Legislative Water Commission

Field Tour Packet

(8/17/16)

Legislative Water Commission Field Trip Itinerary

Wednesday 8/17/16

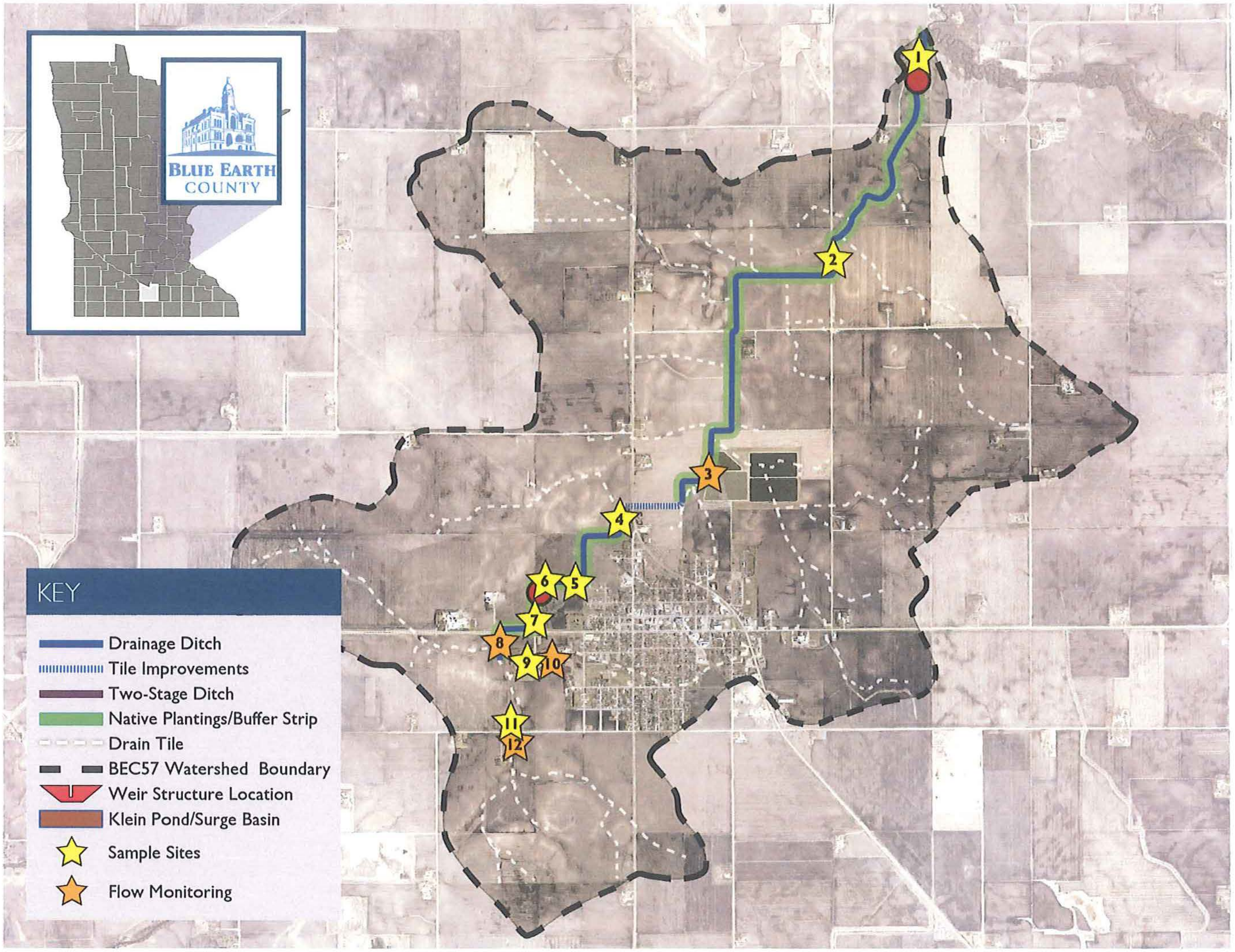
The public is welcome to join any of the stops on this tour. Parking is limited at some stops; please read the route column. Outdoor stops will involve walking up to 1/2 mile on flat,but uneven ground, wiht some mud and tall grass. Indoor stops will include some stairs and noise. For questions or to request disability accommodations, please contact at barb.huberty@lcc.leg.mn or at 651/284-6431 before noon on Tues 8/16.

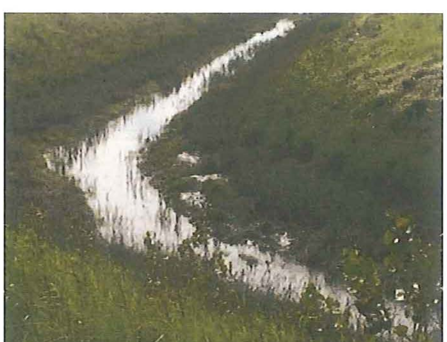
	Site	Route	Timeframe	Time (min)	Distance (miles)	Issues	Location	Particpants	Contact Phone#	Contact email
1	Travel to Mapleton	MLK Blvd S/E to Cedar; S to 12th, W to 35E ramp; S on 35E/35; W on 60 (construction backup likely before the exit); S Co 3 to Janesville; W 2nd St (1 block before the T); S on Main (becomes Co 3); W on Co 9/Co10; S on 22, R on Central; there is limited parking at the Ditch 57 site (access via the City compost site), so *those in cars should park at the park across from Caseys & hop on the mini coach for the next stop*; will return people to their cars	7:30 to 9:30	120	100		Meet in front of the State Office Building (100 Rev Dr Martin Luther King Blvd)			
2	Caseys {restroom opportunity}		9:30 to 10:00	30		Before leaving Caseys, we'll look at the 2-stage section of Ditch 57 from the back of the store	504 Central Ave N, Mapleton, MN	Chuck Brandel, ISG; *Pat Duncanson, invited*	507/387-6651	chuck.brandel@is-grp.com
3	Travel to Ditch 57 site (access via city compost site)	S on Central, W on 30; 1st R after cemetery; park on left site & leave end spot for the mini coach	10:00 to 10:10	10	2					
4	Ditch 57		10:10 to 10:30	20		buffers, ditch design and maintenance, adding water storage	~0.5 mi west of Central Ave & Silver St (aka MN Hwy 30) @ the compost site	Chuck Brandel, ISG; *Pat Duncanson, invited*	507/387-6651	chuck.brandel@is-grp.com
5	Travel to Le Sueur River site	E 30, N Central, N 22, W 16; *car drivers park in DNR's canoe access lot befor crossing the Le Sueur River (18426 568th Ave, Mankato) & hop on the minicoach* (limited parking at Wel's home); will return people to their cars	10:30 to 10:55	25	13					
6	Le Sueur River oxbow	we will start in the Wel's side yard for an introduction & circle the oxbow to view several banks	10:55 to 11:45	50		causes/solutions for accelerated hydrology & erosion in the MRB (REACH and CSSR studies; link to Le Sueur Watershed WRAPS)	18532 568th Avenue, Mankato	Dr Patrick Belmont		patrick.belmont@usu.edu
7	Travel to Mankato Wastewater Treatment Facility {restroom opportunity}	N 16, R on S Riverfront Dr (reduced to 1 lane for construction in 1 segment); L on Lafayette/3rd Ave; L on Pine	11:45 to noon	15	8					
8	Mankato WWTF	take a left after the gate/in front of the round equalization basins & park in front of the main/office building	Noon to 12:45	45		wastewater reuse, P trading/removal efficiencies @ WWTF, + other City water initiatives/needs	701 Pine St, Mankato	Mary Fralish	507/340-4199 (cell)	mfralish@city.mankato.mn.us
9	Travel to St Peter via US 22 (NOTE: Hwy 169 is closed between St Peter and Mankato)	R on Pine, L on 3rd Ave (becomes Co 5 & then Co 21), R on 101, L on MN 22, R on Minnesota Ave, L on College, R on Washington; use Entrance B	12:45 to 1:00	15	11					
10	St Peter Senior/Community Center {restroom opportunity}	NOTE: Erberts & Gerberts box lunches will be provided for LWC members & the 2 luncheon speakers; other attendees are on their own for lunch. Others can either orderia box lunch ahead of time from Erberts & Gerberts and have it delivered to the Senior Center (see address) or grab lunch to go from a nearby fast food option on your way (Subway, Arby's & Kwik Trip are near the intersection of 22/MN Ave)	1:00 to 1:50	50		lunch with overview of cooperative wellhead protection history	601 South Washington Ave; Suite 219	Pete Moulton Bruce Montgomery	507/934-0670 651/201-6178	petem@saintpetermn.gov bruce.montgomery@state.mn.us
11	Travel to WTF	R on Washington; L on Broadway; L after watertower	1:50 to 1:55	5	1					
12	tour of water treatment facility	there are some stairs and noisy areas on this tour	2:00 to 2:30	30		treatment train/processes, O & M, testing	1312 Broadway Ave	Jeff Knutson Chris Voeltz	507/934-0670 507/934-0670 (X651)	jeffk@saintpetermn.gov chrisv@saintpetermn.gov
13	Travel to Peter/Payne farms	*those in cars should hop on the minicoach @ the WTF to travel to the next stop (* narrow parking on shoulder is limited); please reserve the field approach for the minicoach; L on Broadway/Old Fort Road; L on 371st Ave/Co 40; R on Mn 99, R on 13	2:45 to 3:00	15	9					
14	Peter/Payne farms	the ground may be soft	3:00 to 3:30	30		7 Mile Creek Project: voluntary/cooperative approach to watershed mgmt & multibenefits drainage project	44891 Co Hwy 13	Karen Galles	507/301-9625	Karen.Galles@nicolletswcd.org
15	Return to WTF to pick up cars	E/S on 13, E 99, L on 371st/Co 40; R on Old Ft Rd/Broadway	3:30 to 3:45	15	9					
16	Travel to Blakely Ravine	R on Broadway; N on 169; L on Co 60 (the intersection after the sign to Blakely; will be marked closed); go to dead end	3:45 to 4:15	30	25					
17	Blakely Ravine collapse/repair	3 min walk down former roadway to view repairs on the right and collapse on the left	4:15 to 4:45	30		effect of large storm events on infrastructure; approach to scale up conservation projects	15801 Blakeley Trail	*Paul Nelson, invited*	952/496-8054	pnelson@co.scott.mn.us
18	Travel to State Office Building, St Paul	E on Co 60; N on 169; E on 494; N on 35E; Kellogg exit to John Ireland to Rice (off load in back of SOB)	4:45 to 6:00	75	53		100 Rev Dr MLK Jr Drive			

Stops 1 & 2
Mapleton, MN

Drainage ditches: their design, enhancement, maintenance and buffers

Blue Earth County Ditch 57
Mapleton, MN





TWO-STAGE DITCH

RATE CONTROL WEIR

KLEIN SURGE POND

Blue Earth County Ditch 57
Mapleton, MN

BACKGROUND

Blue Earth County Ditch (CD 57) is a 6,040 acre drainage system that was deteriorating and in need of improvements due to severe flood damage to farmland and roadways. ISG was selected to conduct a feasibility study based on their agricultural and environmental expertise. In 2007, landowners petitioned to make improvements to the system to increase drainage capacity on this public drainage system, while also being conscious about downstream flooding and water quality. Budget allocations required landowner contributions as well as outside funding sources.

PARTNERS

- Blue Earth County Drainage Authority
- ISG
- Minnesota Department of Natural Resources (MN DNR)
- Minnesota Department of Agriculture
- Blue Earth County Soil and Water Conservation District
- Minnesota State University, Mankato Departments of Civil and Mechanical Engineering, Chemistry and Geology

LCCMR FUNDING

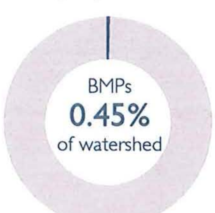
After ISG determined cost and capacities, several grant applications were submitted, and a grant was awarded by the LCCMR for $485,000 to be utilized for the water quality portion of the project. Multiple storage options were reviewed with the landowners and they selected the improvements in collaboration with ISG and the other agencies. The following options were considered:

- In-channel storage
- Two-stage ditch
- Wetland restoration
- Surge ponds
- Enhanced buffers
- Rate Control Weir

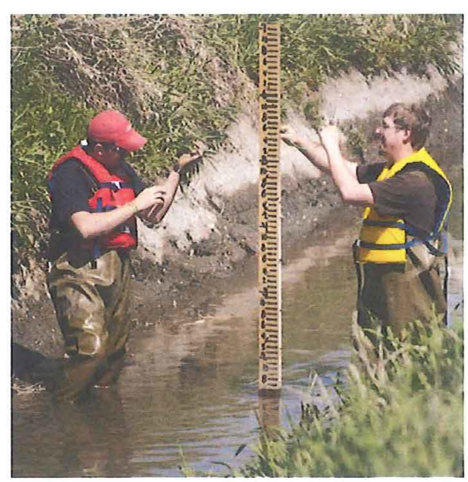
Based on cost and capacities for the system, the following improvement projects were implemented: **Enhanced Buffers**, **Two-Stage Ditch**, **Rate Control Weir**, **In-channel Storage**, **Klein Pond** and a **City Pond**. Due to cooperation with landowners and Blue Earth County, no easements were taken without full support from landowners.

METHODOLOGY AND IMPLEMENTATION

Data was collected prior to construction of BMPs in order to compare the changes in water quality due these practices. Implementation of the plan included expanding native grass buffers along the sides of the original ditch. The installation of two large storage ponds were designed to capture and hold runoff to reduce peak flows and improve water quality. A two-stage ditch managed perennial flow and a rate control weir was built at the outlet of the system.



