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Brief Analysis of Flooding in Minnesota

Recent Flood Events, Statewide Flood Risk Assessment, and Hazard Mitigation




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Minnesota Department of Public Safety, Division of Homeland Security and Emergency Management

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Minnesota Board of Water & Soil Resources

Brief Analysis of Flooding in Minnesota – March 2011

Estimated Cost of Preparing Report
(per Minnesota Statutes Section 3.197)

BWSR staff time	$4,380
DNR and DPS-HSEM staff time	$ 500
Total	$4,880

This report is available online at www.bwsr.state.mn.us

Purpose

This report was prepared in response to the following directive of the Minnesota Legislature.

2010 2nd Special Session

Chapter 1 -- H.F. No. 1

Article 1

Flood Disaster Relief

Sec. 10. **Board of Water and Soil Resources**

Subd. 5. **Flood Areas**

The Board of Soil and Water Resources, with the cooperation of the commissioner of natural resources, shall provide testimony to the chairs of the senate and house finance committees, by March 1, 2011, with an analysis of recent flood events in Minnesota that have been the subject of federal disaster declaration, and shall make an estimate as to the likelihood of such events occurring in the future. This testimony shall include estimates of rainfall that may cause future flooding, areas that will be prone to flooding, and the volume of water that will need to be stored or retained for prevention.

Importance of Flood Damage Mitigation

Floods are the number one hazard in Minnesota in terms of frequency of occurrence and total damages. The state of Minnesota was granted Presidential Disaster Declarations 43 times between 1965 and 2010 (45 years). Of those declarations, 36 involved flooding (HSEM, 2011). Nationwide, hundreds of floods occur each year, making it one of the most common hazards in all 50 states and U.S. territories (FEMA, 1997).

Flooding in Minnesota is caused by two key natural phenomena – snowmelt and rainfall. Geology and topography are key factors affecting flooding potential. Antecedent moisture conditions, such as a very wet fall prior to winter, rainfall intensity, or back to back rainfall events, often play a significant role in flood events. Anthropogenic factors can also contribute to flooding, such as land use and associated land cover that results in increased runoff, agricultural drainage or urban drainage. Antecedent conditions, snowmelt and rainfall events are highly variable and the effects of anthropogenic factors can also vary spatially and for different runoff events. Therefore, flooding is complex as well as destructive.

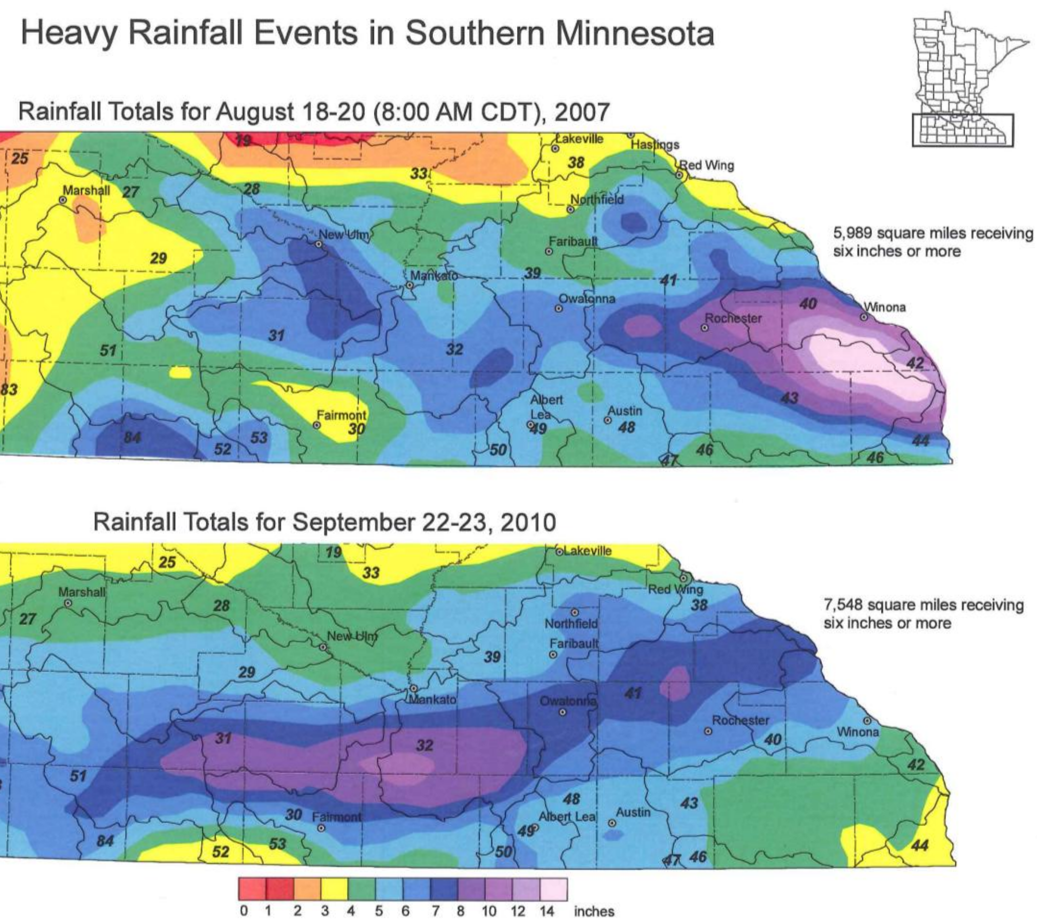
Flood damage results from land use that enables public and/or private infrastructure to be located in a current or future floodplain. Relatively dry climatic periods can encourage development that is at risk of flooding during wet periods. Federal and state programs are in place to help evaluate flood risks, mitigate flooding potential, and aid flood recovery. Hazard mitigation is any sustained action taken to reduce or eliminate long-term risk to people and property from the effects of natural or human caused hazards. Flood damage mitigation is a very important aspect of state and federal floodplain management programs.

