

Enhancing the Advanced Hydrologic Prediction Service

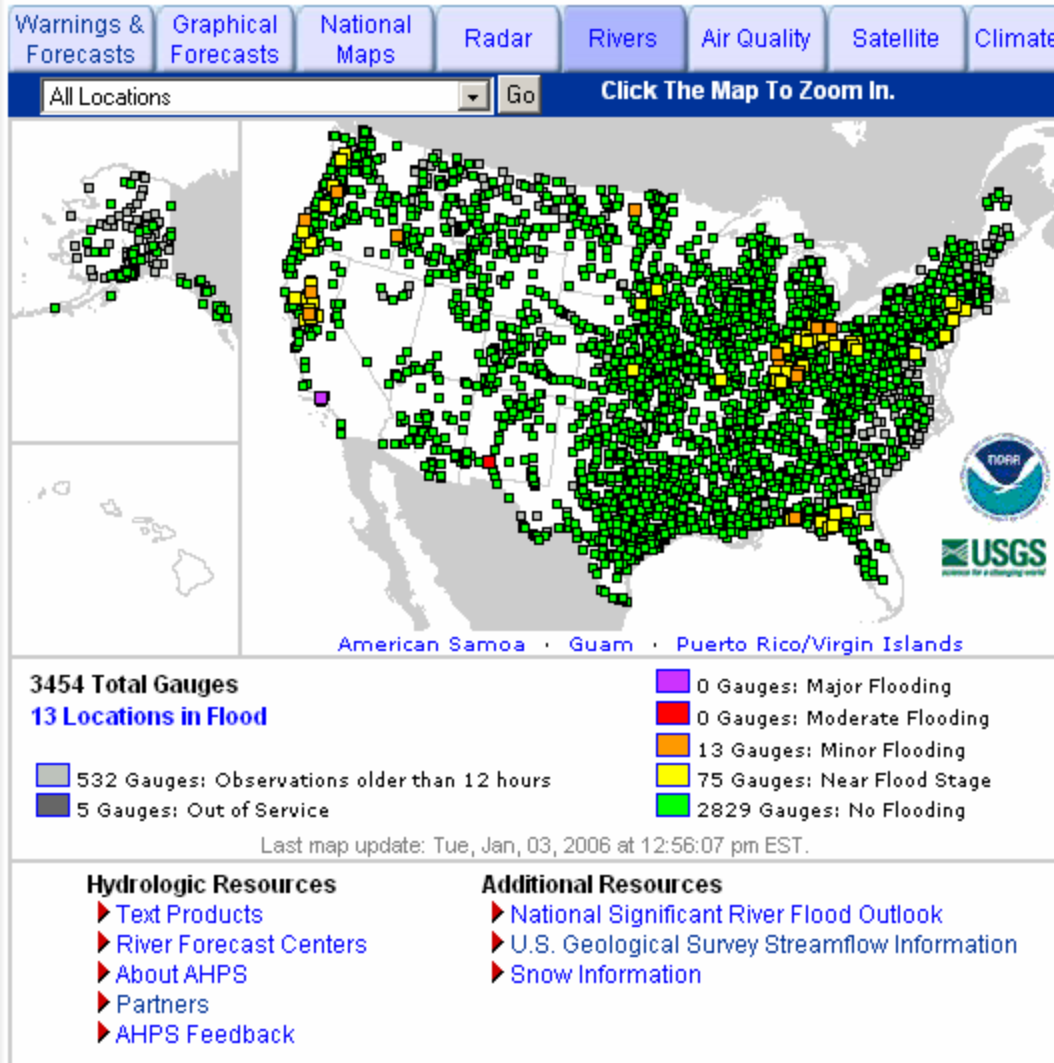
A Program to Develop A Low-Flow/Stage Impacts Database for NWS Forecast Points

Dr. Cody L. Knutson, Water Resources Scientist
National Drought Mitigation Center
University of Nebraska-Lincoln

Co-Authors: M. Higgins, M.D. Svoboda, and D.R. Kluck



Advanced Hydrologic Prediction Service



- Flood early warning system
- Network of 3508 stream gauges
- Providing current river flow/stage data
- Up to 7-day forecasts at many forecast points
- 90-day probabilistic forecasts at 1,359 forecast points