ISG collaborated with private and public sector stakeholders and coordinated monitoring assistance from Minnesota State University, Mankato students and faculty. Involving students in the process allows them to broaden their experiences and further develop their skills and knowledge as future environmental professionals.



Water quality monitoring allowed ISG to analyze results of the improvements. Three seasons of water quality monitoring were completed following the construction of the improvements. Data logging devices recorded depth of water in five-minute increments continuously. Twelve monitoring locations and seven water quality sample stations were designed throughout the system to record depth and water quality data. Minnesota State University, Mankato Laboratory analyzed all samples.

Recognized as a model project, CD 57 is the result of an important collaboration with farmers, landowners, county authorities, engineers, surveyors, tiling contractors, DNR, and other state and county agencies. Together, this group developed several goals which included replacing a deteriorating tile system, increasing drainage capacity, improving water quality and reducing peak flows, and increasing diversified habitat all while protecting downstream landowners and natural features. From these goals, a multi-purpose drainage management plan was created.

Together, the enhancements are making an ongoing difference. In one particular significant rain event, 2.63 inches fell in two hours. Eighteen hours after the event occurred, the two storage ponds were still doing their job which allowed the farmland to drain down in time to save the crop. The two-stage ditch, storage ponds and rate control weir together reduce peak flows, Total Suspended Solids, Total Nitrogen and Total Phosphorus, all while providing adequate drainage to the system. The adjacent figure summarizes the average reduction for these parameters from 2012-2014.

Precipitation

- Rain gauge records every 0.01" of rainfall & barometric pressure
- Weather station records rainfall (total & intensity), temperature, wind speed & direction, relative humidity

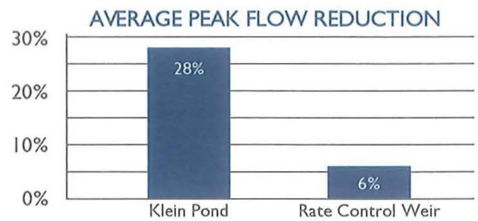
Flow Monitoring

- Data logger records water depth every 5 minutes
- Staff gauge for manual readings taken by camera
- Camera takes pictures every 5 minutes to verify and calibrate the data logging device

Frequency

- Data collection for 3 years post construction (2012, 2013, 2014)
- Monitoring begins in March or after ice out
- Monitoring continues through October
- At least one water quality sample and manual flow reading were taken during base flow conditions per month
- Water quality samples were taken after one-inch rain events

MONITORING

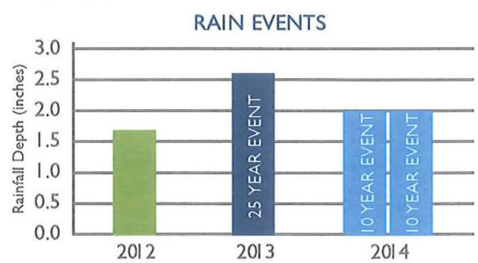


Parameters - Grab Samples

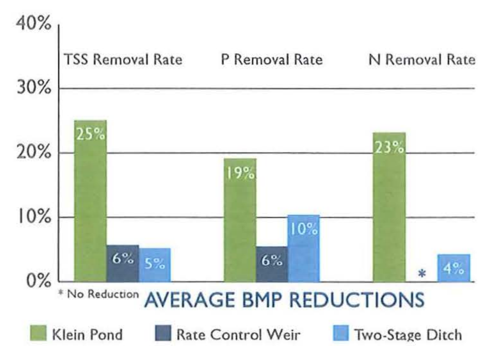
- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)
- Total Phosphorous (TP)
- Ortho-Phosphorous
- Nitrate
- Nitrite

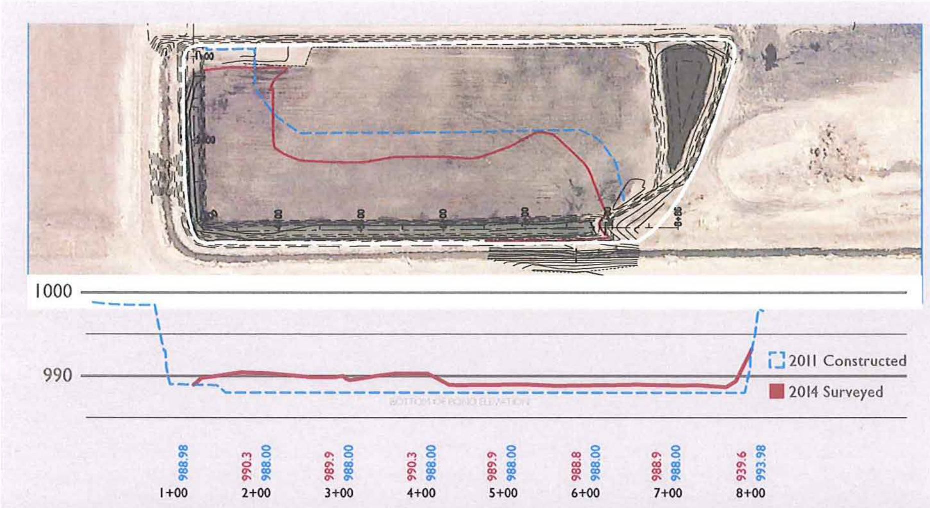
Parameters - Instrumental Readings

- Temperature
- pH
- Dissolved Oxygen
- Specific Conductivity
- Turbidity
- T-Tube



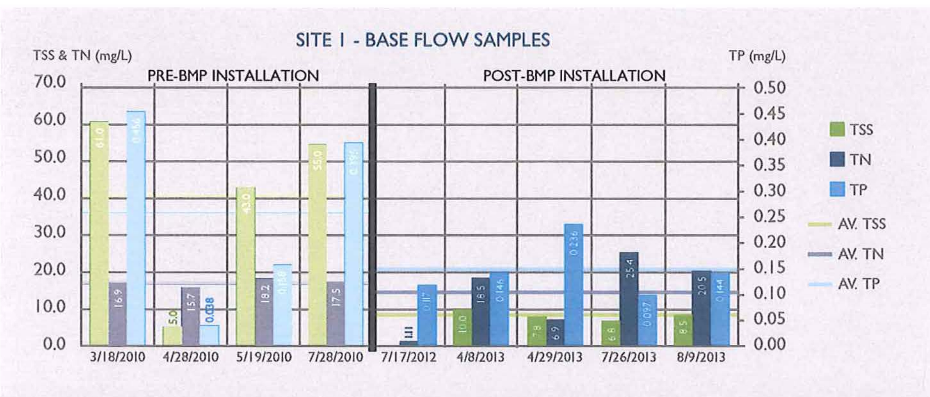
ACCOMPLISHMENTS + RESULTS



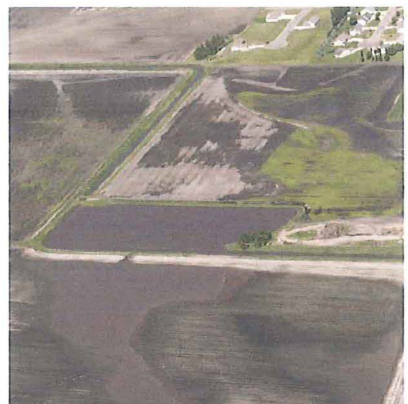


70 TRUCK LOADS OF SEDIMENT CAPTURED IN KLEIN POND

DIVERSIFIED WILDLIFE



BASEFLOW MONITORING RESULTS



AERIAL OF KLEIN POND

NEXT STEPS

Continued monitoring is taking place through Minnesota Department of Agriculture, Minnesota State University, Blue Earth County, and ISG with funds from multiple sources including LCCMR. The analysis of the data, BMP effectiveness, ongoing maintenance costs associated with the BMPs and sharing results is necessary to maximize on the past success of this research. Implementation of these and other innovative concepts on a larger scale will further benefit the landscape, water quality, and producers into the future.

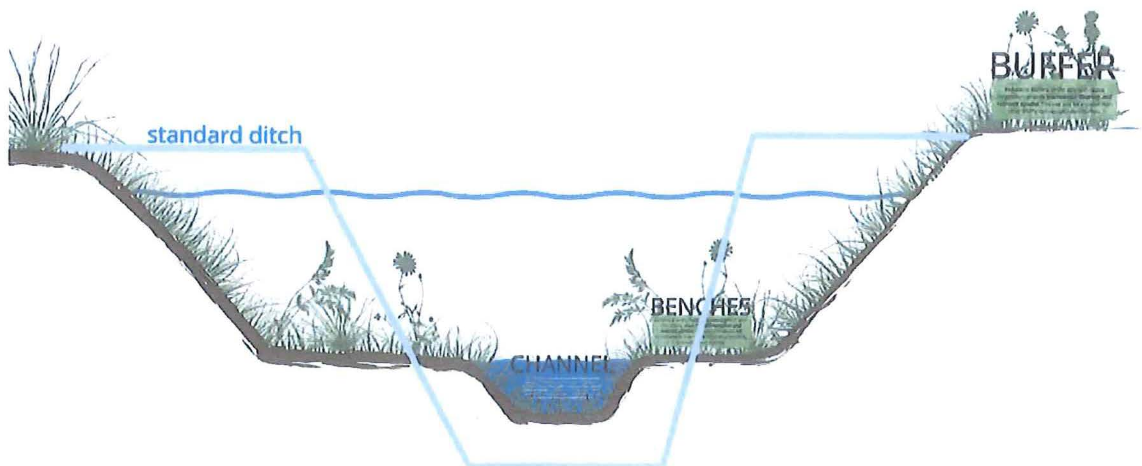
PARTNERS

BLUE EARTH COUNTY

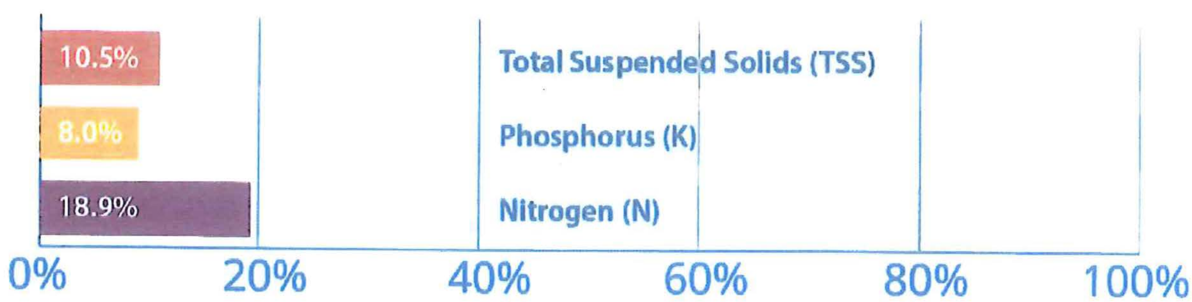
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

ISG

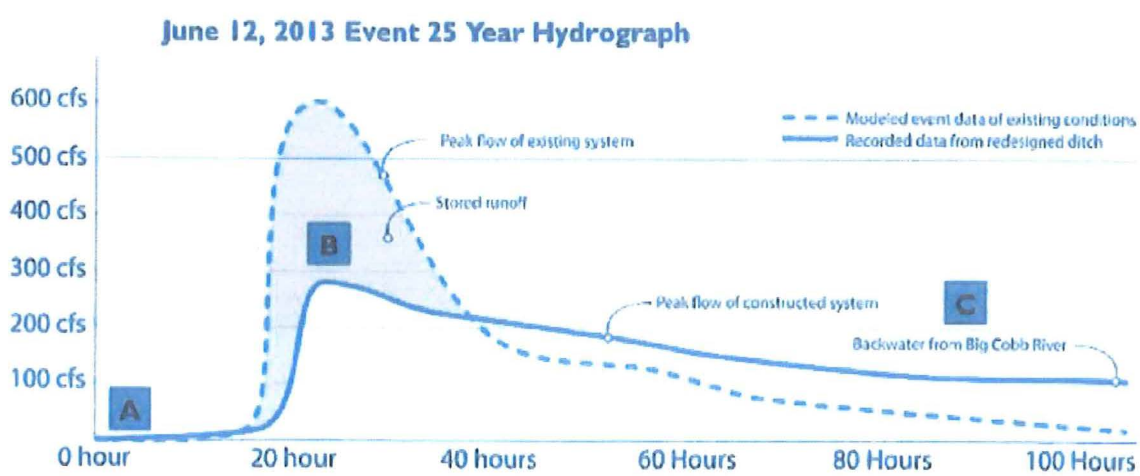
Cross sections comparing a two stage ditch to a standard ditch:



2013 two stage ditch average reductions:



Peak flow reductions due to the added rate control weir:



Drainage Work Group

Fact Sheet

Drainage Work Group Purpose

The stakeholder Drainage Work Group has been meeting since 2006 for the following purposes:

- Foster science-based mutual understandings regarding drainage topics and issues;
- Develop consensus recommendations for drainage system management and related water management, including recommendations for updating Minnesota Statutes Chapter 103E drainage law and other provisions.

