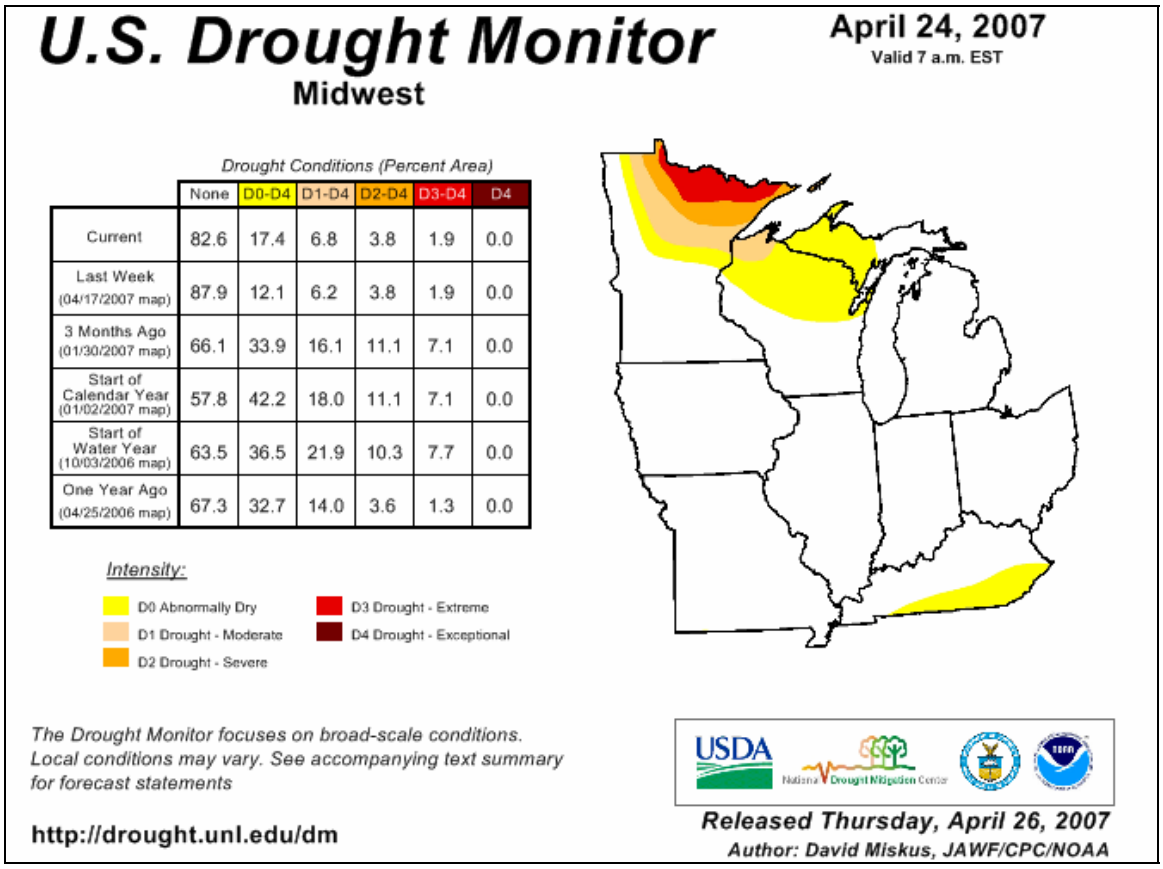


Figure 5: Drought Monitor Classification Change maps. Updated charts available through http://drought.unl.edu/dm.

The Current Situation:

Currently river flow levels have returned to near normal levels for the first time since early last year, primarily as the results of significant late winter snows and widespread rains over the past few weeks. This improvement is also reflected in the latest U.S. Drought Monitor product issued on April 24, 2007 (Figure 6).



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	82.6	17.4	6.8	3.8	1.9	0.0
Last Week (04/17/2007 map)	87.9	12.1	6.2	3.8	1.9	0.0
3 Months Ago (01/30/2007 map)	66.1	33.9	16.1	11.1	7.1	0.0
Start of Calendar Year (01/02/2007 map)	57.8	42.2	18.0	11.1	7.1	0.0
Start of Water Year (10/03/2006 map)	63.5	36.5	21.9	10.3	7.7	0.0
One Year Ago (04/25/2006 map)	67.3	32.7	14.0	3.6	1.3	0.0

Figure 6: U.S. Drought Monitor

Drought Links:

- Latest Drought Monitor
- Latest Drought Outlook

The Outlook for the summer of 2007:

The outlook for the summer of 2007 supports continued improvement in river flow levels as the summer develops. The El Nino pattern we have experienced over the past winter season continues to transition toward La Nina. The pattern of sea surface temperature (SST) anomalies during March was consistent with neutral conditions.