Recent Flood Events in Minnesota

Table 1. Major MN Flood Events 2001-2010 Involving a Presidential Disaster Declaration		
Year	**Counties and Other Areas Declared**	**Declaration Number and Type of Event**
2010	Counties: Blue Earth, Brown, Carver, Cottonwood, Dodge, Faribault, Freeborn, Goodhue, Jackson, Le Sueur, Lincoln, Lyon , Martin, Mower, Murray, Nicollet, Nobles, Olmsted, Pipestone, Redwood, Rice, Rock, Sibley, Steele, Wabasha, Waseca, Watonwan, Winona, and Yellow Medicine	Presidential Disaster Declaration DR-1941-MN was declared due to severe rain storms and flooding beginning on September 22 through October 14, 2010.
2010	Counties: Blue Earth, Brown, Faribault, Freeborn, Houston, Kittson, Nicollet, Olmsted, Otter Tail, Polk, Sibley, Steele, and Wadena	DR-1921-MN was declared for severe storms, tornadoes and flooding during June 17-26, 2010.
2010	Counties: Big Stone, Blue Earth, Brown, Carver, Chippewa, Clay, Cottonwood, Kittson, Lac Qui Parle, Marshall, McLeod, Norman, Pennington, Polk, Ramsey, Red Lake, Redwood, Renville, Scott, Sibley, Stevens, Traverse, Wilkin, and Yellow Medicine; and the Tribal Nations of the Upper Sioux, and Prairie Island Indian Communities.	DR-1900-MN was issued on April 19, 2010 and amended through 6-29-10 for spring flooding in the Red River Basin and elsewhere in Minnesota. The combination of high water content snowpack, saturated soils, ice jams, and flat terrain resulted in severe flooding in the Red River Basin.
2009	Counties: Becker, Beltrami, Chippewa, Clay, Clearwater, Cook, Douglas, Grant, Hubbard, Kittson, Lac Qui Parle, Lake, Lake of the Woods, Mahnomen, Marshall, Norman, Otter Tail, Pennington, Polk, Pope, Red Lake, Roseau, Stevens, Swift, Traverse, Wadena, Wilkin and Yellow Medicine; and Band of Chippewa Indians	DR-1830-MN was amended through 5-6-09 for severe storms and flooding in the Red River Basin and elsewhere in Minnesota due to snow melt and rainfall.
2008	Counties: Fillmore, Freeborn, Houston, Mower, Nobles and Cook	DR-1772-MN was declared due to severe rainfall and flash flooding and amended through 8-5-08.
2007	Counties: Winona, Fillmore, Houston, Olmsted, Dodge, Steele and Wabasha	DR-1717-MN was declared on August 23, 2007 for seven southeast Minnesota Counties due to severe rainfall and flooding from August 18-20. This event produced the largest 24-hour rainfall total ever recorded by an official National Weather Service reporting location in Minnesota (15.10 inches).
2006	Counties: Becker, Clay, Kittson, Marshall, Norman, Polk, Red Lake, Roseau and Wilkin	DR-1648-MN was declared on June 5, 2006 for nine northwest Minnesota counties due to flooding from March 30th to May 3rd.
2004	Counties: Becker, Beltrami, Clay, Clearwater, Dodge, Faribault, Freeborn, Itasca, Kittson, McLeod, Mower, Pennington, Polk, Roseau and Steele	DR-1569-MN was declared on October 7, 2004 for five southern Minnesota counties due to severe rain storms and flooding and other northwest Minnesota counties were added later.
2002	Counties: Goodhue, Hubbard, McLeod and Wright	DR-1419-MN resulted from severe rain and flooding that occurred on June 14, 2002.
2001	Throughout much of Minnesota	DR-1370-MN resulted from flooding due to snow melt and heavy rainfall in March to July in 61 counties and 4 Tribal Government areas. A total of 66 counties were approved for some form of disaster assistance.

The flood events listed in Table 1 include both snowmelt and/or rainfall events. Some of the rainfall events qualify as flash floods. An analysis of flash floods in Minnesota titled "Minnesota Flash Floods: 1970-2008" was prepared by the Minnesota State Climatology Office of the Department of Natural Resources (DNR), together with the University of Minnesota (http://climate.umn.edu/doc/flashflood.htm). The definition of a flash flood used in the study is the occurrence of 6 inches or more of rainfall within a 24-hour period.

Figure 1.



The Minnesota State Climatology Office gathers, archives, manages, and disseminates historical climate data in order to address questions involving the impact of climate on Minnesota and its citizens. The State Climatologist is Jim Zandlo, 651-296-4214, james.zandlo@state.mn.us. The Minnesota Climatology Working Group includes the State Climatology Office, University of Minnesota Department of Soil, Water and Climate, University of Minnesota Department of Geography, University of Minnesota Extension Service, and the National Weather Service. The working group maintains a list of pertinent resources on its website at: http://climate.umn.edu/.

Due to the frequency and magnitude of large rainfall events in Minnesota and elsewhere in recent years, there has been ongoing discussion about rainfall-frequency relationships, climate cycles and climate change. The Hydrometeorological Design Studies Center within the Office of Hydrologic Development of the National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) is currently conducting a Precipitation Frequency Project for 12 Midwestern States, including Minnesota. This project is updating precipitation frequency estimates for durations from 5 minutes to 60 days and average recurrence intervals between 1 and 1,000 years. The products will be published in NOAA Atlas 14. Similar projects have been completed for 4 southwestern states (NOAA Atlas 14, Volume 1) and 13 east central states (Volume 2). Similar projects for other parts of the U.S. are also planned or underway.

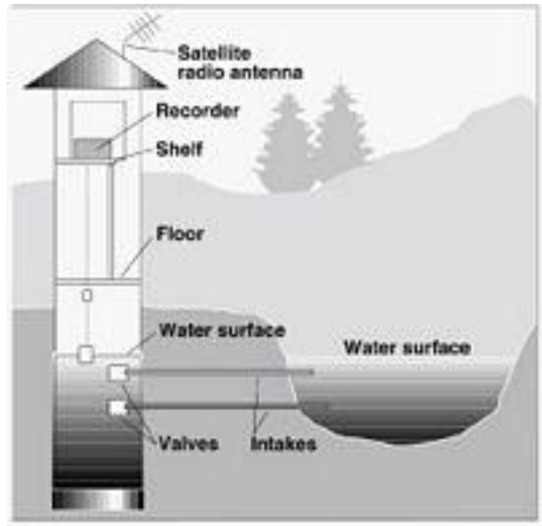


Figure 2. Example USGS Stream Gage

The U.S. Geological Survey (USGS) monitors and maintains 149 stream gaging stations in Minnesota and periodically publishes reports about specific flood events and discharge-frequency relationships at gaging stations. A report about the September 2010 floods in southern Minnesota is anticipated to be published in March 2011.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) was created by Congress in 1968 in response to rising costs of damage caused by floods and associated disaster relief. Minnesota enacted the State Floodplain Management Act (Minnesota Statutes, Chapter 103F) in 1969. The Federal Emergency Management Agency (FEMA) administers the NFIP nationally, including the floodplain mapping and flood insurance components. In Minnesota, the Department of Natural Resources administers the NFIP and the State Floodplain Management Act. The lead staff person for the DNR Floodplain Management Unit is Ceil Strauss, State Floodplain Manager (State NFIP Coordinator), 651-259-5713, ceil.strauss@state.mn.us.

The NFIP makes available federally backed flood insurance to the homeowners, renters and business owners in the communities (cities, counties, townships) that participate in the program by adopting and enforcing floodplain management ordinances to insure at-risk homes and reduce future flood damages. As of February 3, 2011, there were 552 communities in Minnesota participating in the NFIP (http://www.fema.gov/cis/MN.pdf). In 2009, there were approximately 9,000 flood insurance policies in Minnesota, and in 2010 that number increased to approximately 12,000 policies.

FEMA floodplain maps have evolved over the years, and continue to evolve, including the following generations.