<http://www.weather.gov/ahps/>

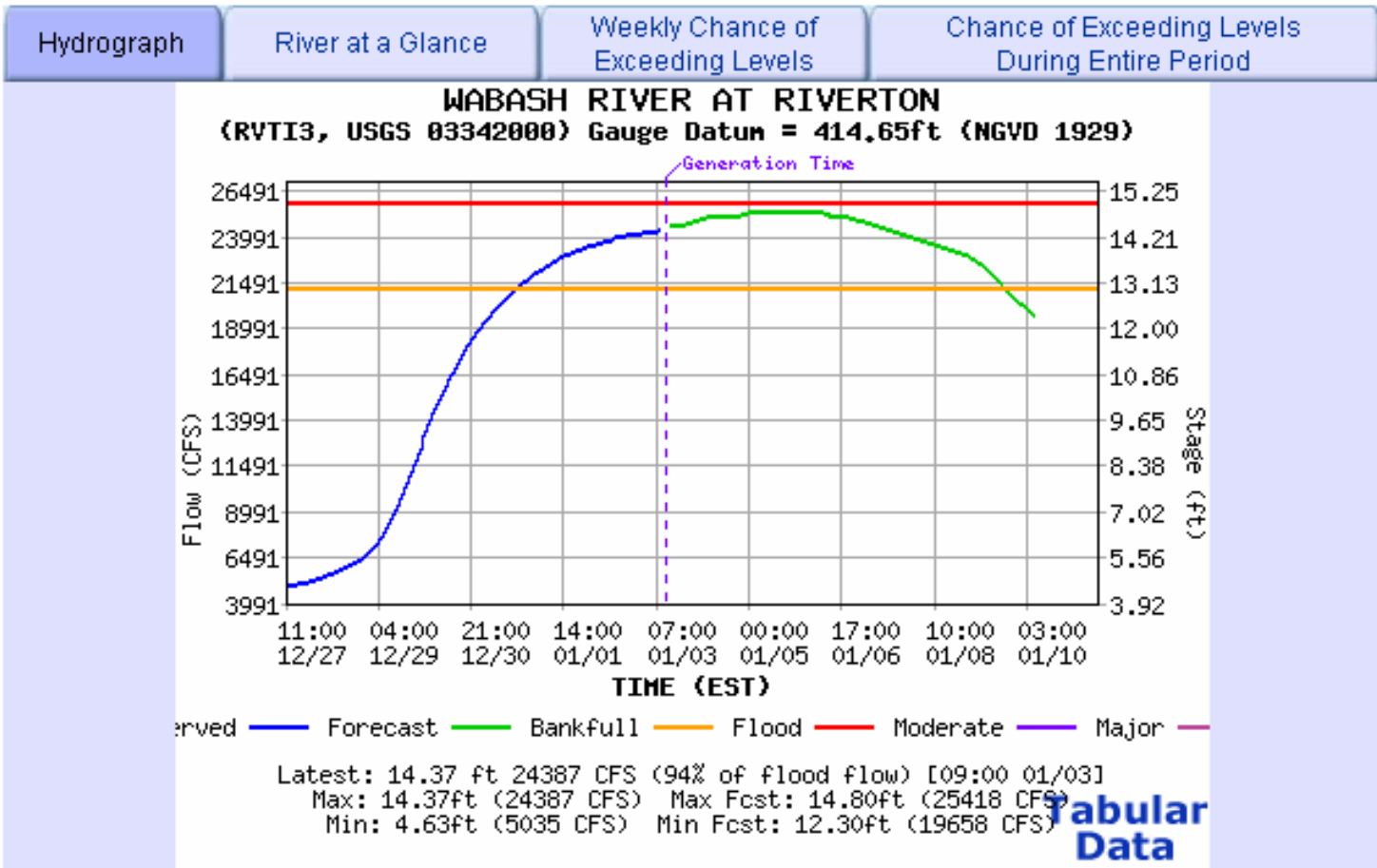
Current Observations and 7-Day Forecast

Weather Forecast Office
Indianapolis, IN

Ohio River Forecast Center

Flood Statement

Observations courtesy of the [US Geological Survey](#).



[About this graph](#)

[Tabular Data](#)

**NOTE: Gauge reading may be affected by ice.
Forecast flows are unadjusted for ice.**

[Return to Area Map](#)



AHPS Flood Classifications

Minor Flooding: minimal or no property damage, but possibly some public threat or inconvenience.

Moderate Flooding: some inundation of structures and roads near stream. Some evacuations of people and/or property to higher elevation is necessary.

Major Flooding: extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.

River Stage and Flood Impact Information

Impacts



- 21 SHORTCUT (GRAVEL ROAD) TO RIVERTON FLOODS AT 20 TO 21 FEET AS WABASH RIVER BACKS UP TURTLE CREEK A FEW MILES SOUTH OF MEROM.
- 20 EXTENSIVE FLOODING IS IN PROGRESS. HIGHER RURAL ROADS BEGIN TO FLOOD. HIGH WATER ISOLATES MANY RIVER CABINS. SEEP WATER BECOMES A PROBLEM.
- 18 HIGH WATER SURROUND ELEVATED RIVER CABINS. COUNTY ROADS TO THESE CABINS ARE IMPASSABLE. AGRICULTURAL FLOODING IS IN PROGRESS. SEEP WATER DEVELOPS BEHIND LEVEES.
- 18 EXTENSIVE LOWLAND FLOODING IS IN PROGRESS. HIGH WATER SURROUNDS MANY RIVER CABINS. ACCESS TO MOST RIVER CABINS IS BY BOAT ONLY. LEVEES BEGIN TO PROTECT FARMLAND. EXTENSIVE FLOODING OF LEAVERTON PARK OCCURS IN PALESTINE, ILLINOIS.
- 16 SOME AGRICULTURAL LANDS UNDERWATER. A FEW RURAL ROADS IN CRAWFORD COUNTY, ILLINOIS CLOSE AS WATER BACKS UP MINNOW SLOUGH. HIGH WATER AFFECTS CAMPGROUND AT LEAVERTON PARK IN PALESTINE. WATER LEVEL IS AT THE TOP OF MOST MAKESHIFT LEVEES.
- 14 LOWEST AGRICULTURAL LANDS BEGIN TO FLOOD. MAKESHIFT LEVEES OFFER SOME PROTECTION. LOWEST RURAL ROADS FLOOD.



(Photo taken by Ken Dewey, 2001)