Drainage Work Group Membership

Drainage Authorities	**AMC** – Association of Minnesota Counties
	MAWD – Minnesota Association of Watershed Districts
Farm Groups	**MFB** – Minnesota Farm Bureau
	MFU – Minnesota Farmers Union
	Lobbyist for several other Agriculture and Producer Groups
Environmental Groups	**MCEA** – Minnesota Center for Environmental Advocacy
	FWLA – Fish and Wildlife Legislative Alliance
	MCF – Minnesota Conservation Federation
Other Associations	**MASWCD** – MN Association of Soil and Water Conservation Districts
	MVA – Minnesota Viewers Association
	MACO – Minnesota Association of County Officers
	MADI – Minnesota Association of Drainage Inspectors
	RRWMB – Red River Watershed Management Board
	MAT – Minnesota Association of Townships
	MAWRC – Minnesota Agricultural Water Resources Coalition
	ADMC – Agricultural Drainage Management Coalition
State Agencies	**BWSR, DNR, MDA, MPCA**
Legislature	Legislators and/or House and Senate staff

Why Drainage is an Important Topic

- Water quality and quantity management are increasingly important as the Impaired Waters List for Minnesota continues to grow, Total Maximum Daily Load (TMDL) studies and plans are developed and implemented, and the Minnesota Clean Water, Land and Legacy Amendment is implemented.
- Because drainage is critical for agriculture, roads and urban areas, drainage management is likewise critical. Drainage involves numerous stakeholders.
- Drainage infrastructure provides substantial opportunity for multipurpose water management practices and projects.

Drainage Work Group Activities and Accomplishments to Date

Through stakeholder coordination facilitated by the Board of Water and Soil Resources, the Drainage Work Group (DWG) has developed a number of consensus recommendations to update Chapter 103E drainage law and to otherwise enhance drainage management. Following is a summary.

In 2006, the DWG developed consensus recommendations to:

- clarify and enhance Chapter 103E drainage law regarding buffer strips and side inlet controls along public drainage ditches (Section 103E.021);
- clarify protection of conservation practices along drainage ditches;
- clarify ditch inspection frequency;
- develop drainage records modernization and preservation guidelines and promote state cost-share for drainage records modernization;
- support updating of the Minnesota Public Drainage Manual; and
- support establishment of an interagency drainage management team to provide coordination and assistance to promote multipurpose drainage management.

These consensus recommendations were substantially adopted by the Legislature in 2007, without controversy.

In 2007, 2008 and 2009, the DWG developed additional consensus recommendations to further update Chapter 103E drainage law and to enhance drainage management, including:

- clarify the scope and process of Section 103E.227 to better enable wetland restorations and other impoundments on drainage systems, and associated funding partnerships between drainage systems and conservation programs;
- clarify the language and process of Section 103E.805 to better enable partial abandonment of drainage systems for wetland restorations and other impoundments;
- require all Chapter 103E drainage authorities (counties and watershed districts) to appoint a drainage inspector;
- update various dollar limits and thresholds in drainage law, primarily for inflation;
- support additional state cost-share for drainage records modernization; and
- provide authority in statute to BWSR for drainage stakeholder coordination.

These consensus recommendations were substantially adopted by the Legislature in 2010, with minimal tweaks. However, additional drainage records modernization cost-share was not addressed (2010 was not a biennial appropriation year).

Other Topics of Discussion to Date

- Review of drainage law and experience regarding transfer of drainage system authority, particularly where urban areas have expanded over agricultural drainage systems.
- Water quality use classifications and public drainage systems.
- Drainage ditch assessments on state Consolidated Conservation lands.
- Sources of sediment in the Minnesota River Basin.
- Current conservation drainage practices – research and experience.
- Methods and process for redetermination of benefits of drainage systems, including adjusting drainage assessments for land use change.
- Lateral effects of drainage on conservation lands and conservation lands on farmland.
- LCCMR projects regarding drainage law evaluation and intensified tile drainage effects.
- Section 103E.015 Considerations before drainage work is done.
- Other current drainage related research, information, legislation, programs and topics.

Redetermination of Benefits Examples

Martin County

Judicial Ditch No. 32: (all subsurface tile system) Original benefits of $21,130 for 337 acres in 1914. After redetermination of benefits in 2005, the drainage system has benefits of $349,601 for 952 acres. Redetermination cost was $2.88 per acre.

County Ditch No. 11: Original benefits of $137,682 for 2,312 acres in 1908. After redetermination of benefits in 2009, total benefits of $6,807,504 for 11,003 acres. A total of 56.7 acres of buffer strips were acquired and established by the drainage system. Redetermination cost was $2.36 per acre.

Kandiyohi County

County Ditch No. 10: Original benefits of $904,170 for 8,004 acres in 1898. After redetermination of benefits in 2010-11, total benefits of $6,537,384 for 15,722 acres. A total of 30.8 acres of buffer strips will be acquired and established by the drainage system. Redetermination cost was $3.18 per acre.

County Ditch No. 38: (all subsurface tile system) Original benefits of $22,995 for 472 acres in 1917. After redetermination of benefits in 2010-11, total benefits of $765,867 for 1,206 acres. Redetermination cost was $3.75 per acre.

Bois de Sioux Watershed District

Judicial Ditch No. 2: Original benefits of $20,507 for 17,577 acres circa 1900. After redetermination of benefits in 1999, total benefits of $3,927,667 for 59,690 acres. A total of 15.1 acres of buffer strips were acquired and established by the drainage system. Redetermination cost was approximately $2.00 - $3.00 per acre.

Drainage Work Group Membership

Drainage Authorities

Association of Minnesota Counties (AMC)
MN Assn. of Watershed Districts (MAWD)

Farm Groups

Minnesota Farm Bureau (MFB)
Minnesota Farmers Union (MFU)
MN Ag. Water Resources Coalition (MAWRC)
Agricultural Drainage Mgmt. Coalition (ADMC)
Representative for several other Ag Groups

Environmental Groups

MN Center for Enviro. Advocacy (MCEA)
Fish and Wildlife Legislative Alliance (FWLA)
Minnesota Conservation Federation (MCF)

Other Associations

Minnesota Association of Soil and Water Conservation Districts (MASWCD)
Minnesota Viewers Association (MVA)
MN Assn. of County Officers (MACO)
MN Assn. of Drainage Inspectors (MADI)
Red River Water Mgmt. Board (RRWMB)
MN Association of Townships (MAT)

State Agencies

Board of Water and Soil Resources (BWSR)
Department of Natural Resources (DNR)
MN Department of Agriculture (MDA)
MN Pollution Control Agency (MPCA)

State Legislature

Legislators and/or House and Senate Staff

January 2011

Minnesota Statutes Chapter 103E – Drainage

Redetermination of Benefits and Damages for Drainage Systems

An Overview Prepared in Collaboration with the Stakeholder Drainage Work Group for Drainage Authorities, Landowners and Others

www.bwsr.state.mn.us/drainage
(under "**Drainage Work Group**")

Key Definitions

Redetermination of Benefits and Damages: A procedure in Chapter 103E, Section 103E.351 to update the determination of benefits and damages for affected parcels and properties of a drainage system, and the total value of benefits for the drainage system.

Drainage Authority: County or watershed district boards, or joint county boards, authorized by Minnesota statutes to administer public drainage systems under Chapter 103E.

Viewers: Residents of Minnesota who are qualified to determine benefits and damages of drainage systems and are appointed by the drainage authority for that purpose.

Minnesota Viewers Association
www.mndrainageviewers.org

Why Redetermine Benefits

1) Benefited lands and benefits of many public drainage systems have not been updated for decades, some for over a century.
2) Drainage system benefits are determined at one point in time, with no provision in Chapter 103E to index for inflation over time. The cost of a repair cannot exceed the total value of benefits of the drainage system on record.
3) The drainage system repair fund limit is 20% of the total assessed benefits of the system, or $100,000, whichever is greater.
4) Chapter 103E projects that require right-of-way (establishment, improvement, or repair by resloping of ditch side slopes) must have viewers appointed to determine associated benefits and damages. Partial system projects can create benefit inequities.
5) As new private drainage is outlet into a public drainage system, the total benefits of the system and the relative benefits to land parcels and other infrastructure change. These benefits and associated assessments for repairs can only be updated via a redetermination of benefits and damages.

How Benefits and Damages are Redetermined

Viewers first verify or identify the land parcels, roads and other infrastructure served by a Chapter 103E drainage system. Viewers then use mass appraisal methods to determine benefits of the drainage system. A number of variables, including land use, productivity and value, drainage outlet potential, and drainage system requirements or impacts are used by viewers to determine drainage system benefits and damages. The redetermined benefits replace those used to apportion drainage system repair or maintenance assessments.

Systematic Redetermination of Benefits

A number of drainage authorities in Minnesota have undertaken a systematic redetermination of benefits and damages for all of the Chapter 103E drainage systems under their jurisdiction, including surface ditches and subsurface tile systems. These drainage authorities include: Freeborn, Martin, Steele, Sibley, Kandiyohi and Faribault Counties. Freeborn County started in 1995 and will complete redeterminations for all of its 119 Chapter 103E public drainage systems in 2011. Martin County started in 2001 and is well along with redeterminations for its 200+ Chapter 103E public drainage systems.

Required Drainage Ditch Buffer Strips

Section 103E.021 requires the establishment of minimum 1-rod (16.5 ft.) buffer strips of perennial vegetation along Chapter 103E drainage ditches whenever viewers are appointed, including for a redetermination of benefits. Land rights for the buffer strips are acquired by the drainage system. Harvesting of perennial vegetation remains a right of the landowner or assigns. The primary purposes of these buffer strips are to improve ditch bank stability and reduce ditch maintenance by setting back tillage from the top of the ditch bank, and to trap sediment and nutrients from adjacent wind erosion and runoff.

Until buffer strip right-of-way is acquired by the drainage system, eligible agricultural lands can sign up for the USDA Continuous Conservation Reserve Program (CCRP). For land enrolled in CCRP prior to right-of-way acquisition by the drainage system, the landowner can collect annual program payments for 10 to 15 years, as well as payment for the land rights acquired by the drainage system. CCRP buffers must be at least 30 ft. wide and harvesting is not allowed. Alternatively, land for buffer strips may be eligible for other state and local buffer programs.

11

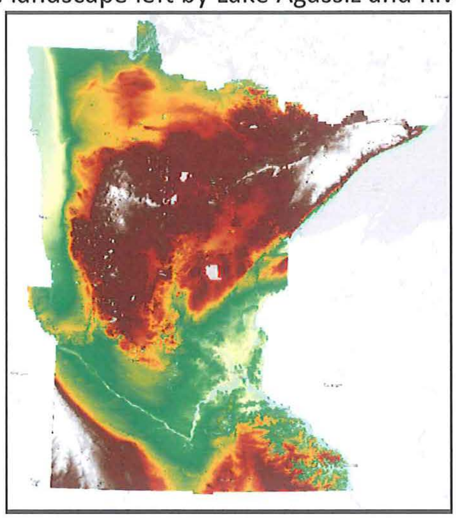
Stop 3
Le Sueur River

Accelerated flows and erosion

WHY ARE THE BANKS OF THE MINNESOTA RIVER SUSCEPTIBLE TO EROSION? IT'S THE GLACIER'S FAULT!

As the last glaciers melted over 10,000 years ago, a very large lake, called Lake Agassiz, covered NW MN.

When Lake Agassiz began to drain, torrents of water excavated a path along what is now the MN River valley. The green areas show the landscape left by Lake Agassiz and River Warren.



Imagine that broad valley filled with water, compared to today's Minnesota River:

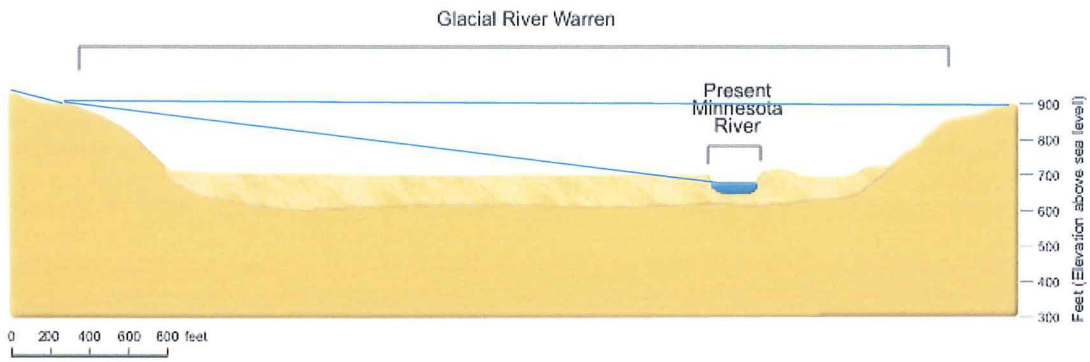


Image source: MN River Basin Data Center (http://mrbdc.mnsu.edu/minnesota-river-valley-formation)

When the water levels dropped, tributaries to River Warren were left stranded at a higher elevation. This created a steeper slope, which increased the tributary's power to carve through the thick layers of sands and gravels deposited by River Warren on the valley floor and edges.

The banks you see along the Le Sueur River are examples of the highly erodible River Warren deposits.