Beginning in 1973 – Flood Insurance Rate Maps (FIRMs): Official hardcopy maps delineating floodplain areas where flood insurance is required for federal loans (1% annual chance (i.e. 100-yr.) floodplain areas) and where communities administer floodplain regulations.
Beginning in 2002 – Map Mod Program – Digital Flood Insurance Rate Maps (DFIRMs): Digital versions of FIRMs. This includes Q3 Flood Data, which is a digital representation of certain features of FEMA Flood Insurance Rate Maps, intended for use with desktop mapping and Geographic Information System (GIS) technology. Digital Q3 Flood Data is developed by scanning the existing FIRM hardcopy and including a thematic overlay of flood risks. The vector Q3 Flood Data files contain only certain features from the existing FIRM hardcopy. Figure 3 shows an example of a Digital Flood Insurance Rate Map for Pine Island, Minnesota.

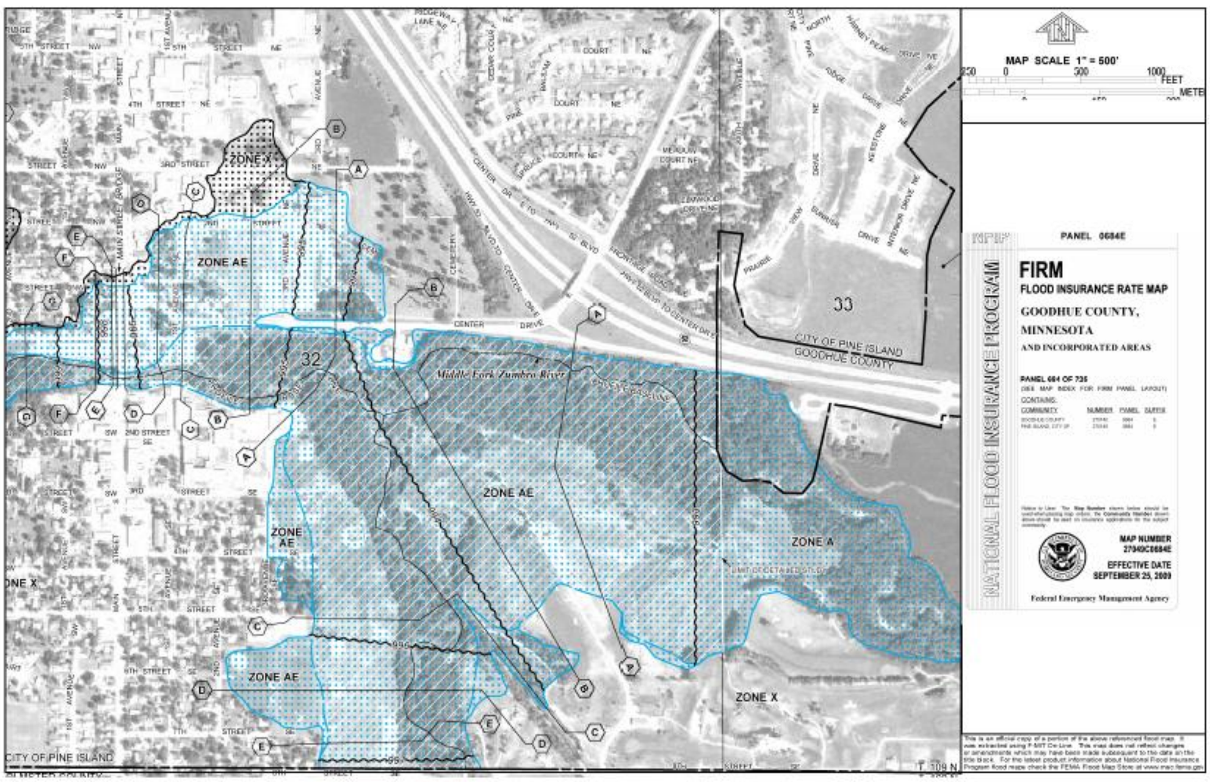


Figure 3. Digital Flood Insurance Rate Map (DFIRM)

Beginning in 2010 – Risk MAP: A new approach using high quality digital elevation data and current hydrologic and hydraulic modeling methods on a watershed basis. The digital elevation data that continues to be developed in Minnesota using LiDAR (Light Detecting and Ranging) technology will enable this new generation of floodplain mapping, hazard modeling techniques, and associated products. The goals of Risk MAP include:

- Further enhance Map Mod products, including DFIRMs, and align flood risk programs;
- Engage communities in planning and assessment with user friendly products;
- Guide watershed entities and communities in communicating risk to constituents;
- Encourage participation in the NFIP.

The products of this new generation of mapping will be digital-based and integrated with GIS mapping resources. Key products include:

- Flooded outlines for various frequency runoff events (10, 25, 50, 100 and 500-year);
- Depth and velocity grids for the different frequency runoff events;
- Percent annual chance of flooding over 30 years (typical duration of a home mortgage).

Figure 4 shows one of the Risk MAP products (500-yr. flood outline and flood depths).