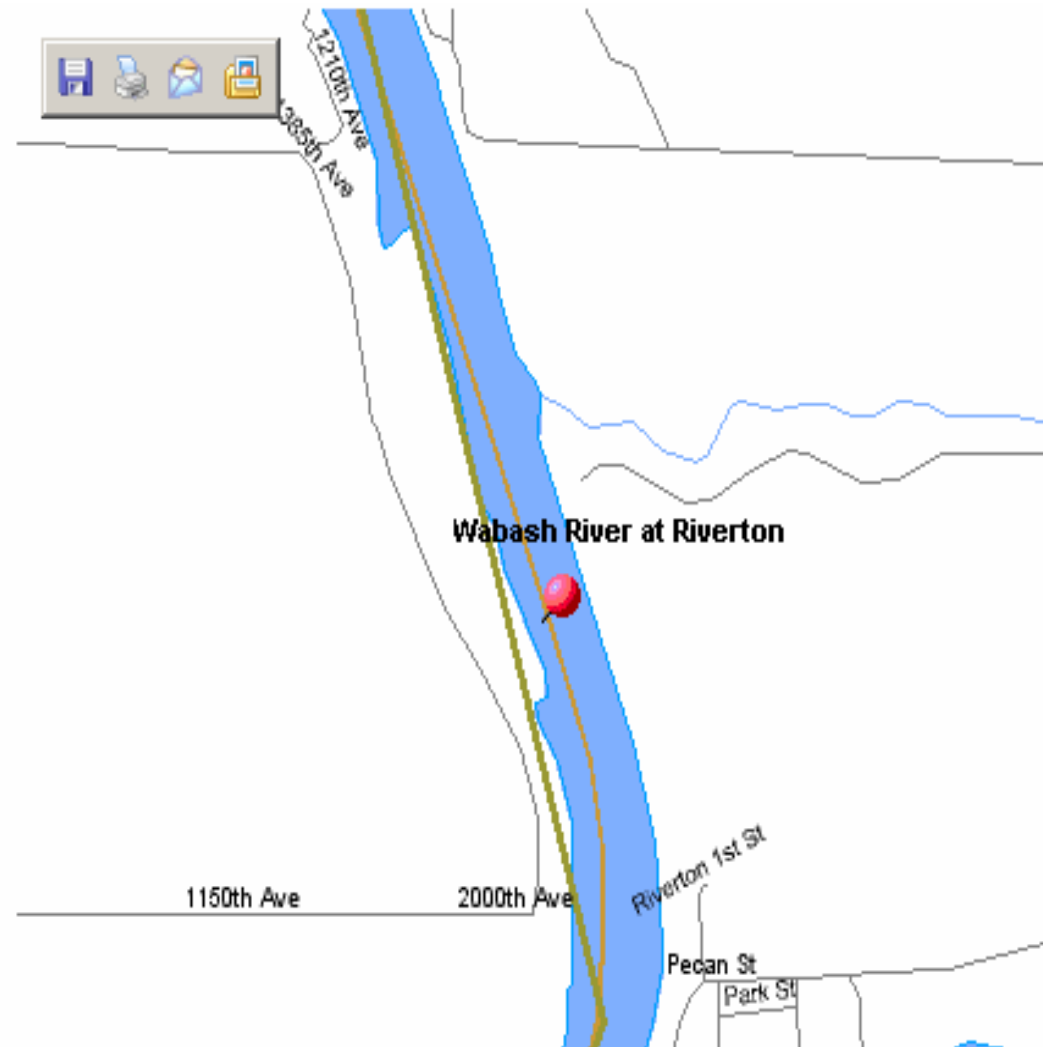
Photos, Maps, Flood Stages, and Historical Data

Flood Categories (in feet)

Major Flood Stage: 24
Moderate Flood Stage: 20
Flood Stage: 15
Action Stage: 9.1

Top 10 Historical Crests

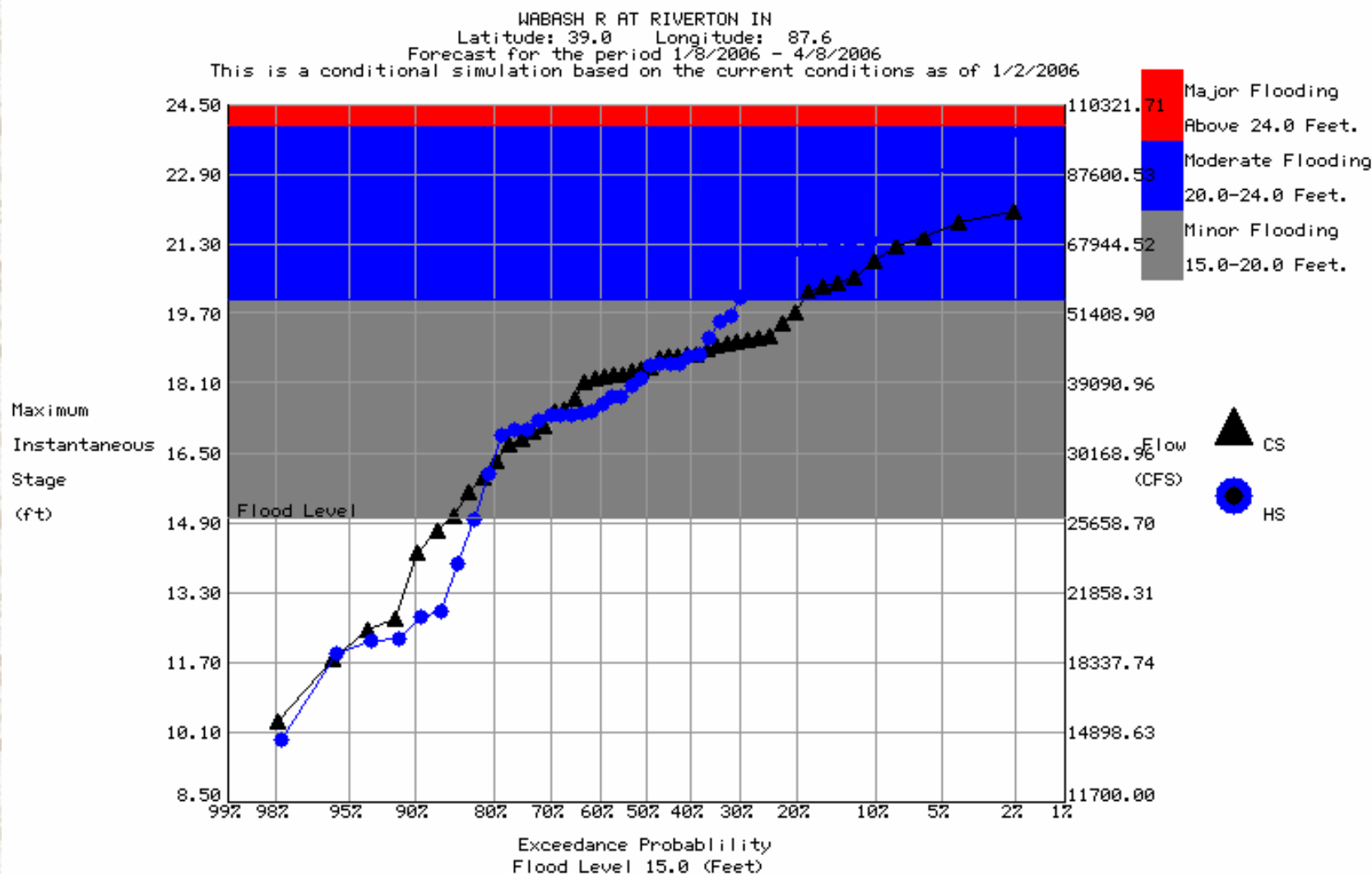
- (1) 29.36 ft on 05/21/1943
(201000 cfs)
- (2) 26.40 ft on 03/28/1913
(250000 cfs)
- (3) 26.24 ft on 01/18/2005
(92100 cfs)
- (4) 25.83 ft on 06/18/1958
(128000 cfs)
- (5) 25.20 ft on 01/18/1950
(121000 cfs)
- (6) 24.46 ft on 03/01/1985
(118000 cfs)
- (7) 24.00 ft on 03/17/1939
(110000 cfs)
- (8) 23.92 ft on 01/05/1991
(101000 cfs)
- (9) 23.78 ft on 02/17/1959
(108000 cfs)
- (10) 23.61 ft on 07/17/2003
(97100 cfs)



Cumulative Chance of Exceeding Levels (90 day outlook)

This probabilistic forecast is issued by the [Ohio River Forecast Center](#).