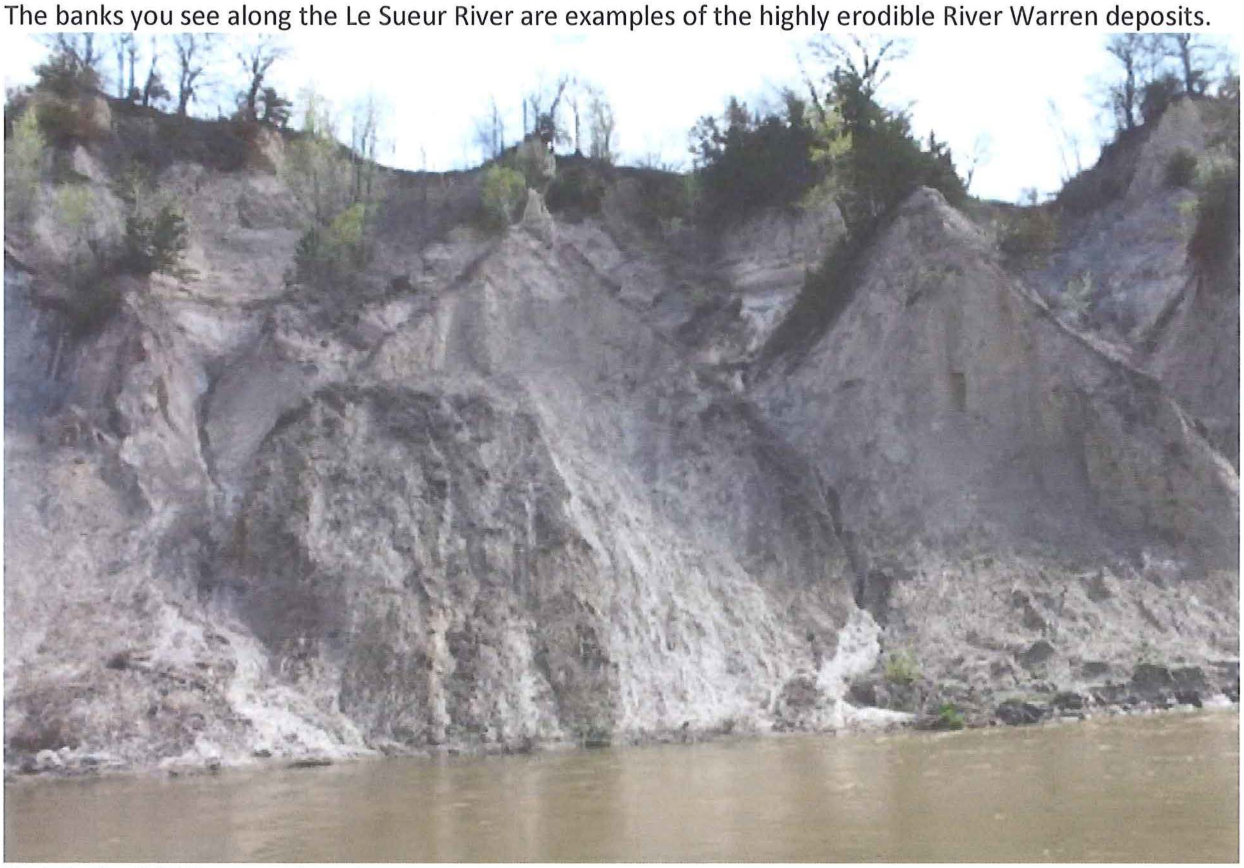
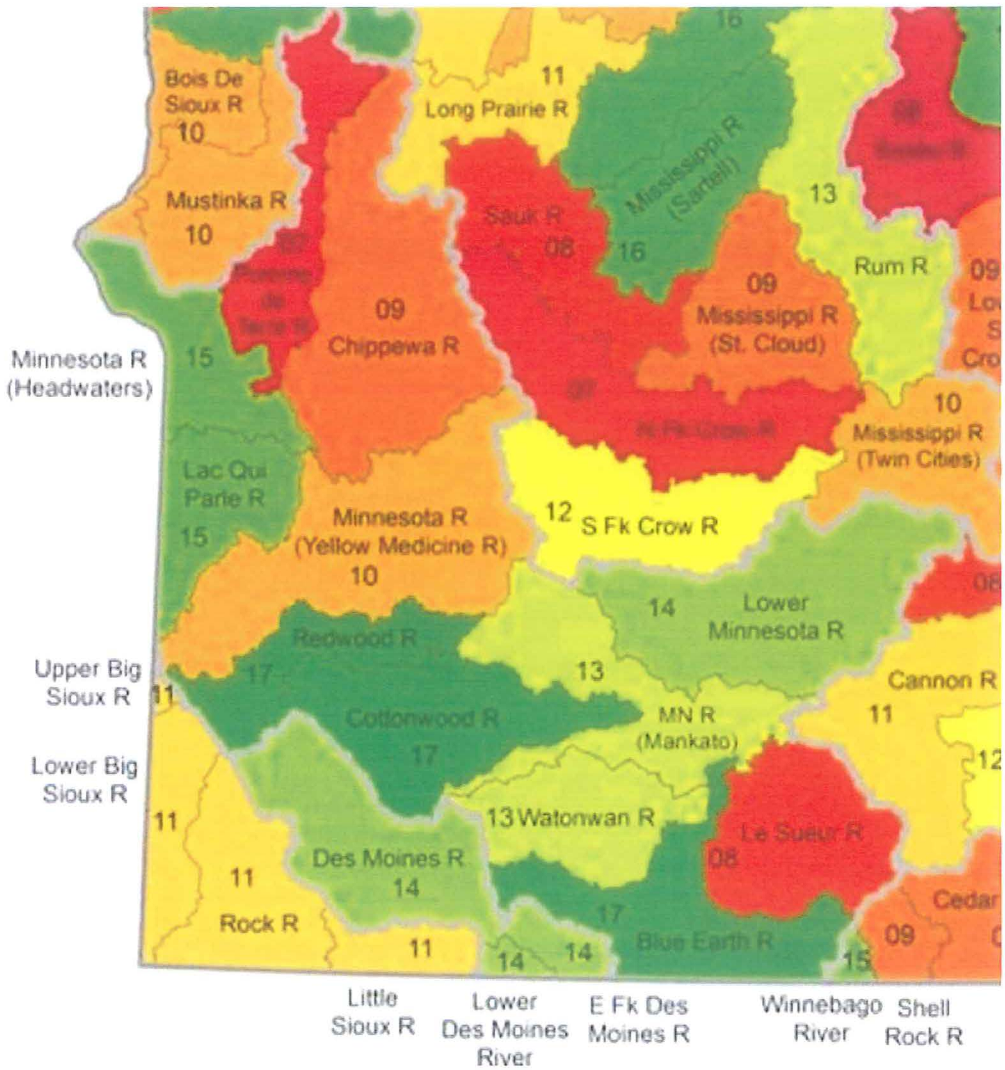


Photo by Kessl127 @ panoramia.com

MPCA intensive watershed monitoring schedule in the Minnesota River Basin:

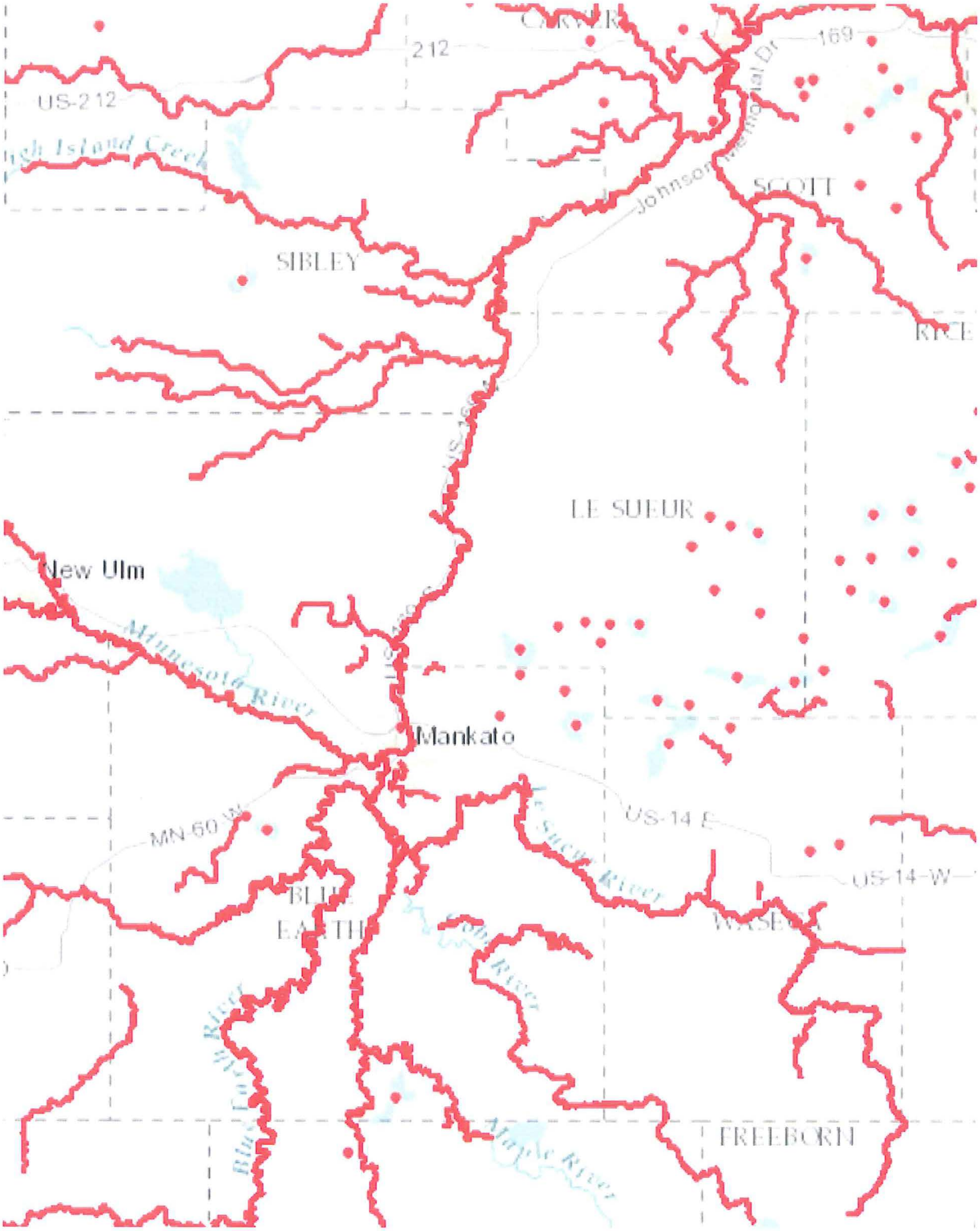


The Wantonwan, Blue Earth and Le Sueur Rivers make up the Greater Blue Earth River (GBER) area being studied as part of the CSSR and REACH projects that Dr Belmont will discuss. (The tour area also includes the MN River – Mankato watershed and the Lower Minnesota River watershed.)

The Le Sueur watershed started its monitoring in 2008 and its WRAPS was published in 2015. The Wantonwan watershed began its monitoring in 2013 (no WRAPS yet) and the Blue Earth River watershed won't begin its monitoring until next year; however a turbidity Total Maximum Daily Load for the Blue Earth River Watershed was completed in 2012.

In the GBER rea, there are no watershed districts or watershed management organizations – only SWCDs. There was not a One Watershed One Plan pilot project here either. The Elm Creek Watershed (part of the Blue Earth River watershed) was one of the MN Ag Water Quality Certification Program pilot areas.

Impaired Waters in the Lower Minnesota River Basin (source MPCA)



Published May 31, 2016

The Minnesota River has long been a significant conservation challenge for Minnesota. Recognition that land use was causing water quality problems began during the Depression. Drought in the region was so severe that in some places, even the river bottom was tilled. Challenges from flooding and excess nutrients accelerated through the last century, and in 1995, the advocacy group American Rivers named the Minnesota River among the most endangered in the United States. But to understand the complicated problems in the Minnesota River, you have to go all the way back to last ice age. Because there is no Minnesota River without Glacial Lake Agassiz.

Phosphorus in the Minnesota River Basin

The debate over its source and ways to mitigate impacts

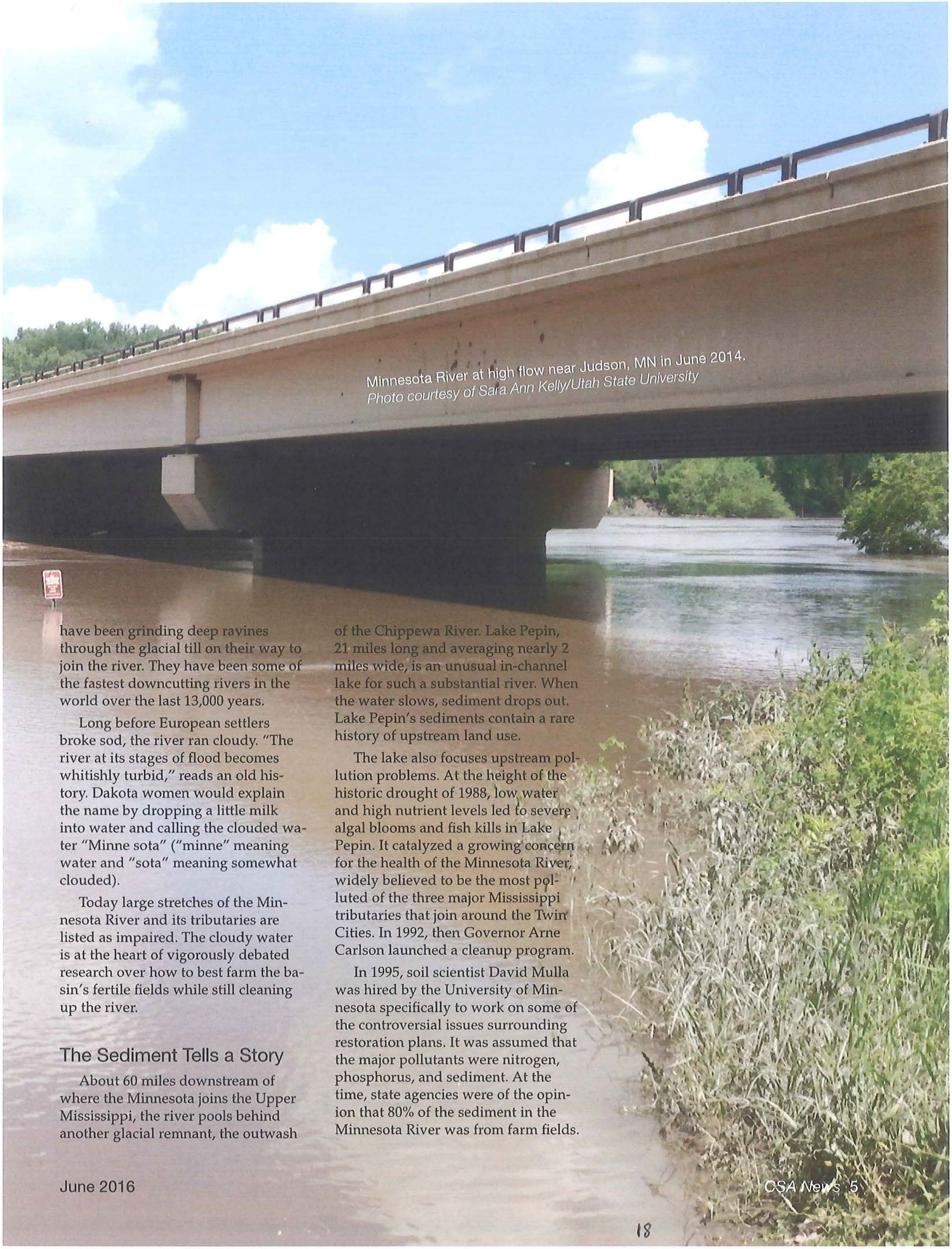
by Erik Ness

doi:10.2134/csa2016-61-6-1

A massive lake formed from the meltwater of retreating glaciers, Agassiz at its peak spanned central Canada 3,000 km east to west and contained nearly twice the freshwater now in Lake Superior. About 13,000 years ago, it unleashed a torrent in what is now thought to be a series of floods over several thousand years. Much of that water rushed down what is now the Minnesota River, carving a channel as much as 5 miles wide and 230 ft deep through an otherwise flat landscape. The flow was sometimes so great that when it joined the Mississippi, it forced the mighty river to flow backwards.