Most statistical and coupled models indicate that the SST will decrease further and El Nino Southern Oscillation (ENSO) transitioning into at least weak La Nina conditions during the April through June period. In fact, some of the forecast models indicate a transition to a full La Nina in the May through July period. More in detail about the El Nino is worth checking out at the Climate Prediction Center website.

Taking a look at expected conditions over the Central Region, for the months of May – July, odds are that cooler than normal temperatures will be found over the north central U.S. The cooler temperatures are most likely to extend from eastern Montana, across North Dakota, into northwest Minnesota, southward into northern South Dakota.

Looking at precipitation, the majority of the Central Region will see equal chances for below, normal or above normal precipitation through the May – July time frame. For the official CPC Outlooks visit their website.

Probabilistic Hydrologic Forecasts

Each month the North Central River Forecast Center (NCRFC) issues a suite of probabilistic forecasts that provide a 90-day hydrologic outlook for most forecast points (See map link). All of these products are based on an ensemble of simulated hydrographs that are generated using the current soil, snow, river, and lake conditions in our hydrologic model as starting conditions. We then run our models out through the end of the period using historical precipitation and temperature time series from water years 1949-2004. We have recently recalibrated our models with an eye towards improving our low flow simulations. See Appendix A for more information.

Figure 7 displays each of these traces for the Mississippi River at St. Cloud, MN. In this case the outlook period extends from April 23rd to September 30th. The first few days of all the hydrographs show a rise in the river due to rainfall April 21-23. From there each hydrograph reflects the precipitation during the year it represents.

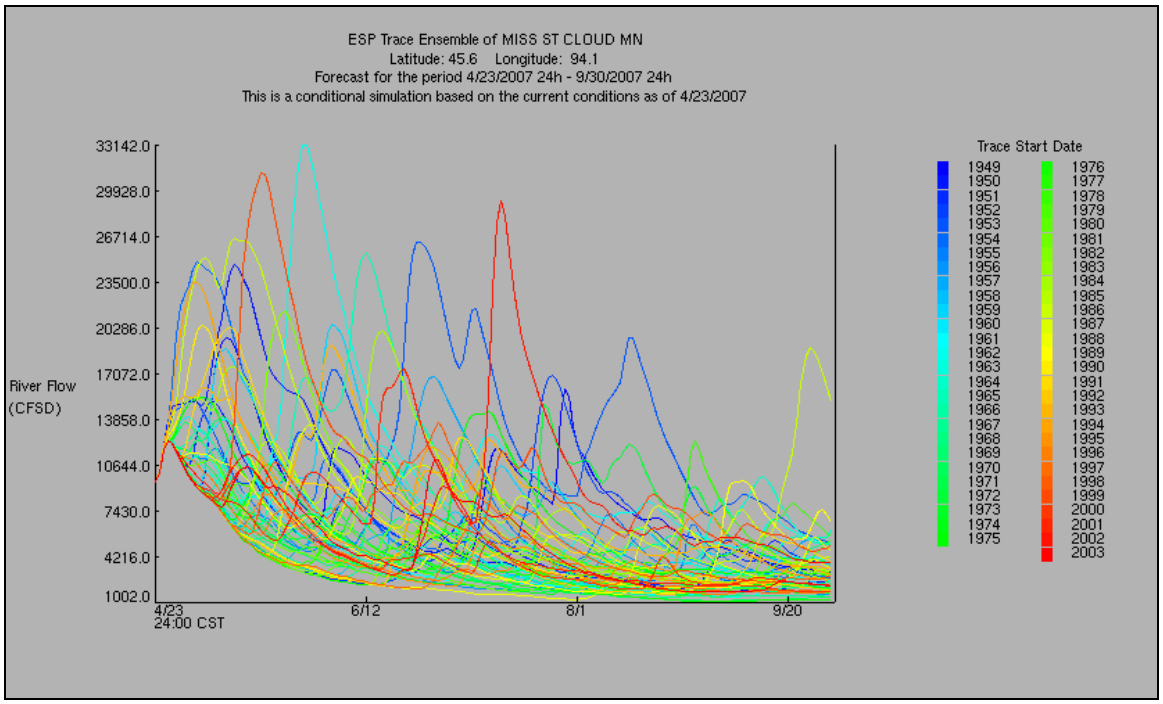


Figure 7: Hydrograph ensemble for the Mississippi River at St. Cloud. The outlook period goes from April 23rd to September 30th. Historical climate data from water years 1949-2004 are used.