- Hydrograph
- River at a Glance
- Weekly Chance of Exceeding Levels
- Chance of Exceeding Levels During Entire Period

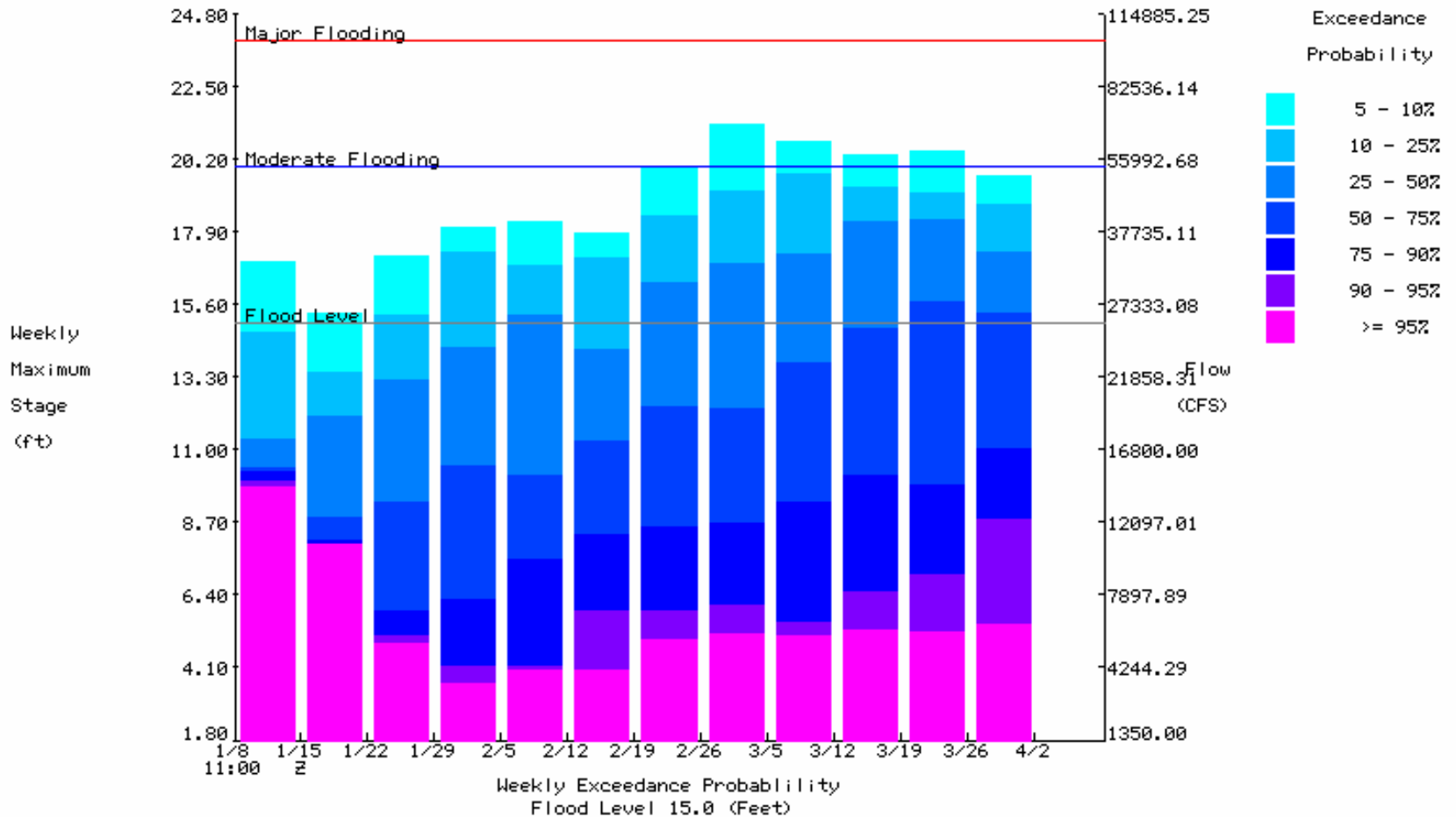


Weekly Chance of Exceeding Levels (90 day forecast)

This probabilistic forecast is issued by the [Ohio River Forecast Center](#).

[Hydrograph](#)
 [River at a Glance](#)
 Weekly Chance of Exceeding Levels
 [Chance of Exceeding Levels During Entire Period](#)

WABASH R AT RIVERTON IN
 Latitude: 39.0 Longitude: 87.6
 Forecast for the period 1/8/2006 - 4/2/2006
 This is a conditional simulation based on the current conditions as of 1/2/2006



Although providing great benefits for flood protection, the AHPS system does not provide the same information for low flow events.

A lack of water in rivers and streams can have similar deleterious effects to flooding in terms of health, economic, and environmental consequences.