Fast forward to today's Minnesota River Basin. The soils formed from the glacial sediment throughout southern Minnesota don't drain particularly well, explains Laura Triplett, a geologist at Gustavus Adolphus College not far from the river's banks. "That's been one of the big controlling factors on agriculture in southern Minnesota," she says. "Lake Agassiz also controls what's happening in our rivers and streams today."

When the meltwater floods gouged the Minnesota River valley, it stranded many tributaries high above the floodplain. Waterfalls at first, these streams



Minnesota River at high flow near Judson, MN in June 2014.
Photo courtesy of Sara Ann Kelly/Utah State University

have been grinding deep ravines through the glacial till on their way to join the river. They have been some of the fastest downcutting rivers in the world over the last 13,000 years.

Long before European settlers broke sod, the river ran cloudy. "The river at its stages of flood becomes whitishly turbid," reads an old history. Dakota women would explain the name by dropping a little milk into water and calling the clouded water "Minne sota" ("minne" meaning water and "sota" meaning somewhat clouded).

Today large stretches of the Minnesota River and its tributaries are listed as impaired. The cloudy water is at the heart of vigorously debated research over how to best farm the basin's fertile fields while still cleaning up the river.

The Sediment Tells a Story

About 60 miles downstream of where the Minnesota joins the Upper Mississippi, the river pools behind another glacial remnant, the outwash of the Chippewa River. Lake Pepin, 21 miles long and averaging nearly 2 miles wide, is an unusual in-channel lake for such a substantial river. When the water slows, sediment drops out. Lake Pepin's sediments contain a rare history of upstream land use.

The lake also focuses upstream pollution problems. At the height of the historic drought of 1988, low water and high nutrient levels led to severe algal blooms and fish kills in Lake Pepin. It catalyzed a growing concern for the health of the Minnesota River, widely believed to be the most polluted of the three major Mississippi tributaries that join around the Twin Cities. In 1992, then Governor Arne Carlson launched a cleanup program.

In 1995, soil scientist David Mulla was hired by the University of Minnesota specifically to work on some of the controversial issues surrounding restoration plans. It was assumed that the major pollutants were nitrogen, phosphorus, and sediment. At the time, state agencies were of the opinion that 80% of the sediment in the Minnesota River was from farm fields.

These seemed like fair assumptions: rivers and lakes all over the world suffered from a similar array of problems. Many freshwater ecosystems are phosphorus limited, and agricultural phosphorus from manure and fertilizer combined with urban sources were seen as a primary culprit. Yet something about the local history of the Minnesota River demanded further inquiry. Not only had it always run cloudier than the Mississippi and the Saint Croix, a few tributaries in particular seemed like outsized contributors to the problems.

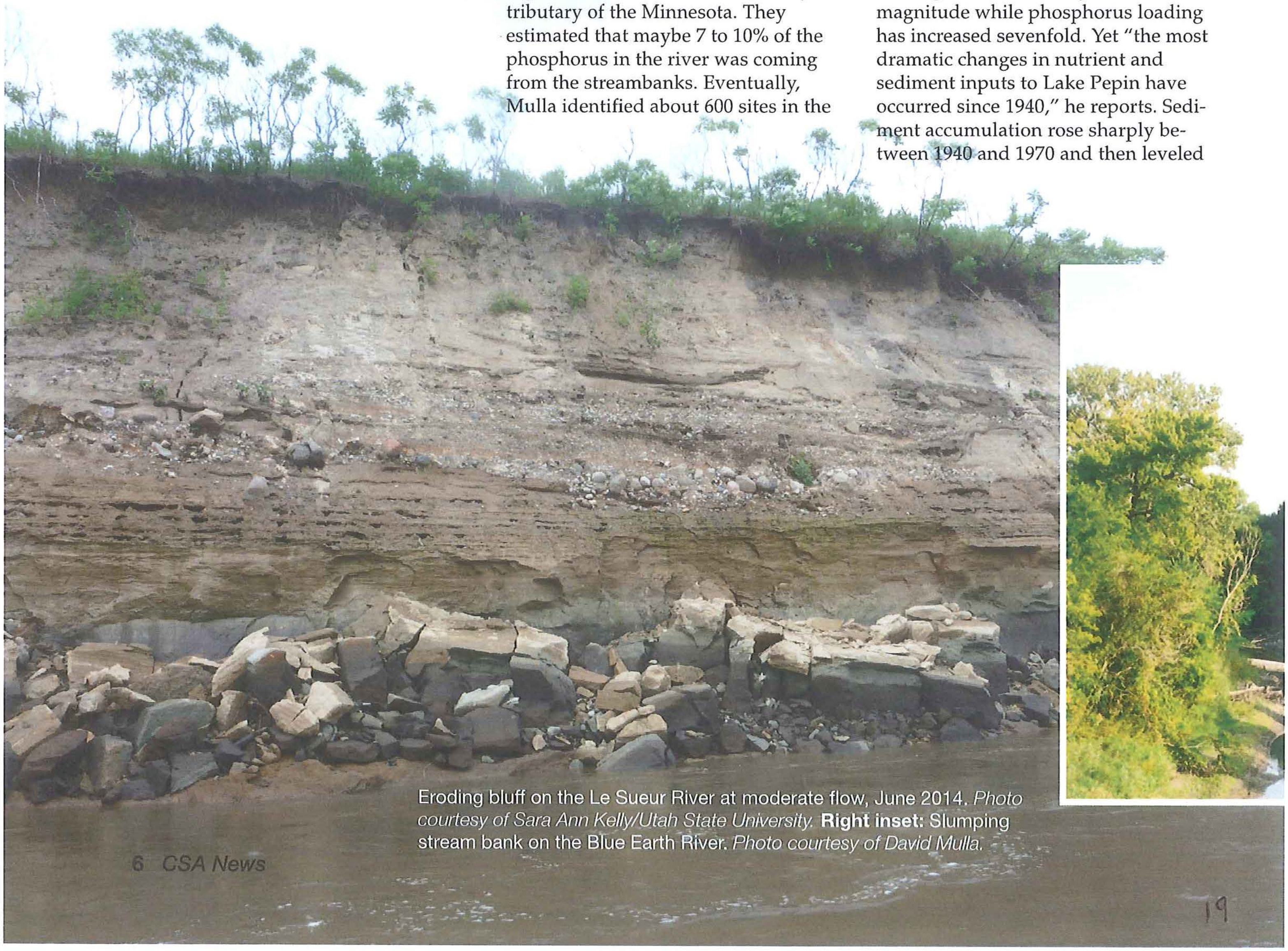
In 2000, a chemical analysis of Lake Pepin sediments confirmed that between 80 and 90% of its sediment comes from glacial deposits predominantly in the Minnesota River Basin. That made sense: next to the Upper Mississippi and the St. Croix, it was the predominant agricultural watershed.

Mulla, an SSSA and ASA Fellow and current director of the university's Precision Agriculture Center, began surveying stream banks on a tributary of the Minnesota River. It didn't take long before he realized that a small number of stream bluffs were generating significant amounts of sediment. When flooding undercuts an 80-ft bank, huge volumes of glacial till can be released in seconds. "They were just dropping directly into the tributaries," he says. They initially estimated that perhaps 40 to 45% of the Minnesota River sediment was due to this streambank erosion.

Mulla and hydrogeologist Adam Sekely went on to look at how much phosphorus these banks were releasing into the Blue Earth River, a major tributary of the Minnesota. They estimated that maybe 7 to 10% of the phosphorus in the river was coming from the streambanks. Eventually, Mulla identified about 600 sites in the watershed that contribute roughly two-thirds of the sediment.

In 2009, Daniel Engstrom, director of the St. Croix Watershed Research Station of the Science Museum of Minnesota, published an analysis of sediments in Lake Pepin, showing that probably 70% of the sediment is coming from bluffs and ravines. Subsequent work solidified the finding. "Scientists have all come to agreement that the majority of the sediment in the Minnesota River is coming from bluffs and ravines and that field sources of sediment are relatively small—30%," Mulla says.

Engstrom's core samples told a distinctly human story. When European settlers introduced the plow, there was "a dramatic increase in sediment." Since 1830, sediment loading has increased by an order of magnitude while phosphorus loading has increased sevenfold. Yet "the most dramatic changes in nutrient and sediment inputs to Lake Pepin have occurred since 1940," he reports. Sediment accumulation rose sharply between 1940 and 1970 and then leveled



Eroding bluff on the Le Sueur River at moderate flow, June 2014. *Photo courtesy of Sara Ann Kelly/Utah State University.* **Right inset:** Slumping stream bank on the Blue Earth River. *Photo courtesy of David Mulla.*

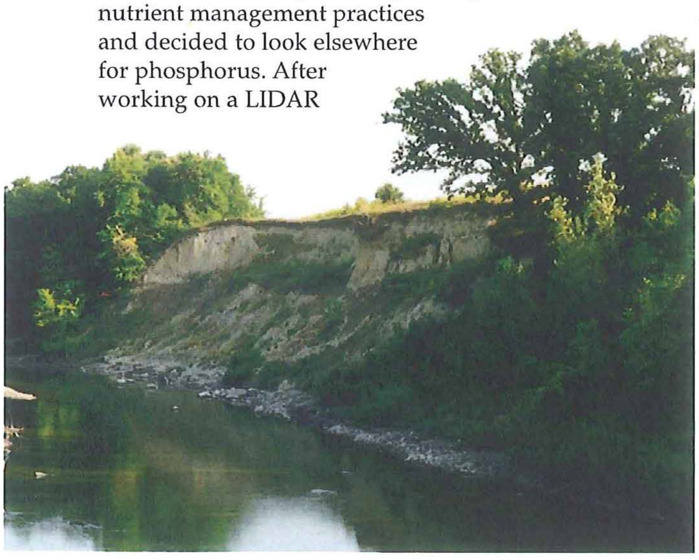
off. The highest levels of phosphorus are recorded after 1970.

Mulla and Sekely simultaneously reported that the Lake Pepin sediment phosphorus was significantly correlated with increases in row crop acreage, river flow, and discharges from metropolitan area wastewater treatment plants.

During the last 20 years, monitoring shows that urban sources of phosphorus have been in decline, primarily due to its removal from detergents and upgrades in wastewater treatment systems. It's also presumed that agricultural sources have been declining: rising prices for phosphorus inputs have led to tighter management regimes, and modern cropping systems extract more from the soil. Has there been meaningful change? Monitoring of state river systems between 1976 and 2005 showed phosphorus levels remaining more or less constant. On a grander scale, phosphorus loading of the Mississippi River to the Gulf of Mexico shows virtually no decline in total phosphorus since 1980.

Where is the Phosphorus Coming from?

SSSA and ASA Fellow Satish Gupta looked at the relatively flat Minnesota landscape and tightening nutrient management practices and decided to look elsewhere for phosphorus. After working on a LIDAR evaluation of Blue Earth and the Le Sueur rivers that helped confirm that eroding banks were a major source of sediment, he pursued a novel legacy phosphorus concept: That the historical phosphorus found in Lake Pepin sediment cores did not come from farms, but from sewage and industrial waste phosphorus. Wastewater treatment plants were already known sources of phosphorus pollution. Gupta compiled other historical sources, including a massive slaughterhouse and a leaking fertilizer plant.



Gupta argues that sediments from bank collapse bound to this phosphorus and carried it to Lake Pepin. His conclusion: to "achieve a substantial reduction in total P loads to Lake Pepin, the major pathway is to eliminate bank sloughing." But because, he argues, bank sloughing is mainly caused by natural forces, "elimination ... will be expensive, difficult, and likely unattainable."

"The farmers, they are being blamed for something that they didn't do," Gupta says. "We're not saying agriculture is not contributing anything," he clarifies. "We do not believe that a lot of phosphorus is moving from the agricultural landscape."