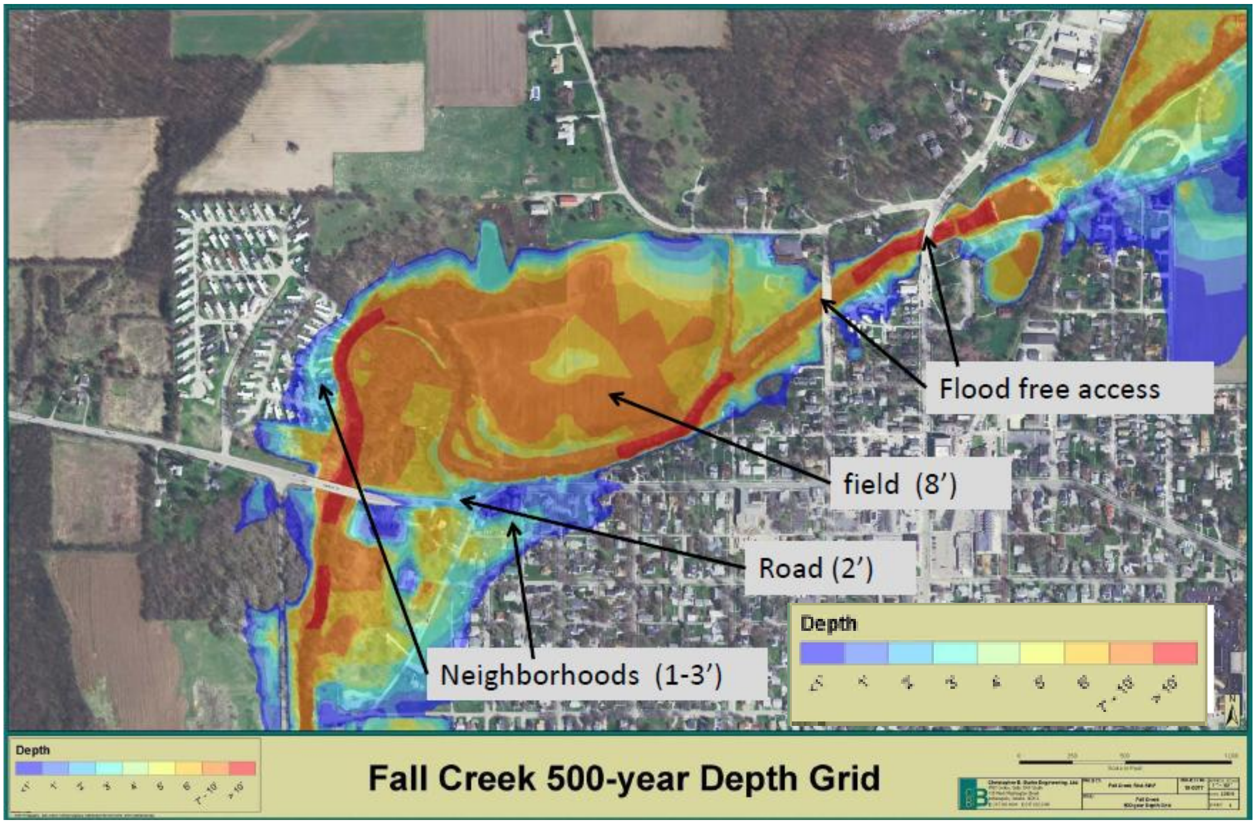


Figure 4. Example Risk MAP Product

Minnesota Statewide Flood Risk Assessment Report, January 2011

The Minnesota Department of Public Safety, Division of Homeland Security and Emergency Management (HSEM) commissioned a statewide flood risk assessment for the primary purpose of flood mitigation planning. This assessment utilized HAZUS-MH (HAZard U.S. Multi-Hazard), a standardized methodology developed by the Federal Emergency Management Agency (FEMA) that contains models for estimating potential losses from floods, earthquakes and hurricanes. This assessment was funded by FEMA and conducted by the University of Minnesota – Duluth, Geographic Information Sciences Laboratory (GISL) in partnership with the Polis Center at Indiana University Purdue University, Indianapolis, Indiana, and in consultation with HSEM. The point of contact at HSEM is Jim McClosky, Senior Community Mitigation Planner, 651-201-7455, james.mcclosky@state.mn.us.

HAZUS uses Geographic Information System (GIS) technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to a flood, earthquake or hurricane. This enables users to visualize the spatial relationships between populations and fixed geographic assets or resources for the specific hazard being modeled, a crucial function in the pre-disaster planning process. HAZUS is used primarily for preparedness and mitigation. Government planners, GIS specialists, and emergency managers use HAZUS to determine losses and the most beneficial mitigation approaches to minimize losses due to hazards. The mitigation planning process is the foundation for a community's long term strategy to reduce disaster losses and break the cycle of damage, reconstruction, and repeated damage. This information can also aid in recovery after a natural disaster.

This Minnesota statewide flood risk assessment utilized the following data sets:

- USGS 30-meter digital elevation model;
- FEMA Flood Insurance Study reports, geo-referenced images of scanned FIRMs, DFIRM vector maps and Q3 vector maps;
- Local hazard mitigation plans were used to identify historical local hazards;
- HAZUS-MH default inventory data about building stock, essential facilities, demographic information, transportation lifeline systems, utility lifeline systems, high potential loss facilities, hazardous materials facilities;
- Schools, hospitals, fire stations, police stations and state owned property inventories were updated with the best available statewide information.

Figure 5 shows the source and status of available flood mapping used for this assessment, as well as 100-yr. flood boundaries.

Potential loss estimates analyzed in HAZUS include:

- **Physical damage** to residential and commercial buildings, schools, critical facilities, and infrastructure;
- **Economic loss**, including lost jobs, business interruptions, repair and reconstruction costs; and
- **Social impacts**, including estimates of shelter requirements, displaced households, and population exposed to scenario floods, earthquakes, and hurricanes.

Figure 6 shows the estimated economic loss by county for the 100-yr. flood event. It is anticipated that these estimates will improve over time as data inputs improve.

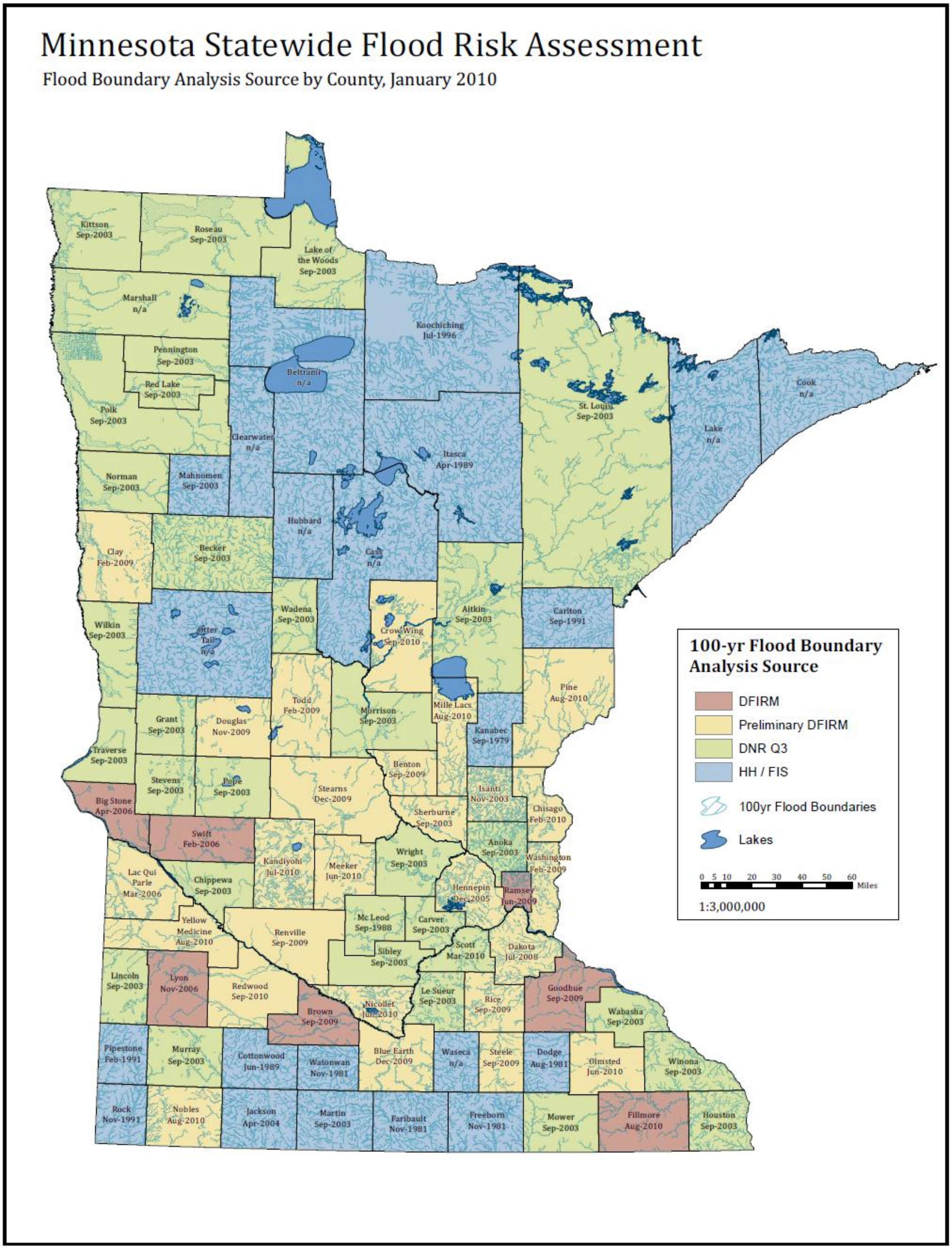


Figure 5. Flood Mapping and Boundaries – Statewide Flood Risk Assessment, Jan. 2011