New Project: Development of a Low Flow/Stage Impacts Database for AHPS Forecast Points

Cody Knutson¹, Mark Svoboda¹, Melissa Higgins¹, and Doug Kluck²

¹National Drought Mitigation Center;

²National Weather Service CRHQ/NOAA

Objective 1: Identify low flow/stage related impacts near NWS forecast points

Objective 2: Use impact information to establish low flow/stage warning triggers (drought stages)

Objective 3: Develop low flow/stage river forecasts

Incorporate data into the current AHPS system

Completed Low Flow Project Studies



- Upper Mississippi (2004) and North Platte (2005) river basins
- 38 NWS AHPS forecast sites analyzed
 - Upper Mississippi River Basin (MN) – 21 forecast points**
 - North Plate River Basin (CO, WY, and NE) – 17 points**
- Conducted internet and literature reviews
- Also collected information on potential low flow impacts from 115 federal, state, and local water experts



Experts Were Asked to Provide Information on:

- The impacts of low river levels
- The stage/flow at which impacts occur
- Which AHPS site(s) best reflect the impacts
- Other factors that affect particular impacts/locations

Key Findings

1. Several potential impacts identified

- loss of municipal, industrial, and agricultural water
- activation of water rights regulation procedures
- activation of state and local drought response plans
- reduced recreational opportunities
- hydropower losses
- dredging to maintain navigation
- fish and wildlife losses
- exposure of infrastructure
- increased effluent testing (NPDES)



2. River basins have common and unique vulnerabilities and management strategies

Upper Mississippi River Basin:

- *mainly municipal water for large cities (St. Paul and Minneapolis), navigation, hydropower, recreation, and fish and wildlife concerns.*
- river gaging stations are often used to trigger low flow management plans (i.e., Q90 flow)

North Platte River Basin:

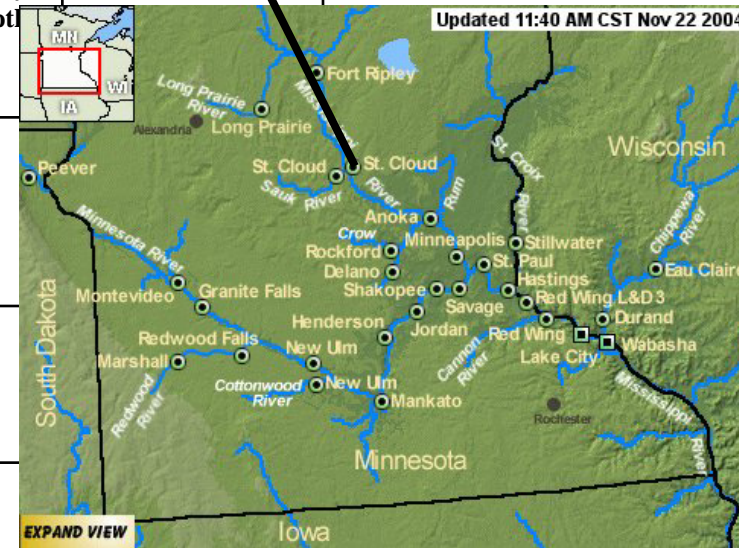
- *mainly agricultural irrigation, municipal water (small and large cities), hydropower, recreation, and fish and wildlife concerns*
- reservoir levels and flow volumes used to trigger low flow management plans (i.e., North Platte Project – 1.1 million acre-feet in reservoirs)



Flow (cfs)	Stage (ft)	Impacts	Timing/Other Considerations	Information Sources
2000		Recreational activities such as boating may become difficult		DNR Trails and Waterways Division (2004)
1400		Hydropower facilities at Champion Dam and St. Cloud Dam will implement measures to adjust river flows as part of the Mississippi River System-Wide Low-Flow Management Plan		DNR System-Wide Low-Flow Management Plan (2004)
	974	The St. Cloud Water Treatment Facility can meet a maximum pumping demand of 16 million gallons of water per day		Lisa Vollbrecht, St. Cloud Water Services Manager
	973.5	The North Intake Structure for the St. Cloud Water Treatment Facility will not be able to draw water	February 2004 – low flows and ice buildup blocked the North Intake – the hydroelectric facility raised the pool depth for the intake to function	
	970.5	The St. Cloud Water Treatment Facility can meet a maximum pumping demand of 12 million gallons of water per day		
	970	The South Intake Structure for the St. Cloud Water Treatment Facility will not be able to draw water		