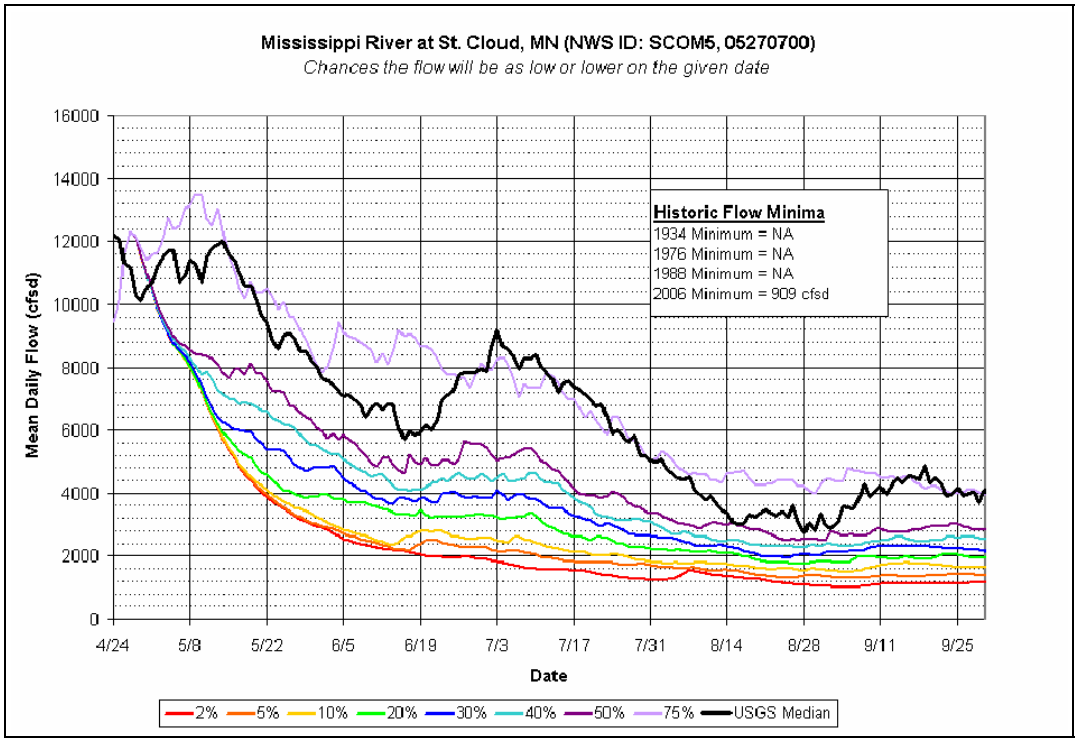


Figure 8. Daily non-exceedance distributions for the Mississippi River at St. Cloud.

Figure 8 shows the chances that the flow in Mississippi River at St. Cloud will be at the level shown on the y-axis or lower by a given date. It is based on the ensemble shown in Figure 7. The mean daily flows from each ensemble member were compiled for each day during the simulation period. An empirical distribution is derived for each day and the cumulative probability is plotted as a family of curves in Figure 8. A file containing the data displayed in this figure can be found at this link.

Figure 8 can be read as follows: There is a 50% chance that the river will fall to around 4000 cubic feet per second-day (CFSD) or lower by July 17th. There is also a 2% chance the river will fall to around 1600 CFSD by the same date.

By definition, the 50% line in Figure 8 shows the median values of each simulated daily distribution. The observed median from the USGS period of record (1989-2007) is also plotted. The simulated median flows are lower than the observed USGS median flows reflecting the dry conditions last year.

Figures 9 and 10 contain similar plots for the Mississippi River near Anoka. It is important to note that the period of record is much longer at Anoka (1931-2007) than St. Cloud (1989-2007). For this reason, the comparison of the 50% line with the USGS median flows is probably more representative at the Anoka site. A file containing the data displayed in this Figure 10 can be found at this link.