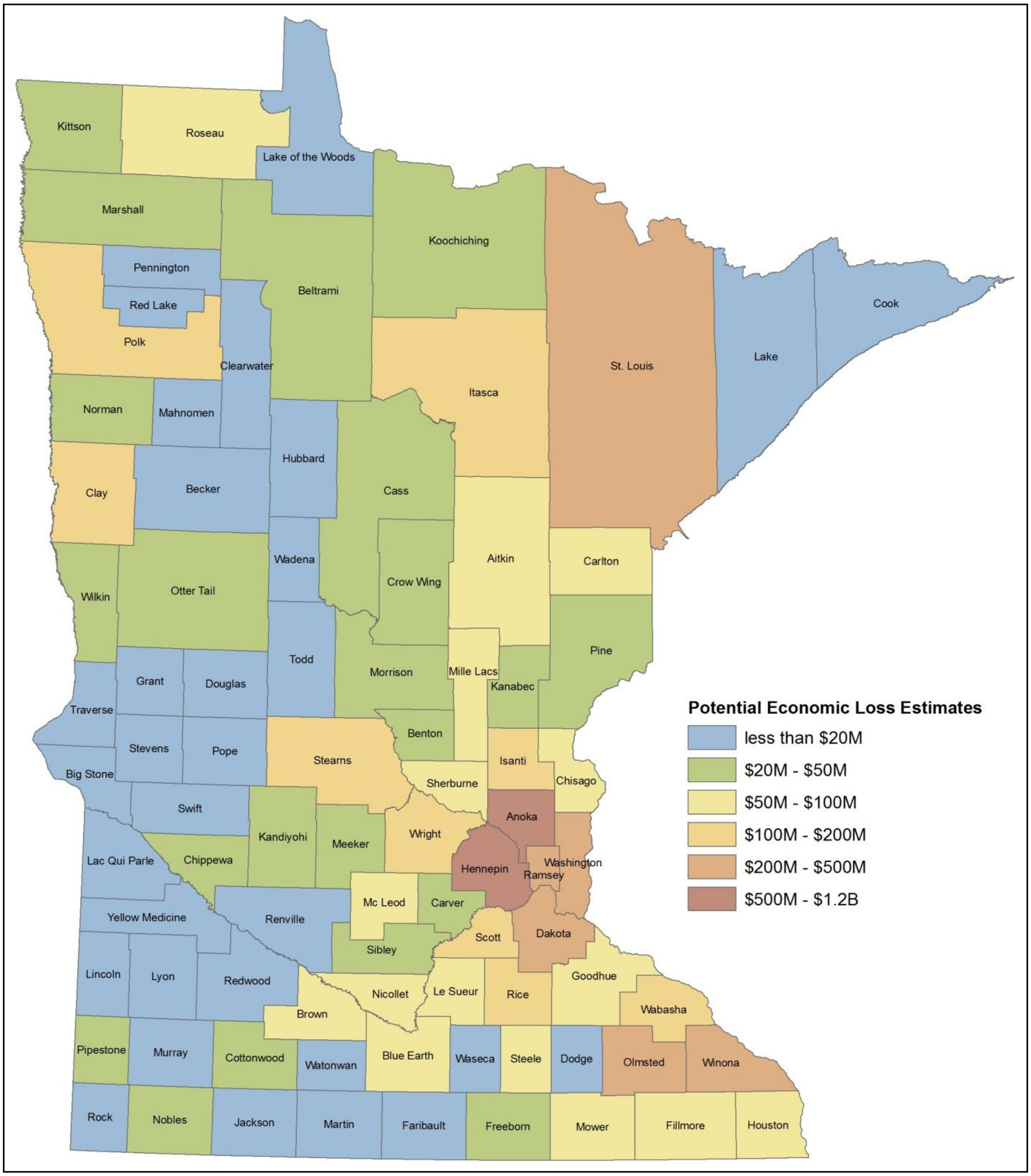
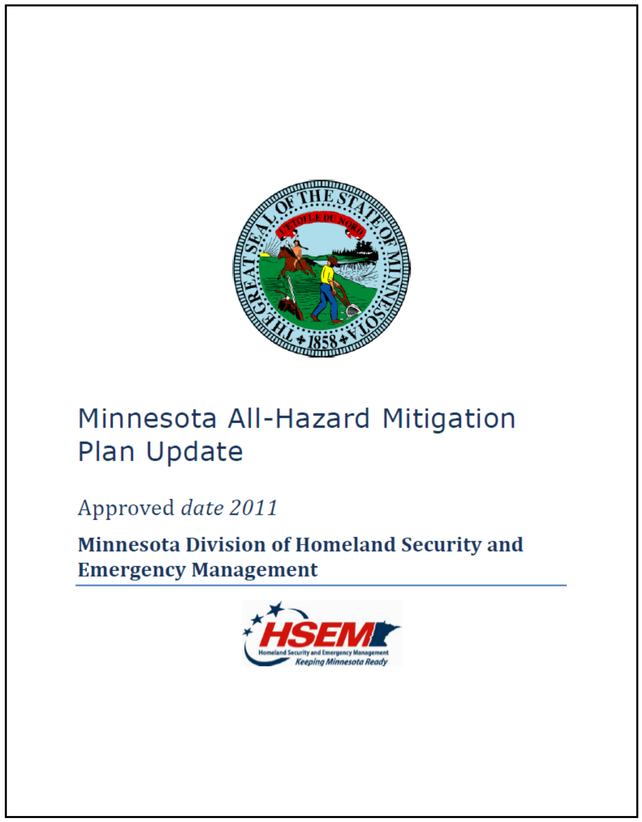


Figure 6. Potential Economic Loss Estimates for 100-Yr. Flood – Statewide Flood Risk Assessment, Jan. 2011

Hazard Mitigation Planning and Implementation

Planning

Participation in federal hazard planning, mitigation and recovery programs requires development and periodic update (3-year cycle) of a State All-Hazard Mitigation Plan. County governments and tribal communities are also required to adopt and periodically update (5-year cycle) an all-hazard mitigation plan in order to be eligible for federal hazard mitigation assistance programs. The draft 2011 Minnesota All-Hazard Mitigation Plan Update (Figure 7), which updates the plan approved in April 2008, is currently available for review at: http://www.hsem.state.mn.us/uploadedfile/2011_MinnesotaAllHazardMitigationPlanDraft.pdf. The updated plan is scheduled to be approved in April 2011. The Minnesota Division of Homeland Security and Emergency Management (HSEM) is responsible for state hazard mitigation planning, as well as for assistance of local planning and implementation. HSEM maintains a web page with information about programs, guidance and tools for local hazard mitigation planners and program applicants at: http://www.hsem.state.mn.us/Hsem_Subcategory_Home.asp?scatid=114&catid=10 . As of December 2010, 80 of 87 Minnesota counties had FEMA approved and locally adopted plans, 3 were under review by the state, 3 in process and 1 plan was FEMA approved pending adoption. FEMA provides funding assistance for planning as well as hazard mitigation.