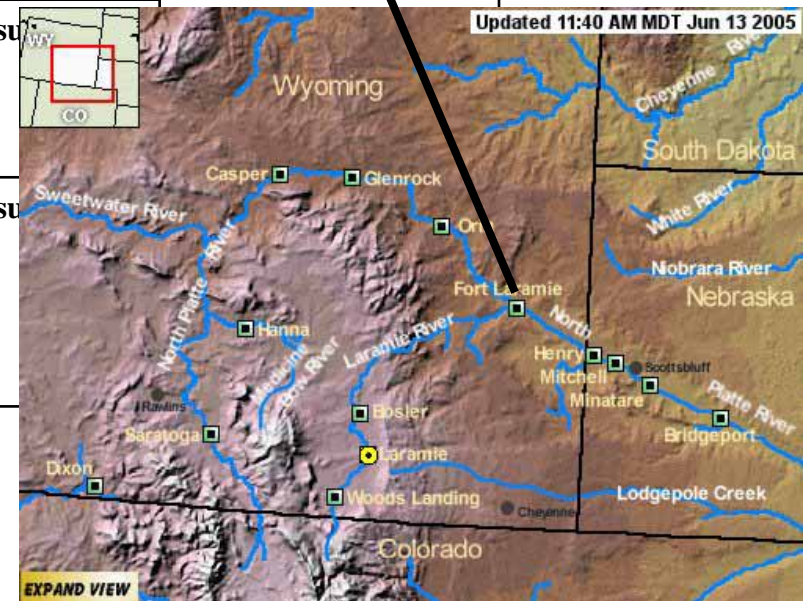
Reported Impacts

St. Cloud Forecast Point, MN



Fort Laramie Forecast Point, Wyoming

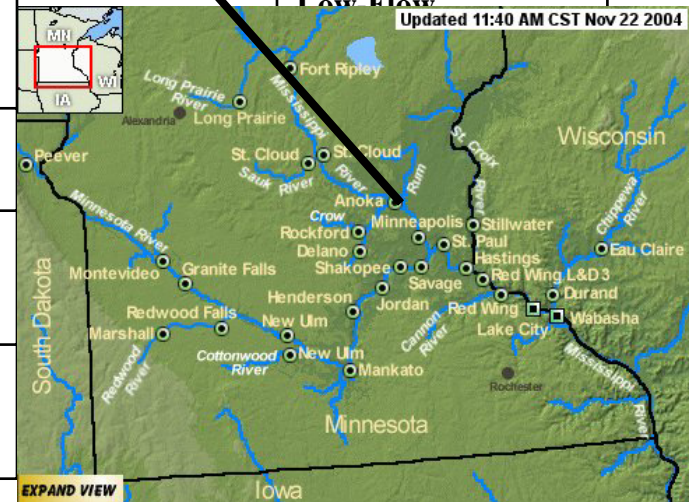
Flow (cfs)	Stage (ft)	Impacts	Timing/Other Considerations	Information Sources
40		Irrigation releases for crops become sporadic; some fields may not receive full allotment of water	Late summer	Brian Artery, District Manager, Platte County Conservation District
20		Recreation opportunities very limited, boat ramps at Greyrocks Reservoir are likely to be inaccessible	Late summer	
10		Irrigation releases cease; crops will require alternative irrigation water supply	Late summer	
10		Conditions are not favorable for aquatic life; fish and other aquatic organisms begin to die	Late summer	
10		Conditions are not favorable for livestock and wildlife water, livestock producers must implement alternative livestock water supply	Late summer	



3. There Are Future Opportunities for Consolidating and Expanding Monitoring Networks

Example: USGS Station # 05288500 near Anoka – Mississippi River (non-AHPS)

Flow (cfs)	Stage (ft)	Impacts	Timing/Other Considerations	Information Source
2120 cfs		If this flow is sustained for 72 hours, surface water appropriations in all contributing upstream major watershed may be subject to suspension	Q90 flow is updated every 5 years	DNR Appropriations Guide (2004b)
2000		Hydropower facilities at Coon Rapids Dam, St. Anthony Upper Lock and Dam, St. Anthony Lower Lock and Dam, and Lock and Dam #1 will implement measures to adjust river flows as part of the Mississippi River System-Wide Low-Flow Management Plan		DNR System-Wide Low-Flow Management Plan (2004c)
2000		May trigger a state “Drought Watch” as described in the MN Department of Natural Resources Drought Response Plan.		DNR System-Wide Low Flow
1200		St. Paul Regional Water Services begins voluntary conservation plan		
1000		St. Paul Regional Water Services begins sprinkling restrictions (reduce withdrawals to 56 MGD limit)		
750		St. Paul Regional Water Services implements mandatory conservation; begin reducing withdrawals toward the 45 MGD limit		





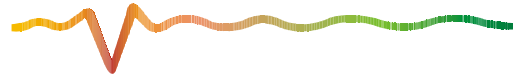
4. Authorities could not describe at what stage/flow impacts at some sites would occur.

Ex) *“Our wells are affected by river flows but I don’t know exactly how much.”*

Ex) *“Fish and wildlife are affected by low flows but we haven’t determined minimum flow requirements.”*

More research is needed in such cases to better understand low-flow vulnerabilities

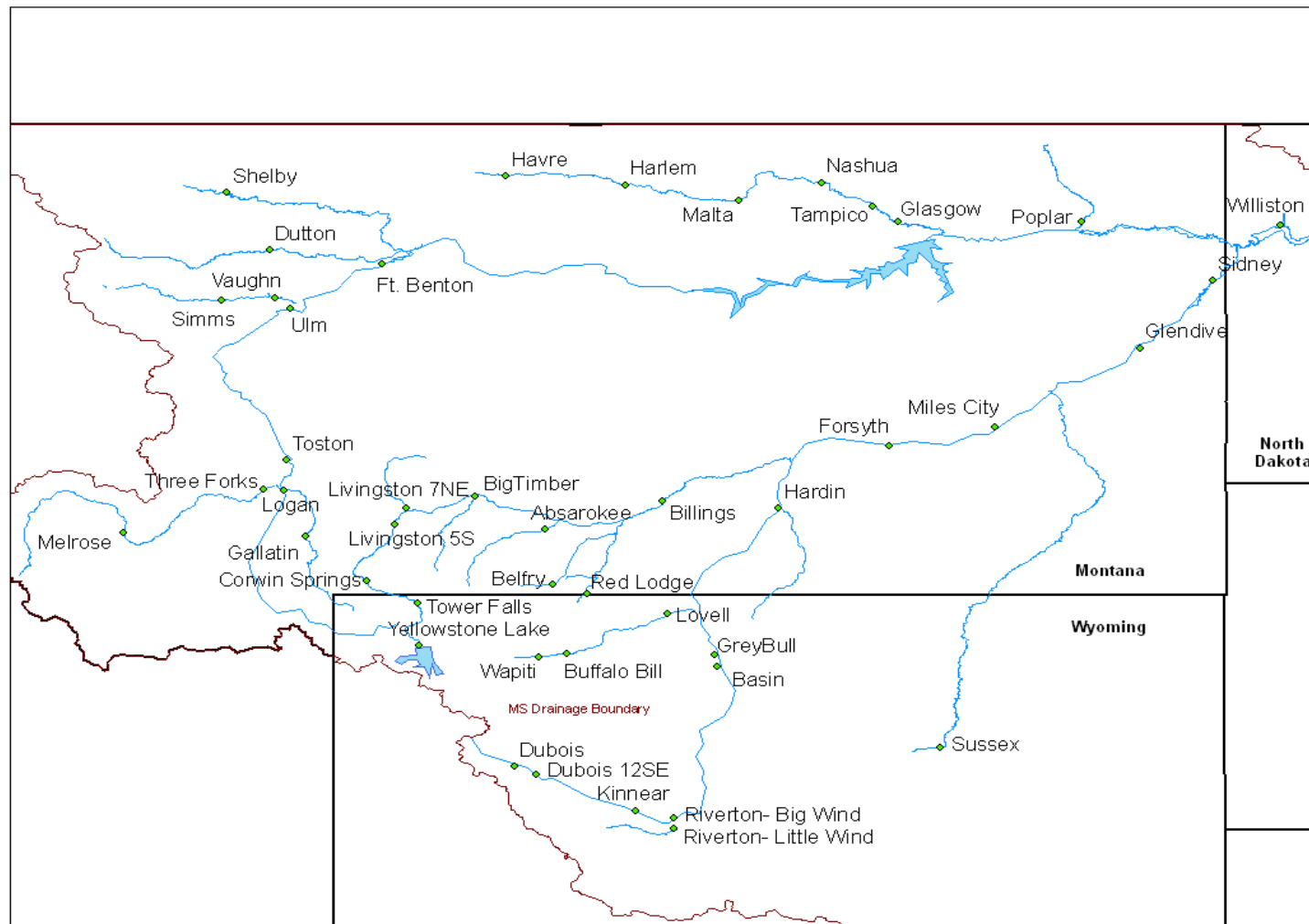
Conclusion of Case Studies...