The minimum flows reached at St. Cloud and Anoka last year were 909 CFSD and 1550 CFSD respectively. Figures 8 and 10 indicate about a 2% chance that they will reach those levels this year. Despite the dry conditions last year, it is unlikely that the flows in the Mississippi River will get as low as last year unless we have another unusually dry summer. The 90-day outlooks issued by the CPC do not show any trend for above, below, or near normal precipitation this summer.

Summary

Overall there has been a slight improvement in the drought conditions over the headwaters of the Upper Mississippi River over the past few months and the prospects are for continued improvement during the coming summer months. Those of you with river interests need to maintain an awareness of any new developments utilizing many of the sites noted in this brief article.

Point of contact: *If you have further questions about the material included here, feel free to contact Brian at brian.connelly@noaa.gov.*

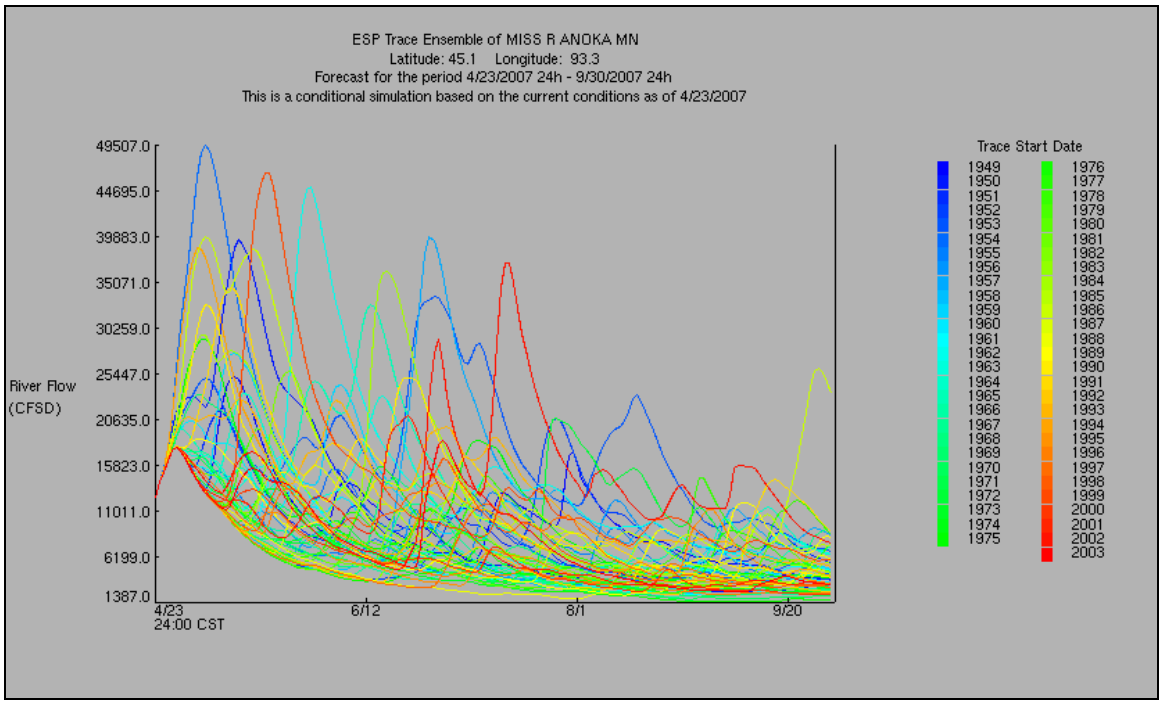


Figure 9: Hydrograph ensemble for the Mississippi River near Anoka. The outlook period goes from April 23rd to September 30th. Historical climate data from water years 1949-2004 are used.