Minnesota All-Hazard Mitigation Plan Update

Approved *date 2011*

Minnesota Division of Homeland Security and Emergency Management

Figure 7. Draft 2011 Minnesota All-Hazard Mitigation Plan Update

The Minnesota All-Hazard Mitigation Plan and local plans include a number of goals and strategies addressing flood mitigation. Following is a consolidated summary:

- Promote and assist flood risk assessment and mitigation planning;
- Promote and assist public awareness and support for flood hazard mitigation and flood insurance;
- Identify repetitive loss structures and lands (urban and agricultural), prioritize, and target for buyout or floodproofing (which can involve floodplain easements);
- Assist local communities to identify and prioritize mitigation projects and partnership strategies involving flood warning, peak flow reduction, and protection.

Implementation

Flood warning is a strategy most applicable for landscapes that have substantial topographic relief and are conducive to flash flooding. Current technology has greatly advanced the potential to use telemetry and other electronic capabilities to provide rapid flood warning. Strategically located stream and river gages can also provide substantial assistance for optimizing operation of gated floodwater impoundments and for flood level modeling and prediction that assists flood preparations and flood fighting. Recent economic constraints at the federal, state and local levels have caused substantial challenges for maintenance of existing gages and installation of new gages at strategic locations.

Acquisition (buyout and/or relocation) is a mitigation strategy directed primarily at high risk, repetitive loss structures, and/or structures substantially damaged by a flood. Since 1989, approximately 1,100 structures have been acquired by local communities in Minnesota with federal and state financial assistance. During that period, an additional 8 flood prone structures were elevated above the 100-yr. flood level to reduce the risk of flood damage.

Figure 8. House Relocation from Floodplain

Levees, floodwalls, diversions and runoff impoundments (temporary storage) are typical structural measures to prevent or reduce flooding. Because these types of measures are often quite expensive, design and implementation typically requires the involvement of one or

Figure 9. Levee at Henderson, MN

Figure 10. Floodwall at Winona, MN

more government units with applicable authority, expertise and funding capabilities. Watershed based hydrologic and hydraulic studies, and alternative analyses involving economic and environmental assessments, are typically required. Federal, state and local partnerships are often necessary for these types of projects.

Figure 11. Euclid East Impoundment, Red Lake Watershed District

In some areas of Minnesota, runoff reduction through floodwater storage is a substantial component of an overall flood mitigation plan. In the Red River Basin (Minnesota, North Dakota, South Dakota and Manitoba), floodwater storage is a major component of a long-term flood solution being developed at this time. Associated hydrologic analyses indicate that approximately 1 million acre-ft. of additional temporary storage throughout the tributary watersheds would reduce the peak flow on the main stem of the Red River by 20% for a flood equivalent to the 1997 flood. (An acre-ft. of volume is equal to 1 ft. of water over an acre of area, or about 326,000 gallons.)

Peak flow reduction through temporary storage can be accomplished at different scales:

- lot,
- neighborhood,
- field,
- drainage system,
- subwatershed, and
- watershed.

A variety of practices can be used to implement temporary storage in urban and agricultural landscapes, including:

- raingardens,
- stormwater ponds,
- conservation tillage,
- terraces,
- water and sediment control basins,
- wetland restorations,
- side inlet controls to ditches and streams,
- culvert sizing at road crossings of ditches and streams, and
- larger impoundments involving dams.

Some of these practices can also reduce flood volume via infiltration and long term storage.

Because headwater ditches and streams greatly outnumber main stem rivers, the opportunities for peak flow reduction practices are correspondingly greater at the small watershed scale. The effects of many temporary storage practices at the small watershed scale accumulate at the larger watershed scale, although typically in a less than linear relationship.

The record 24-hr. rainfall in the state occurred in August 2007 (15.10 inches at an official rain gage) in southeast Minnesota. While many conservation practices on private lands such as grassed waterways, terraces and water and sediment control basins suffered some damage during that record event, overall these practices held up very well. This flood event prompted an inventory of the water and sediment control basins and ponds in Winona County, which was found to total approximately 1,600. These types of conservation practices have been constructed over many years, and have provided peak flow reduction and associated erosion reduction for countless runoff events throughout the headwaters of the streams and rivers in the areas where they have been implemented across Minnesota.

Figure. 12. Water and Sediment Control Basin, Southeast MN

Figure 13. Conservation Easement, Minnesota River Valley, September 2010

Since 1986, conservation easements through the Reinvest in Minnesota (RIM) Reserve program, together with associated state-federal program partnerships, have helped prevent flood damage on thousands of acres of flood prone agricultural lands in floodplains and topographic depressions, in conjunction with restoring numerous wetlands, floodplain and prairie areas for erosion control, wildlife habitat, and runoff reduction. Use of marginal lands for natural resource enhancement and runoff reduction can also help protect higher quality agricultural lands.

A comprehensive flood mitigation strategy involves a variety of prevention and protection practices. The wide range of temporary runoff storage practices can also have erosion reduction and water quality benefits by reducing peak flows in ditches, ravines, streams, and rivers. Reduced erosion potential and sediment transport capacity reduces bed load and suspended sediment, which are greatest at high flows. Managing peak flows helps manage the geomorphology of ravines, streams and rivers (i.e. channel stability), which is a major factor affecting erosion and sediment sources in the Minnesota River Basin, based on sediment source fingerprinting conducted by the St. Croix Research Station of the Science Museum of Minnesota and other research projects conducted by the University of Minnesota.