Developing a better understanding of low river impacts at the local level will provide more detailed information for water resources planning applications at all levels of government, as well as in advancing the development of the AHPS system.

2006 – Upper Missouri River Basin Low Flow Project

Identify potential low flow/stage impacts near 46 forecast points in the Upper Missouri River Basin of North Dakota, Montana, and Wyoming.



Potential MT/WY/ND Contacts

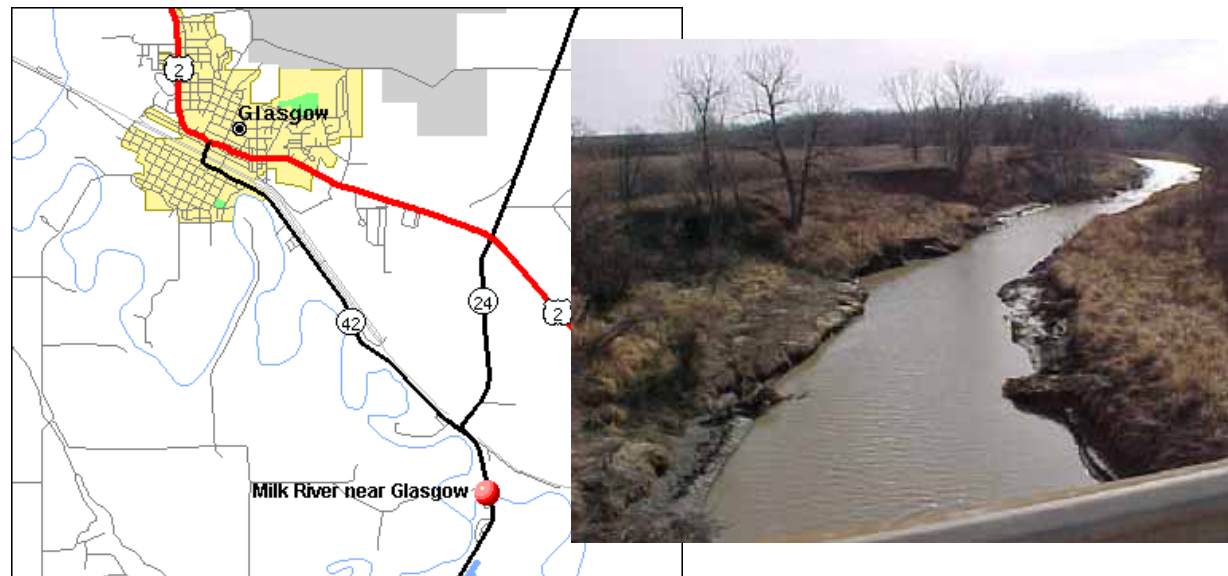
NDMC staff will be contacting Montana, Wyoming, and North Dakota water experts during the spring of 2006, such as:

- Community water managers near AHPS points
- Montana Drought Advisory Committee
- MT Department of Natural Resources and Conservation
- Montana Homeland Security
- Montana Fish, Wildlife, and Parks
- National Weather Service
- US Bureau of Reclamation/US Army Corp of Engineers

They will be asked to help identify potential low-flow related impacts that can be linked to river flow/stages at NWS AHPS forecast points.

Montana Example

1) What effects would typically occur as the Milk River flow decreases at the AHPS forecast point near Glasgow?



- 2) At what general stage/flow would those impacts occur?
3) Are these impacts seasonal?