Phosphorus is tricky to study. It's ubiquitous in natural systems, occurring in both dissolved and particulate form. Both dissolved and particulate phosphorus can come from streambank and bluff materials and from agricultural sources. Tracing the precise source, and the flux between particulate and dissolved form, has not yet been accomplished in the Minnesota River Basin.

Engstrom disagrees with Gupta's interpretation of the Lake Pepin sediment record. While the narrative is plausible, it neglects the fact that the lake is still a river. Particulate phosphorus may settle out, but much of the dissolved phosphorus remains in the water or has been incorporated in algae, and most of this continues downstream. "There's a whole lot of phosphorus that doesn't go to the bottom," Engstrom says. "He is only accounting for at most 20% of the phosphorus."

Jacques Finlay, also at the University of Minnesota, adds that within the Minnesota River Basin, there is a lot of dissolved phosphorus that's unaccounted for. "It's just not on the radar screen," he says. "The sources aren't well defined, and they are elusive." Research by his graduate student, Evelyn Boardman, suggests that the strongest correlation to phosphorus levels in the water is agricultural land.

How much of this dissolved phosphorus is simply from current agricultural practices or the result of legacy phosphorus is very difficult to say. Either way, some watersheds "are losing large amounts of phosphorus through dissolved pathways," Finlay says.

Wherever the phosphorus is coming from, there is one thing we do know, Finlay says: "We haven't improved water quality in proportion to the effort and dollars that we've put into the problem."

That's the crux of the challenge identified in "Sustainable Phosphorus Management and the Need for a Long-Term Perspective: The Legacy Hypothesis," an opinion published in 2014 in *Environmental Science and Technology* and co-authored by SSSA President-Elect Andrew Sharpley, an SSSA and ASA Fellow. Another co-author, ASA member Heidi Peterson, is now a research scientist with the Minnesota Department of Agriculture and has spent time studying legacy phosphorus in the Albert Lea watershed, just to the south of the Minnesota River. "If you start with a simple balance, then you're able to see if more is going into the system than is coming out," she says.

Though the Albert Lea doesn't have the same stream dynamics as the Minnesota River, the landscape

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and cultivation history are otherwise similar. She found that farmers there have been very efficient with their inputs and outputs. "If we're operating very efficiently and still seeing high phosphorus levels in our rivers and streams, then that means there is likely a legacy issue," she explains. "It may be a long time before we see changes in water quality because of the legacy effect."

What's Driving Increased Streamflows: Land Use or Climatic Changes?

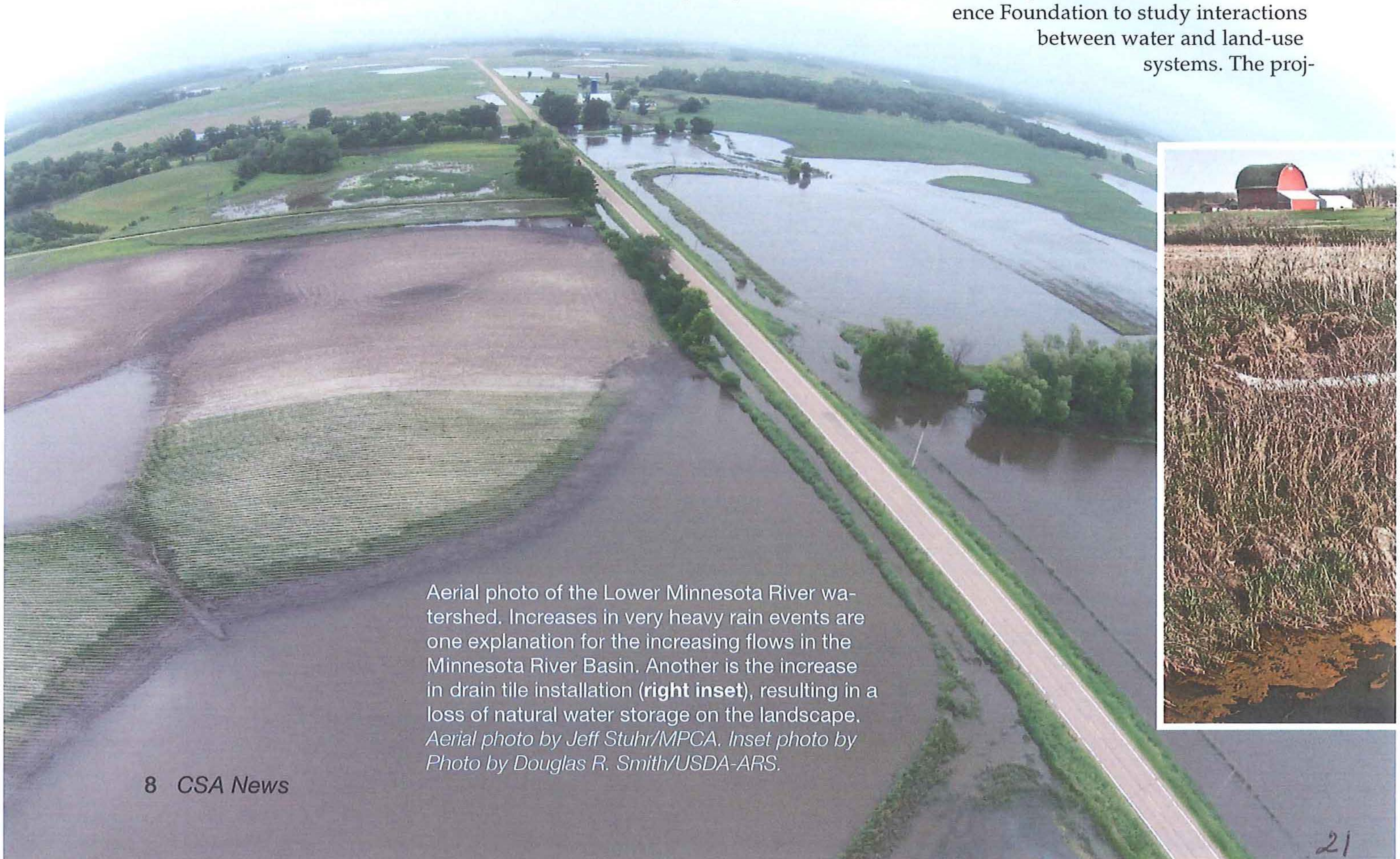
Phosphorus accounting cannot be divorced from sediment, and sediment issues are becoming phosphorus issues because of steadily increasing flows in the Minnesota River Basin. Debate about the causes turns on the question of agricultural drainage. Drain tile installation in the basin has increased steadily over the last few decades as corn and soy production has supplanted small grains. But precipitation levels have also steadily increased over that time.

"Uncertainty in separating these drivers of streamflow fuels debate between agricultural and environmental interests on responsibility and solutions," says Shawn Schottler of the St. Croix Watershed Research Station in a study published in *Hydrological Processes* in 2014. He examined 21 Minnesota watersheds from 1940 and found that those with large changes in land use showed increases in seasonal and annual water yields of more than 50% since 1940. Changes in precipitation and evapotranspiration explained less than half of the increase. The bulk of the flow came from artificial drainage and the loss of natural water storage on the landscape.

Tom Kalahar spent more than 30 years as a conservation technician in the Renville Soil and Water Conservation District, and his experience confirms Schottler's analysis. "We haven't had a natural rain event for about 50 years," he argues. "We store no water on the landscape anymore. We have directed every drop of water to get to the Minnesota River as rapidly as possible."

David Mulla disagrees. "Yes, the flows in the Minnesota River have gone up a lot since the early 1900s, but what we've found is that a lot of that increase was due to changes in our climate," he says, flipping the equation. "That's responsible for at least 60% of the increase in the river flows. The other 40% is due to non-climatic effects: drainage, cropping system changes, development." Satish Gupta makes a similar case, and in a 2015 Water Resources Research article argues that Schottler's analysis "fails to fully account for similarity in the streamflow versus precipitation relationships ... and in turn fails to tease out the true anthropogenic impacts." Gupta's methods and conclusions have drawn fire from several quarters, and rebuttals are working their way toward publication.

In 2012, the University of Minnesota–Twin Cities received a $4.3 million grant from the National Science Foundation to study interactions between water and land-use systems. The proj-



Aerial photo of the Lower Minnesota River watershed. Increases in very heavy rain events are one explanation for the increasing flows in the Minnesota River Basin. Another is the increase in drain tile installation (**right inset**), resulting in a loss of natural water storage on the landscape. *Aerial photo by Jeff Stuhr/MPCA. Inset photo by Photo by Douglas R. Smith/USDA-ARS.*

ect explores human-amplified natural change and benefits from the large body of research being generated by efforts to untangle the complexity of the Minnesota River Basin. Among the investigators is Patrick Belmont, now associate professor of watershed sciences at Utah State University. A hydrologist and geomorphologist, he first came to the National Center for Earth-Surface Dynamics at the University of Minnesota in 2007.

Belmont set out to build a sediment budget, finding all sources and sinks of sediments in the Le Sueur River, one of the most turbid tributaries of the Minnesota. Using geochemical fingerprinting, terrestrial LIDAR, field surveys, air photos going back eight decades, and an extraordinary amount of water and sediment gaging data from Minnesota state agencies, his team built all of this information into a single balance sheet.

"Between the bluffs and the streambanks and the channel just downcutting, those three sources were about 70% of the sediment," he says. "That was the first time we could really say that on the landscape scale." Agricultural fields contributed about a quarter of the sediment.

Dig Deeper

For more information on this topic, view presentations from a symposium at last year's Annual Meeting titled "Tracking Legacy Phosphorus in Lakes and Rivers": **http://bit.ly/1qoi6fZ.** Also view the following article in the *Journal of Environmental Quality* titled "River Bank Materials as a Source and as Carriers of Phosphorus to Lake Pepin": **http://bit.ly/1sslYi1.**

Comparing these findings with geochemical measurements in Lake Pepin sediment cores, they were also able to plot change over time. The geochemistry tells us that 500 ago, the sediment was all derived from channel sources: banks and bluffs. In the mid-20th century, there is an increase in sediments from field erosion, rich in agricultural chemicals. But over the last three decades, Lake Pepin sediment origins have switched back toward bluffs and banks. The amount of sediments hasn't changed much, "but geochemically, we can see that the source has actually shifted," Belmont says.

The good news is that agricultural sediment is down. The bad news is that it has been offset by increasing channel erosion. Drainage can increase water infiltration and thus decrease surface runoff. But the drain tiles are also increasing high flows, which are nearly doubled at high water.

"That makes the channel more dynamic. It's moving around laterally more, so it's eroding the banks and the bluffs more aggressively," he says. And while increasing precipitation plays a role, he asserts there is no question drainage is the real driver.

The best proof of this, he says, comes from Efi Foufoula-Georgiou, a civil engineering professor in the University of Minnesota College of Science and Engineering and lead investigator on the NSF grant. She examined the conversion of cropland around the Minnesota River from hay and small grains to corn and soybeans, which has gradually swept across the basin. In the Le Sueur area for example, this happened in the 1950s and 1960s. The transition didn't occur in the furthest reaches of the basin until 1991. This change in cropping systems is a proxy for drainage. "If you track how the hydrology has changed according to when those land use conversions occurred, you can see very clearly that the hydrologic changes match land use conversion," Belmont says. "Climate change has played some role. It is raining a bit more. But all the drainage has exacerbated those increased flows."

The Debate Continues

Debate will certainly continue. The NSF team has a number of papers slated for release in the next few years while other researchers continue their work. Some of the state's new water quality standards are also facing legal challenge.

David Mulla is encouraged by the development of aggressive new nutri-

continued on page 11

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the reductions in residual agricultural nitrogen or nitrate discharge from Chicago caused changes in nitrate concentrations or loads in the river. The results are, however, strongly suggestive of the connections."

Precipitation, River Flow Are Important Factors

Nitrate loads are strongly influenced by precipitation and river flow, which can be highly erratic. It is promising that nitrate loads have declined in recent years despite higher-than-average river flows. The five-year average river flow from 2007 to 2011 was the highest recorded since the start of measurement in 1939.

Nitrate concentrations, on the other hand, have declined more consistently since about 1990, which was a period of high concentrations. The reason for the divergence between nitrate concentration and load, explains McIsaac, is that the load is the product of both concentration and river flow and the flow is strongly influenced by precipitation while concentrations are not. Higher flows allow the river to carry more pounds of nitrate, but it doesn't necessarily change the concentrations.

Whether nitrate concentrations and loads continue to decline in the future depends on several factors, according to the researchers. "If the annual river flows return to their 1976–2005 average values, and if nitrogen fertilizer efficiency remains high or continues to improve, there likely will be a decline in nitrate loads in the Illinois River," David explains. "On the other hand, if river flows remain high, which may be a consequence of climate change, meeting the nitrate reduction goals will likely require more conservation effort than originally proposed."

D.L. Larson, University of Illinois, Urbana–Champaign

Dig Deeper

View the original open access article in the *Journal of Environmental Quality* at http://bit.ly/1TSorb8.

doi:10.2134/csa2016-61-6-2

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Phosphorus *from page 9*

ent reduction strategies, which have an interim goal of a 12% reduction by 2025. The toolkit is wide open, including cover crops, buffers, reduced tillage, optimization of fertilizer, and converting row crops to perennials. New in-ditch bioreactor technology is being developed to remove nutrients in place (learn more about the latest in bioreactor technology here: http://bit.ly/1TLFykv). And he remains hopeful that we'll find a way to help stabilize collapsing river banks. "If we can find a solution, it would not need to cover a very large area" he says.