Figure 14. Terraces on Sloping Agricultural Land

River Basin Floodwater Detention Planning and Implementation

Minnesota River Basin

The U.S. Army Corps of Engineers (USACE), St. Paul District, and the USDA - Natural Resources Conservation Service (NRCS), Minnesota State Office, have conducted a number of flood damage reduction studies within Minnesota over the years, including studies at the watershed and river basin scales. In the 1970s, the USDA - Soil Conservation Service (SCS), which became the NRCS in the 1990s, conducted flood damage reduction studies for 4 subareas of the Minnesota River Basin. Because the SCS authority for watershed studies and implementation is limited to 250,000 acre watershed areas, federal authority was sought and obtained in the mid 1970s (Public Law 87-639) for a joint study by the SCS and the USACE, which has authority for work in watersheds both less than and greater than 250,000 acres. These studies evaluated approximately 200 floodwater detention sites in what was called Study Area II on the southern side of the Minnesota River

Figure 15. Lake Laura Flood Reduction Impoundment, Redwood County

from the South Dakota boarder to near New Ulm, Minnesota. This area includes the Minnesota portion of the Coteau de Prairie, also known as Buffalo Ridge, which has a relatively steep and extensive northeastern slope on which snowmelt and rainfall runoff is quite fast. The Lac Qui Parle, Yellow Medicine, Redwood and Cottonwood River watersheds are located in this area of the Minnesota River Basin. As an outcome of these studies, 9 floodwater detention impoundments have been constructed to date in Study Area II, involving federal, state and local funding.

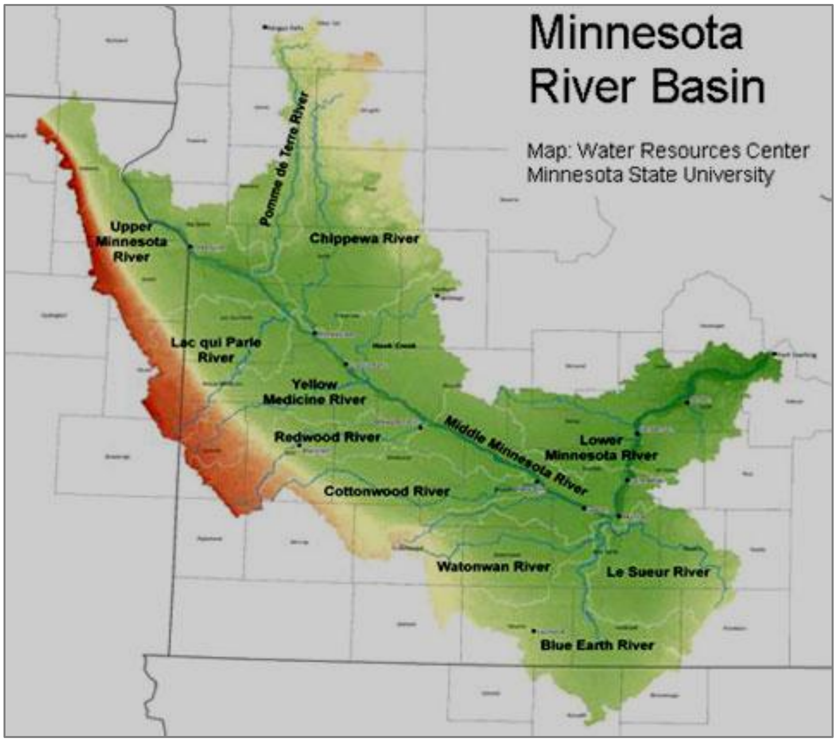


Figure 15. Minnesota River Basin (red represents highest elevations and green lowest elevations)

A joint powers group of 9 counties in Study Area II (Area II Minnesota River Basin Projects, Inc.) became a local partner with the SCS/NRCS to help implement floodwater detention projects, with assistance from the State of Minnesota through the Soil and Water Conservation Board, which became part of the Board of Water and Soil Resources in 1986. Area II Minnesota River Basin Projects, Inc. has also implemented many “road retention” projects in cooperation with local and state road authorities for temporary runoff storage and peak flow reduction. These projects typically involve raising a road across a ravine or valley (often for sight distance improvements) and down-sizing of old bridges or culverts to meter flood flows over about 72 hours, reducing peak flows downstream.

In September 2008, the USACE and State of Minnesota entered into a cost-share agreement for an Integrated Watershed Study for the entire Minnesota River Basin. The purpose of this study is to produce a watershed management plan and decision support system to assist water and land managers in the basin. The decision support system will assist planning for flood damage reduction, water quality and ecosystem restoration needs at the small and major watershed scales. Study efforts to date have identified available data sources and complementary computer models for different watershed scales and purposes to begin developing a decision support system. The detailed digital elevation data funded by the State of Minnesota and collected in 2010 via LiDAR in the Minnesota River Basin is currently being processed into readily available data sets that will greatly facilitate the modeling efforts of this Integrated Watershed Study. The cost of this digital elevation data will count toward the state cost-share for this study.

Red River Basin

The Red River of the North Basin (also known as the Red River Valley) in northwest Minnesota, eastern North Dakota, the northeast corner of South Dakota, and southern Manitoba, Canada is an area with a long history of flooding problems associated primarily with its geologic history at the southern end of the extensive Glacial Lake Agassiz. The basin has substantial topography along its eastern and western sides in Minnesota and North Dakota, with a very broad, flat plain along the Red River, which slopes gently to the north and outlets into Lake Winnipeg, as shown in Figure 16.