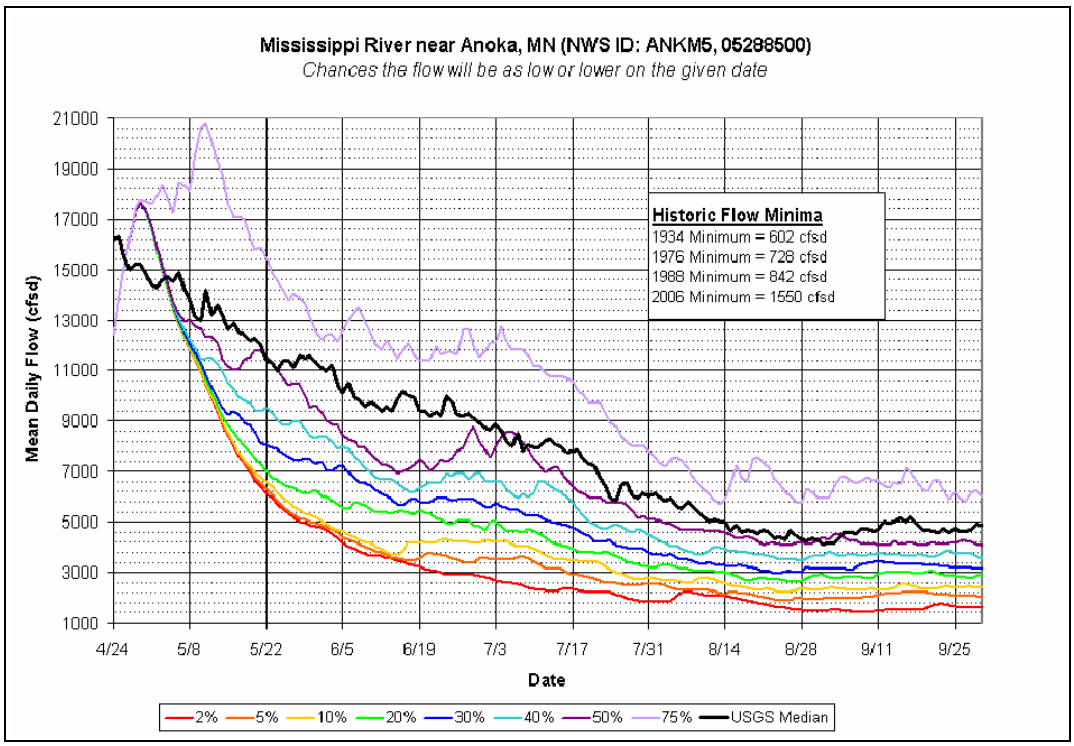


Figure 10: Daily non-exceedance distributions for the Mississippi River at Anoka.

Appendix A: Model Calibration

Because of all the concern about drought this year, we spent the last month reviewing our model calibrations at low flows in the Mississippi River Basin above Anoka. We made some changes to improve our simulations.

Figure A1 contains two non-exceedance plots for low flows at Anoka. It is generated by taking the lowest flow value from each ensemble member for the outlook period and fitting an empirical distribution to it.