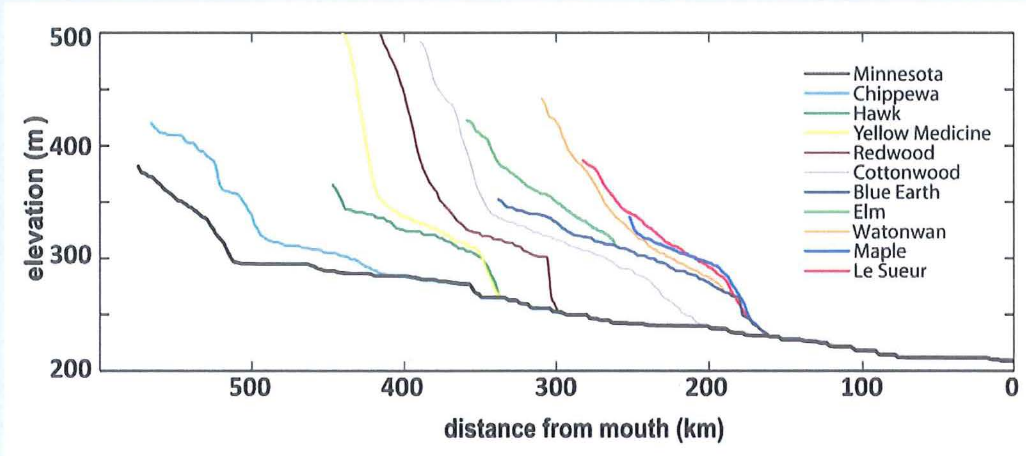
Patrick Belmont is more interested in controlling flow. The good news for farmers is that he doesn't think removing tile is the right solution. It's not economically feasible and will ultimately just shift the sediment source back to agricultural lands.

"But we do need to slow the flow," he cautions. That means installing wetlands and detention basins to temporarily store water locally. Slowing the rush to the river won't be cheap but can be done in ways that not only reduce sediment, but also provide other benefits like nitrogen reduction. Another option would be to increase soil organic matter, which would also provide resilience to drought.

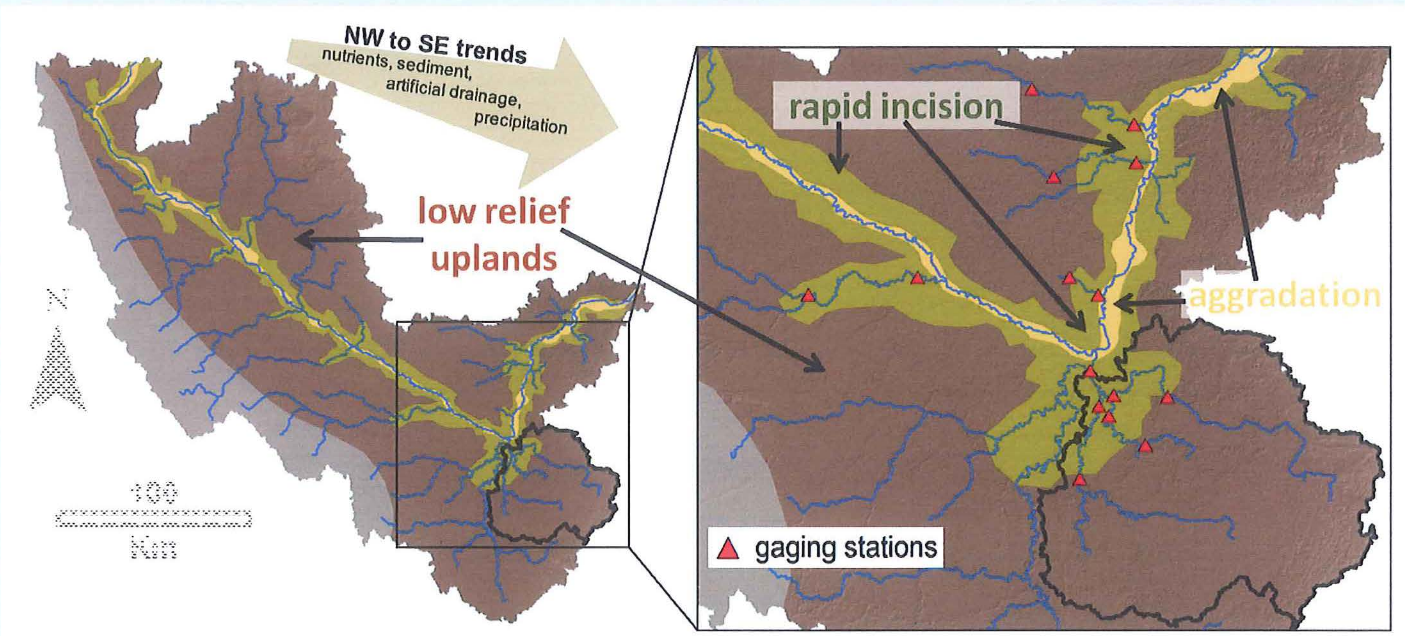
The Setting

LWC Presentation
Dr. Patrick Belmont
Patrick.Belmont@usu.edu
8/17/2016

Geologic history has made southern Minnesota...



...a unique and highly sensitive landscape.



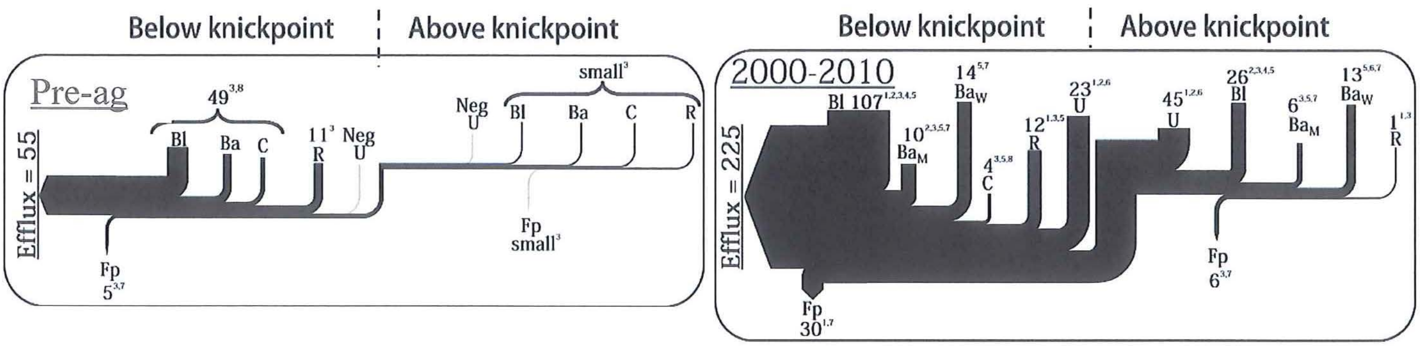
Today, this is a thriving agricultural landscape...
...with pervasive and costly [but solvable!] erosion and water quality problems

The Situation

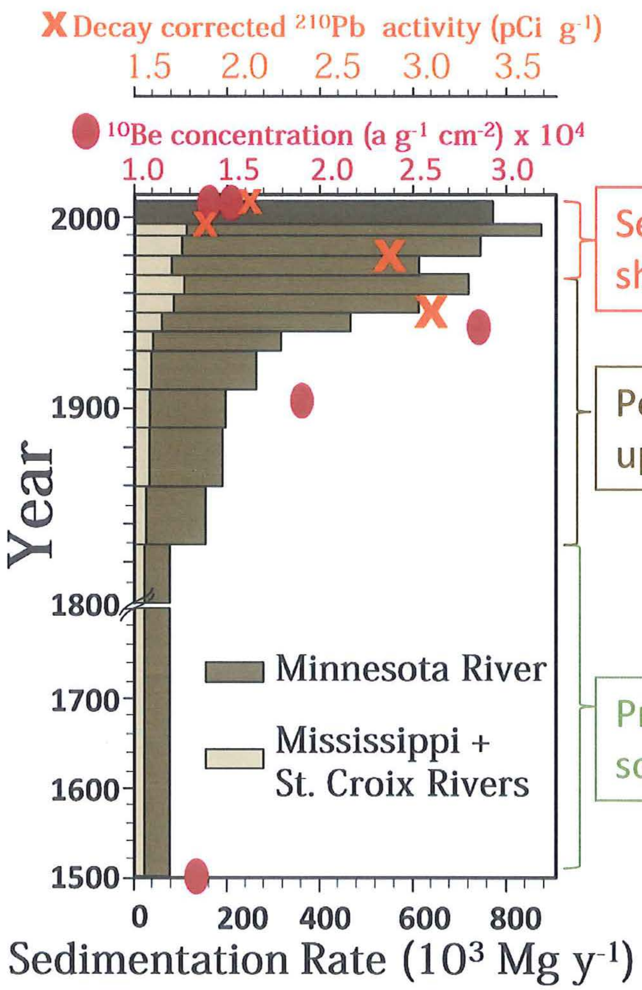
Key Discovery:

Farmers have reduced ag soil erosion, but increased river erosion

Sediment budget for Le Sueur River



Sediment fingerprinting in Lake Pepin



Sediment loading remains high but sources shift from top soil to banks & bluffs

Poor land management causes pulse of upland soil erosion

Pre-settlement: primarily near-channel sources

Collaborators and Students: Amy Hansen, Carrie Jennings, Barbara Heitkamp, Shawn Schottler, Stephanie Day, Brent Dalzell, Shannon Belmont, Gary Parker, Chris Lenhart, J. Wesley Lauer, Se Jong Cho, Zeinab Takbiri, Jon Czuba, Martin Bevis, Nate Mitchell, Sara Kelly, Karthik Kumarasamy, Shayler Levine, Adam Fisher

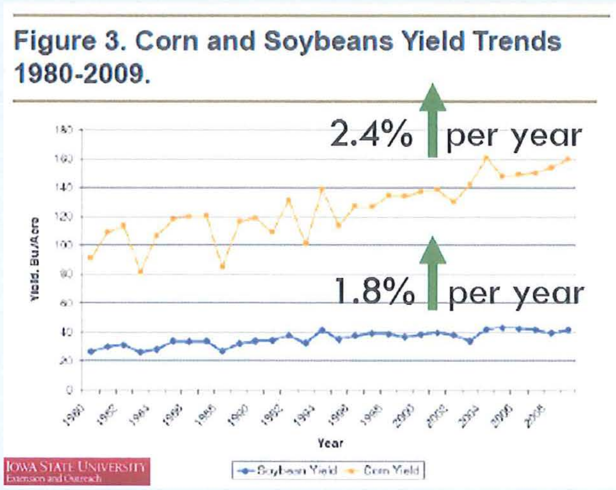
Funding: USDA, Minnesota Pollution Control Agency

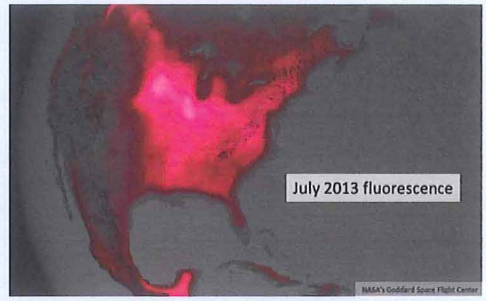
The Situation

Two sides of the agricultural drainage issue

Up-sides of drainage

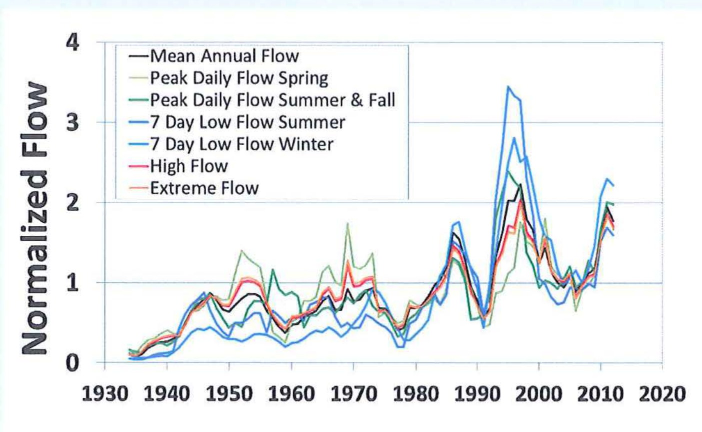
1. Crop productivity and consistency are way up!
2. More rain infiltrates into the soil, less runs off the surface

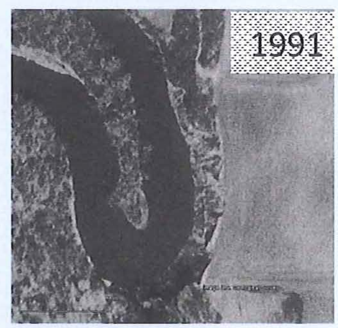


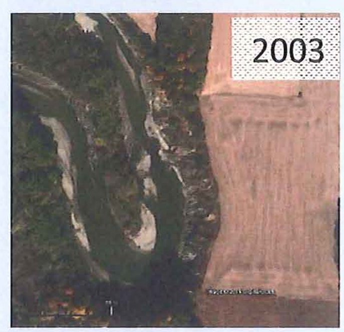


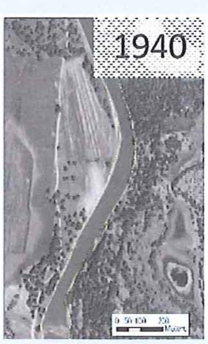
Down-sides of drainage

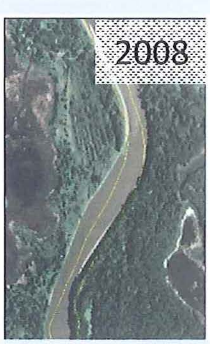
1. Concentrating flow in some sensitive areas
2. Increasing the amount and rate of water delivered to the river
3. Increasing N delivery