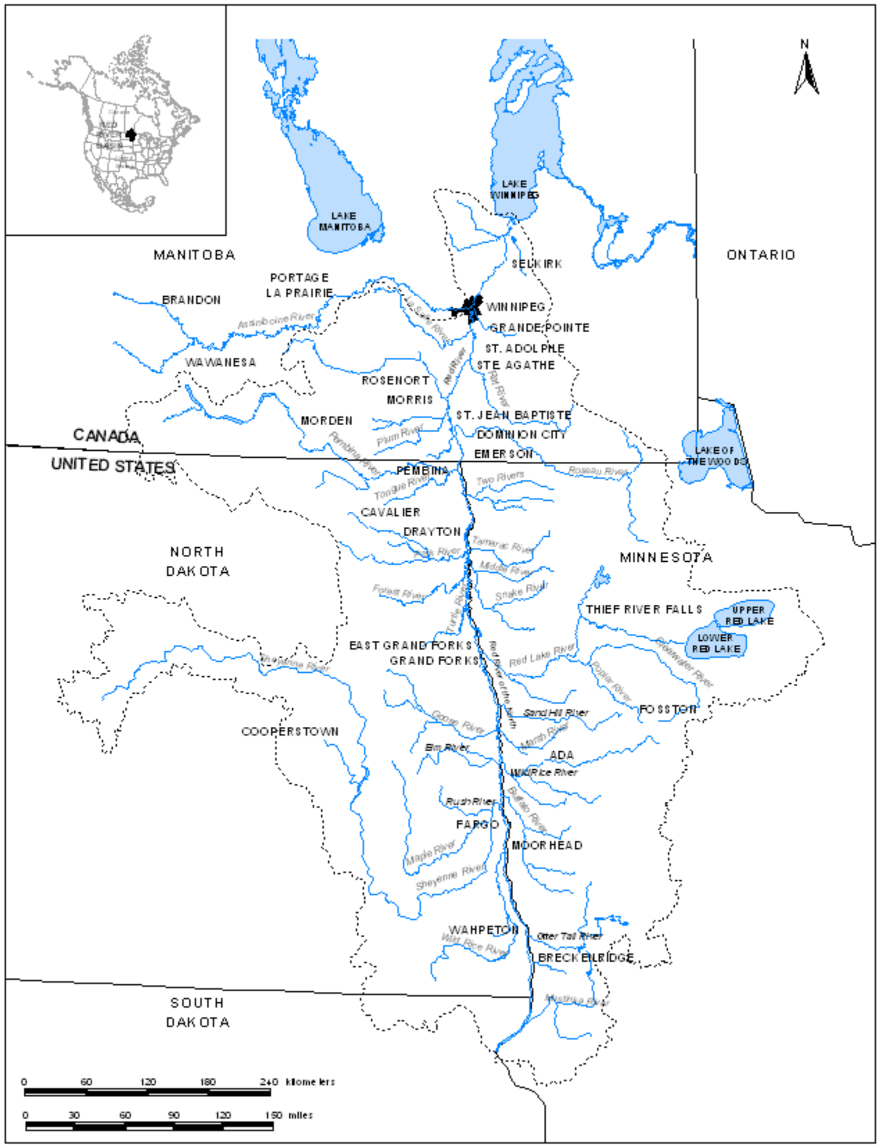


Figure 16. Red River of the North Basin

The first interstate planning and implementation efforts of Minnesota, North Dakota and South Dakota to address flooding in the Red River Basin occurred in the early 20th century. After Minnesota passed the Watershed Act in 1955, watershed districts began to be established in the Red River Basin on the Minnesota side of the Red River. Flood damage reduction was a substantial purpose of these watershed districts. The Red River Watershed Management Board (RRWMB) was established in 1976 to help coordinate planning and funding for flood damage reduction projects, with a focus on temporary storage of floodwaters to reduce peak flows and flooding on tributaries and the main stem of the Red River. By the mid 1990s, watershed districts in the Red River Basin had constructed approximately 35 floodwater impoundments, several of which involved partnerships for waterfowl and wildlife lands. However, due to concerns about cumulative environmental impacts, a permitting moratorium was declared by the USACE and an Environmental Impact Statement was prepared. The resulting stalemate was broken by the development of a mediated stakeholder agreement for flood damage reduction and natural resource enhancement in the Red River Basin in Minnesota, which was signed by numerous stakeholders in 1998. Since the Mediation Agreement and associated coordination and permitting process was adopted in 1998, watershed districts in the Red River Basin in Minnesota have implemented, and are planning, a number of floodwater detention and natural resource enhancement projects, as shown in Figure 17.

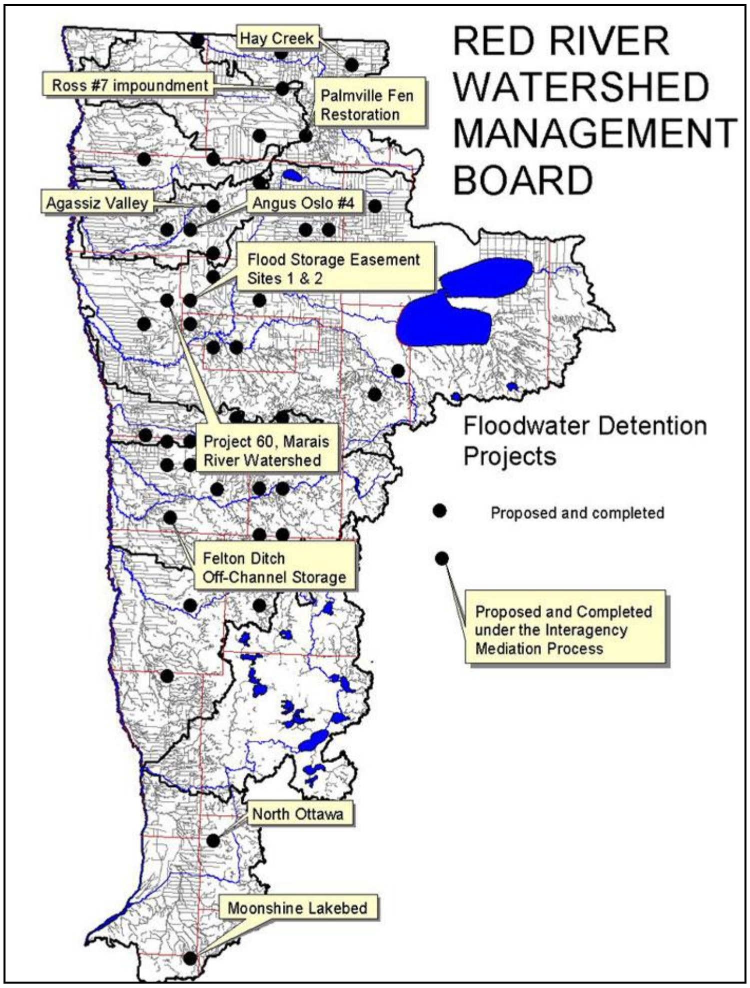


Figure 17. Red River Basin Floodwater Detention Projects in Minnesota

During the past fourteen years, the Red River flooded in 1997, 2004, 2006, 2009 and 2010, in spite of the floodwater detention projects constructed to date in the Red River Basin in Minnesota and North Dakota. Many towns, cities and farmsteads in the Red River Basin utilize emergency or permanent levees and floodwalls to help protect them from flooding. A catastrophic failure of the emergency levees around Grand Forks, North Dakota and East Grand Forks, Minnesota, occurred during the very large 1997 spring flood.

In 2009, the Minnesota and North Dakota legislatures appropriated funding for the Red River Basin Commission (RRBC) to prepare a comprehensive Long-Term Flood Solution (LTFS) plan for the Red River Basin. A final report is due by June 30, 2011. This effort involves many stakeholders and technical experts, including agencies and officials from all levels of government that work with flooding issues. The study is being coordinated with a basin-wide feasibility study lead by the Corps of Engineers, which is utilizing detailed digital elevation data for the entire Red River Basin in the U.S. to develop 2-dimensional flow hydraulic models for the main stem and tributaries of the Red River. This new elevation data was recently acquired through the International Water Institute using LiDAR technology and was funded by a federal, state and local partnership.

A significant component of this LTFS planning involves defining potential project sites within the tributary watersheds for floodwater detention to reduce peak flows on the main stem by at least 20%. It has been determined that approximately 1 million additional acre-ft. of distributed temporary storage within tributary watersheds is needed to accomplish this goal. Known and potential sites are being identified by water management districts in Minnesota, North Dakota and South Dakota. For example, the Bois des Sioux Watershed District in Minnesota has identified 27 potential floodwater detention sites with a total storage potential of approximately 100,000 acre-ft. of gated (i.e. operable) storage.

A new Red River Retention Authority has been established through a joint powers agreement between the Red River Watershed Management Board (RRWMB) in Minnesota and the North Dakota Red River Joint Water Resources Board (RRJWRB). This interstate authority intends to facilitate and coordinate the planning, funding and implementation of floodwater detention projects throughout the Minnesota and North Dakota portions of the Red River Basin to help achieve a watershed based approach to flood damage reduction in the Red River Basin.