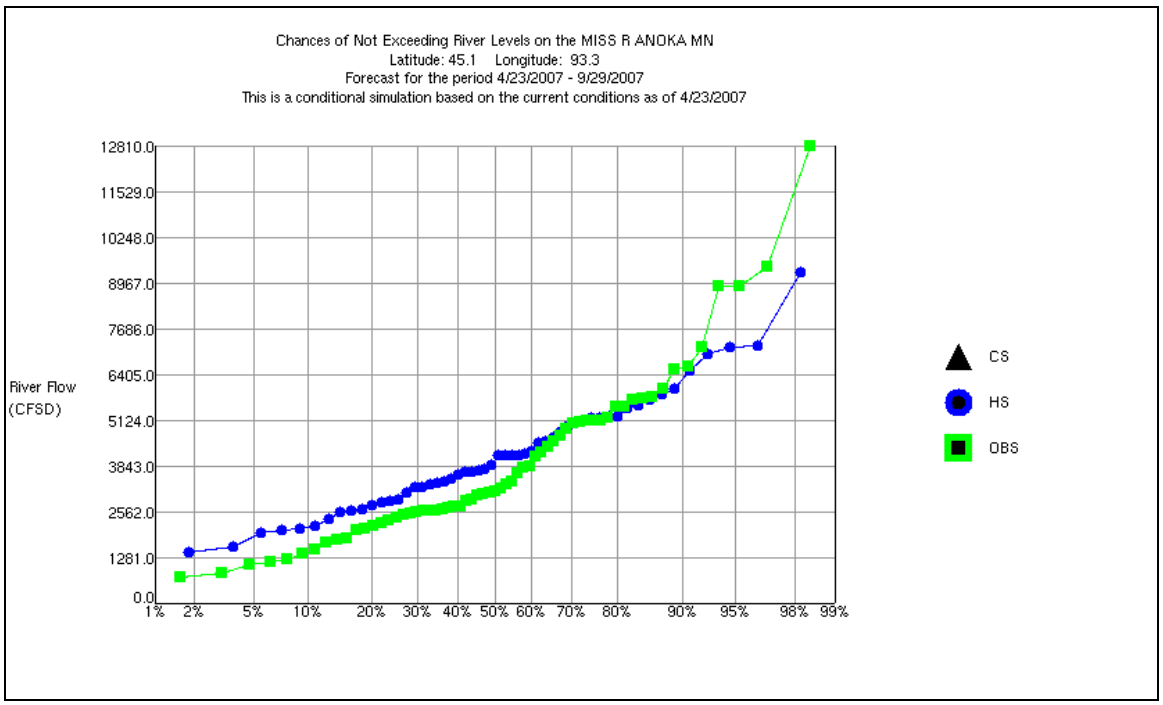


Figure A1: Non-exceedance plot for the outlook period 4/23 through 9/29 before model recalibration.

Two distributions are shown in the plot: HS and OBS. The HS distribution is derived from a historical simulation of our model where we run the model continuously from 1949 through 2004. The OBS distribution is based on observed mean daily flow data from the USGS. If our model calibrations were perfect, these two distributions would be identical.

Figure A1 contains the plots from before our model recalibrations. Note the positive bias at very low flows and the negative bias at higher low flows. During our recalibration effort we focused on the very low flows because that is where the concern is.

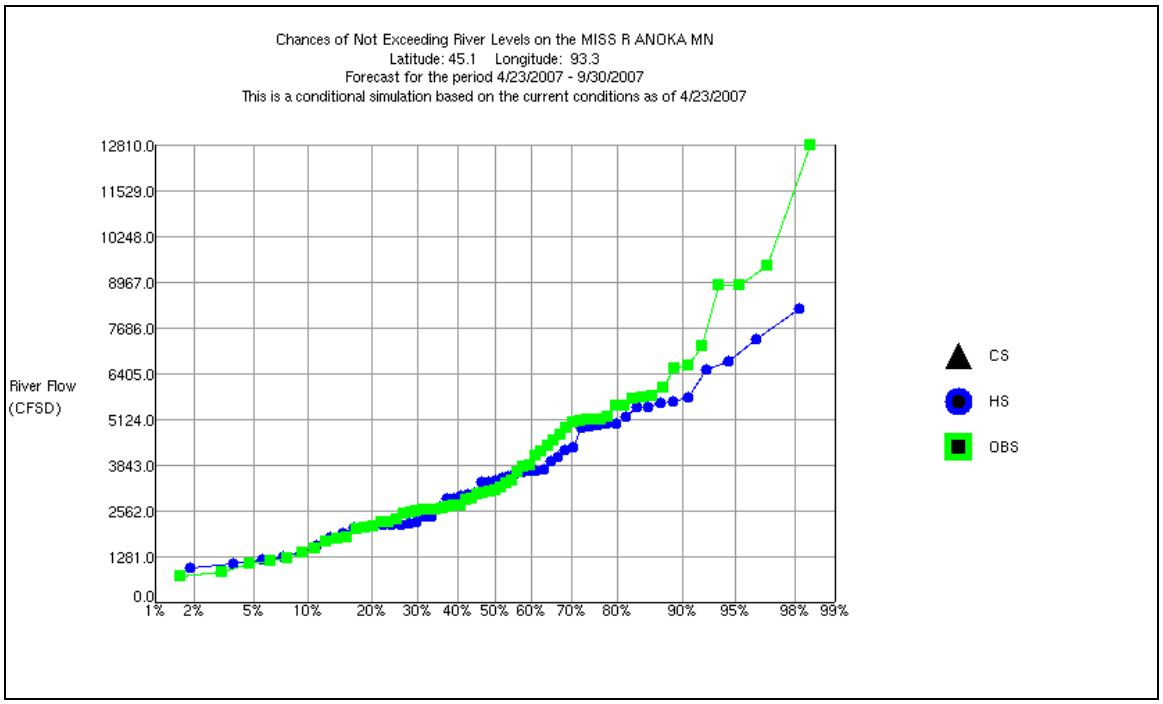


Figure A2: Non-exceedance plot for the outlook period 4/23 through 9/29 after model recalibration.

Figure A2 shows the distributions after recalibration. The simulations at very low flows improved dramatically. The results presented in this article are based on the recalibrated model.