Current Milk River AHPS Forecast Point Near Glasgow

Impacts

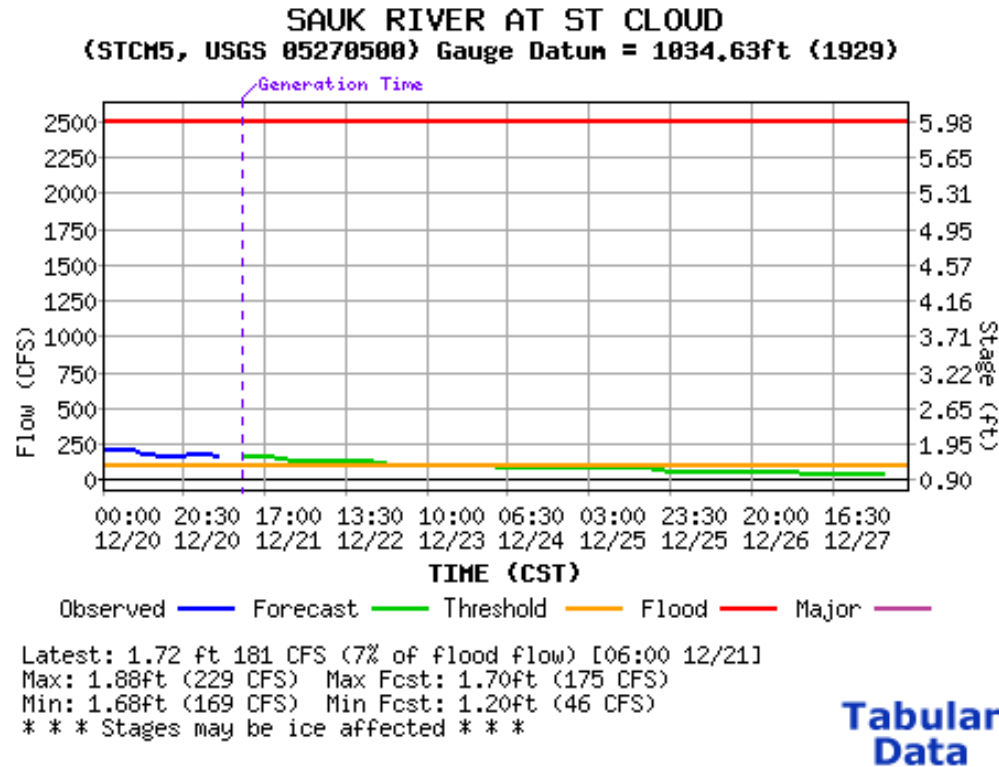


- 38 Entire length of Glasgow levee overtopped resulting in substantial flooding in the city. All residents south of the railroad tracks should have sought higher ground.
- 36 About half of Glasgow levee overtopped. Residents protected by this levee should seek higher ground.
- 34 Water starting to overflow the east end of the Glasgow levee. Residents should be evacuating southside of Glasgow.
- 34 Water overtopping the Green Meadows levee. Homes behind this levee should be evacuated.
- 33 Highway 42 near Sullivan Park Submerged. Traffic barriers should be placed by law enforcement to restrict traffic.
- 33 This matches the stage level of the 1952 flood of record.
- 32 Major Flood. Most access roads to ranches and farm homes in the lower Milk River Valley are flooded. Many homes near the Highway 24 bridge and outside the Glasgow levee are also flooded.
- 32 Homes immediately to the southwest side of the highway 24 bridge are threatened.
- 32 Homes on the northeast side of the highway 24 bridge start to flood. Homes immediately to the east side of Sullivan Park are flooded.
- 31 Home on the northeast side of the 6th Avenue Bridge becomes isolated by flood waters with water in the basement.
- 31 Flooding will begin to affect buildings between the Fort Peck Highway and the Milk River east of Glasgow. Sullivan Park will be totally covered by flood waters.
- 30 Flood waters will begin to cover 6th Avenue South. Many farmhouses will be cut-off by the floodwaters. Storm drainage valves along Glasgow levee will back-flood into the southside of Glasgow if not closed.
- 29 Livestock/feedlots adjacent to Milk River become isolated by flood water. Livestock relocation to higher ground should have started.
- 26 Flooding begins in the Sullivan recreation park. Some flooding will also occur on area farmlands.
- 25 This is flood stage. Expect some low-land flooding to occur.

What would happen as stage/flow decreases?



Future Work for River Forecast Centers...

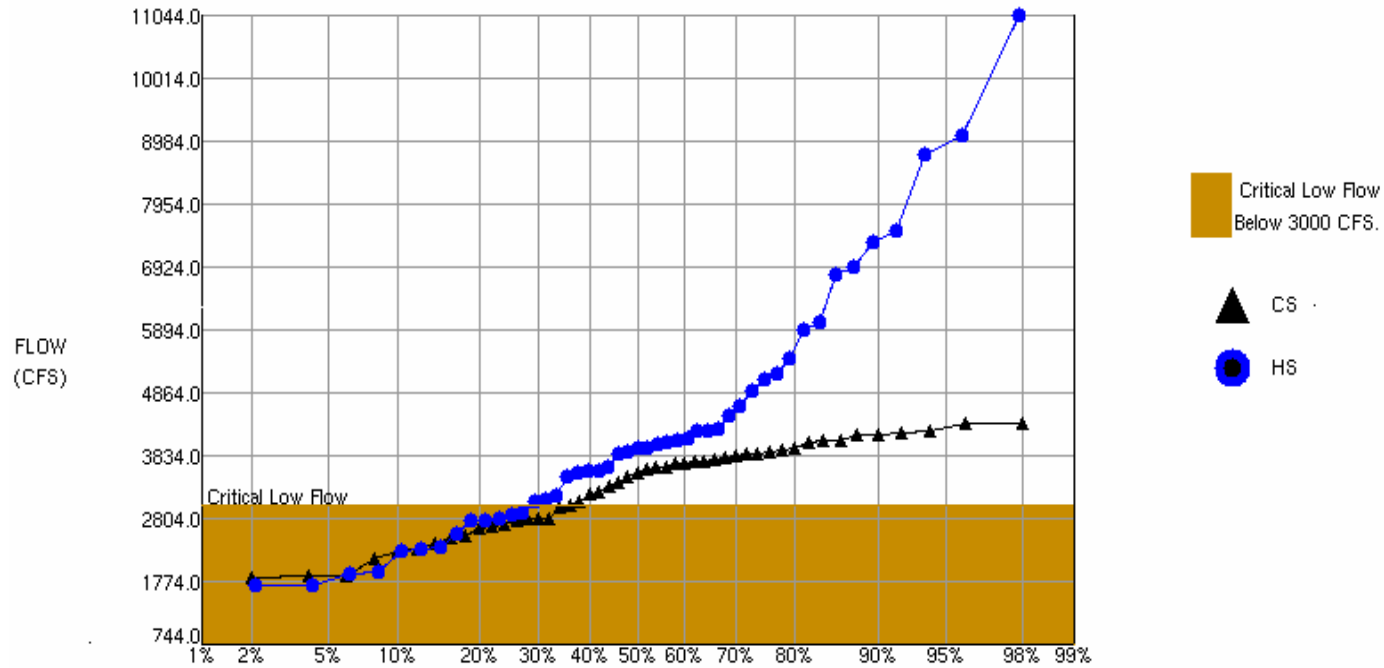


North Central River Forecast Center

Figure 3. An example of a seven-day river forecast hydrograph with indicators of critical low flow and flood levels. The red line indicates the flood level. The tan line indicates the critical low flow level at this forecast point. The blue line shows the current river level and the green line is the actual forecast.



PROBABILITY OF FALLING TO LOW FLOW LEVELS
Mississippi River at Minneapolis, MN
Forecast for the period 3/10/2004 - 6/23/2004
This is a conditional simulation based on the current conditions as of 3/10/2004



North Central River Forecast Center

Figure 4. An example of a 90-day streamflow outlook for low water. The values along the x axis show the probability of reaching a particular flow (y axis). The brown zone at the bottom of the graph shows the critical level for this forecast point at which low water impacts begin to take effect.

CS = conditional simulation; HS = historical simulation.



Current and Future

Continue to move forward in partnership with the NDMC in CR and SR (FY07)

Continue with creation of base line low flow impacts database for country

Continue to show the value and importance for NOAA and NIDIS in hopes of it being adopted nationally

Low flow impacts will be part of NWS Hydro infrastructure/database by Fall FY06 (OB7.1)

Contact: Doug Kluck, Central Region HQ-NWS
816-891-7734x705, doug.kluck@noaa.gov