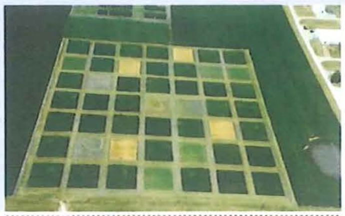
The Solutions

Many feasible policy and management options

Drainage management

Ditch management

Wetland restoration



Cover crops

Conservation tillage

Buffer strips

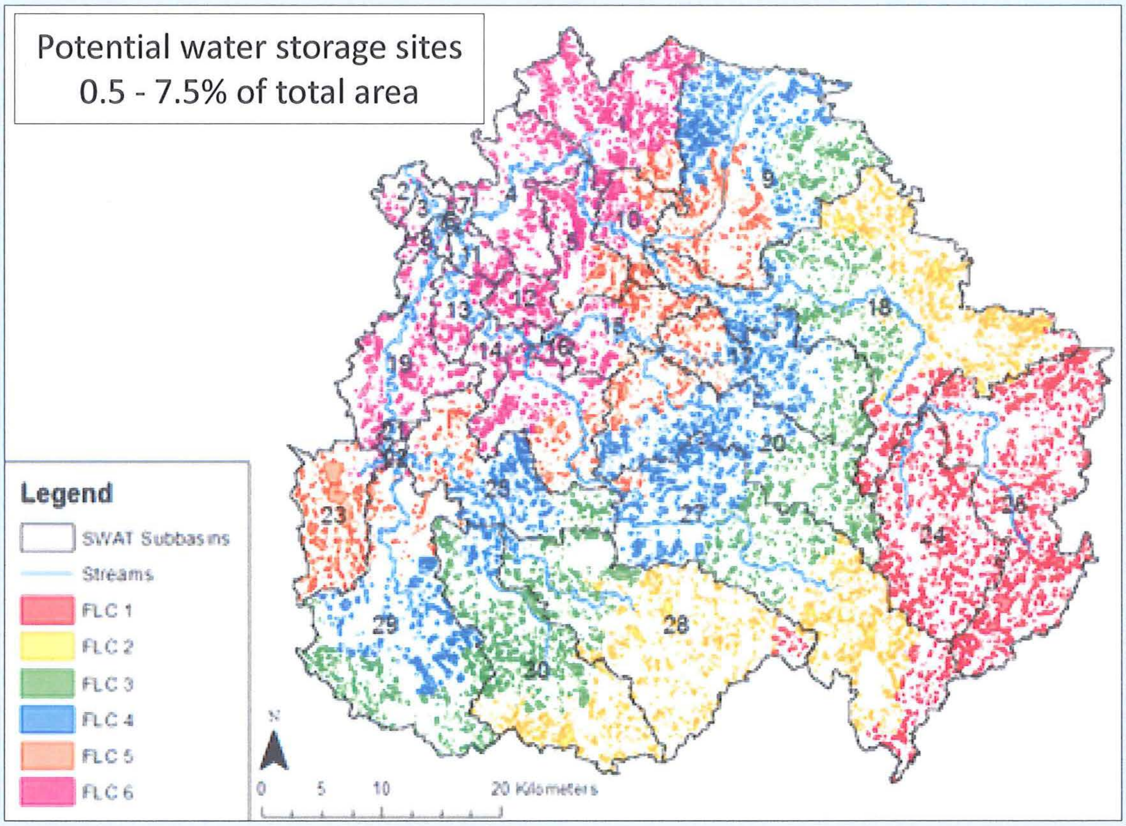
Soil organic matter

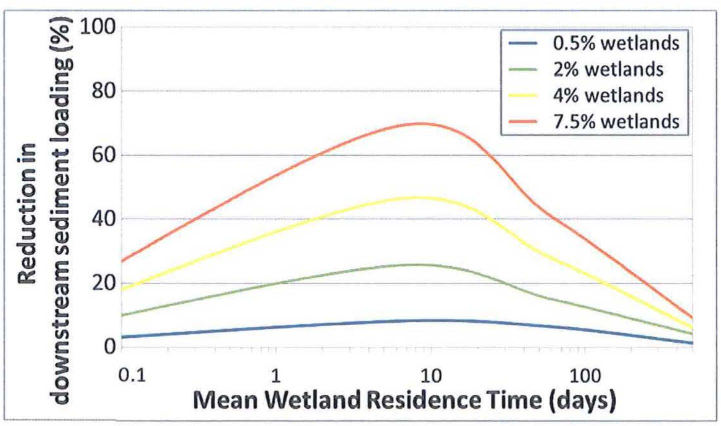
Bank stabilization

Management option groups	Functions		
	1°	2°	3°
Tillage (TLMO)	Reduce erosion	Trap Sediment	Nutrient Reduction
Conservation Tillage			Habitat
Soil Health			
Agricultural Field (AFMO)	Trap Sediment	Flow Reduction	Habitat
Grassed Waterways		Reduce Erosion	
Buffers, Filter Strips			
Terraces			
Water Conservation (WCMO)	Flow reduction → Reduce downstream erosion	Trap Sediment	Nutrient Reduction
Wetland Restoration			Habitat
Water and Sediment Control Basins			
Sediment Ponds			
In-Channel (ICMO)	Flow reduction → Reduce downstream erosion	Trap Sediment	Habitat
In-ditch storage			Nutrient Reduction
Near-Channel (NCMO)	Reduce erosion	Trap Sediment	Habitat
Bluff Stabilization			Flow Reduction
Streambank stabilization			
Ravine (RAMO)	Reduce erosion	Trap Sediment	Habitat
Ravine Stabilization			Flow Reduction

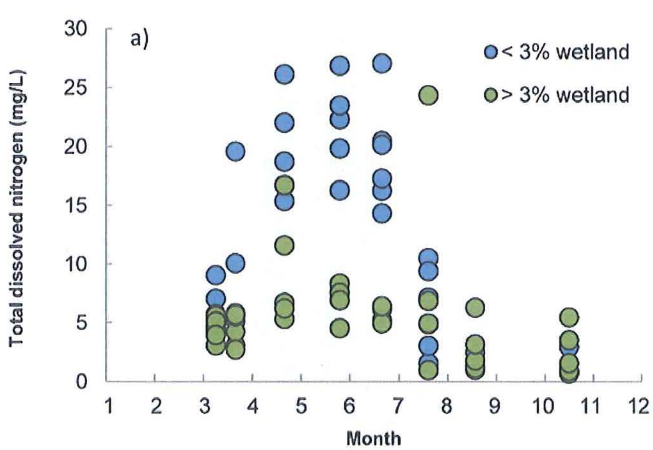
The Solutions

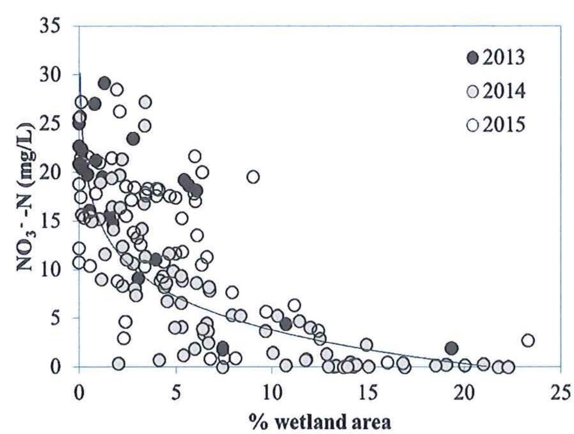
A little bit of wetlands goes a long way…





- REDUCE FLOOD RISK
- TRAP SEDIMENT LOCALLY
- REDUCE EROSION DOWNSTREAM
- REMOVE NITRATE

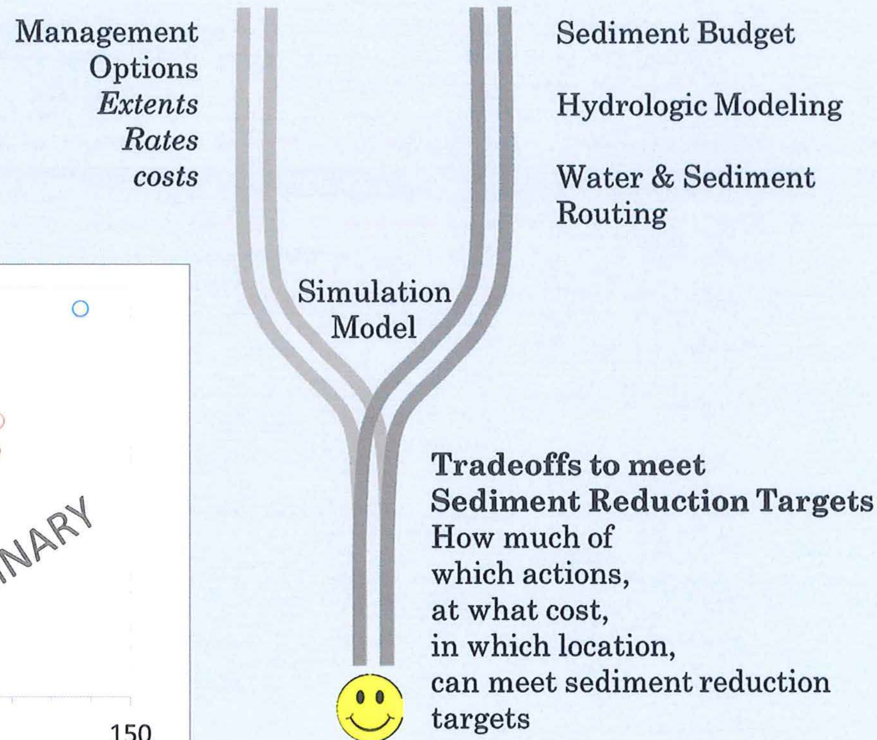


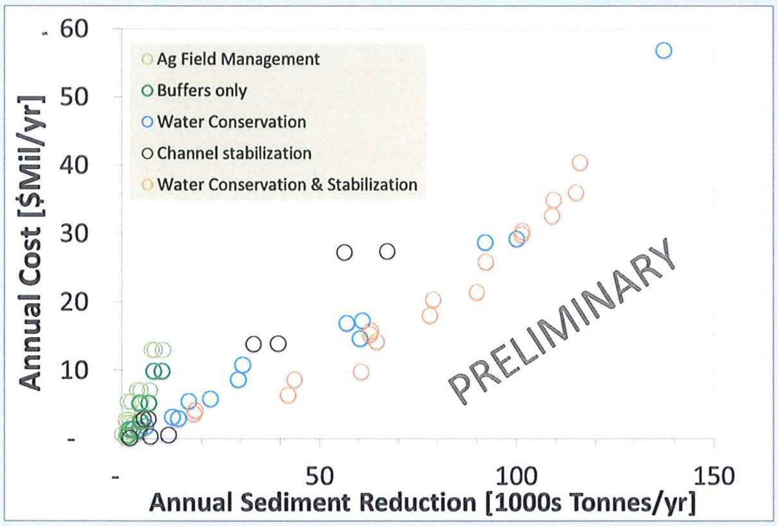


The Solutions

Which portfolio gives us the best return on investment?

The CSSR model, developed with a broad stakeholder group, predicts *significant and cost-effective reductions* in peak flows, sediment and nutrient pollution from implementation strategies that include creation of new water storage sites.



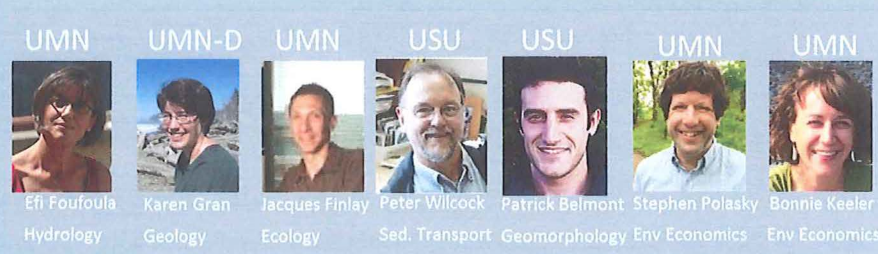


Key points:

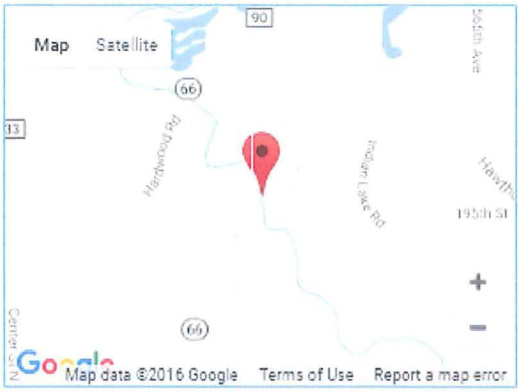
1. Thriving agriculture and good water quality are not mutually exclusive.
2. Geologic history made the MRB vulnerable. Human actions have degraded it.
3. Slow the flow! Dedicating a small portion of landscape to water storage can solve water, sediment, nitrate problems.
4. Continue to maintain and improve field practices. We are making progress!
5. Provide incentives with minimal red tape.
6. Enhance resources at the critical SWCD level, where rubber meets the road.

Dr. Patrick Belmont
Patrick.Belmont@usu.edu

REACH
Resilience under Accelerated Change



Site report
Le Sueur River nr Rapidan, MN66 (32077002)
USGS ID:05320500, Water Chemistry ID:S000-340
Provider: MDA



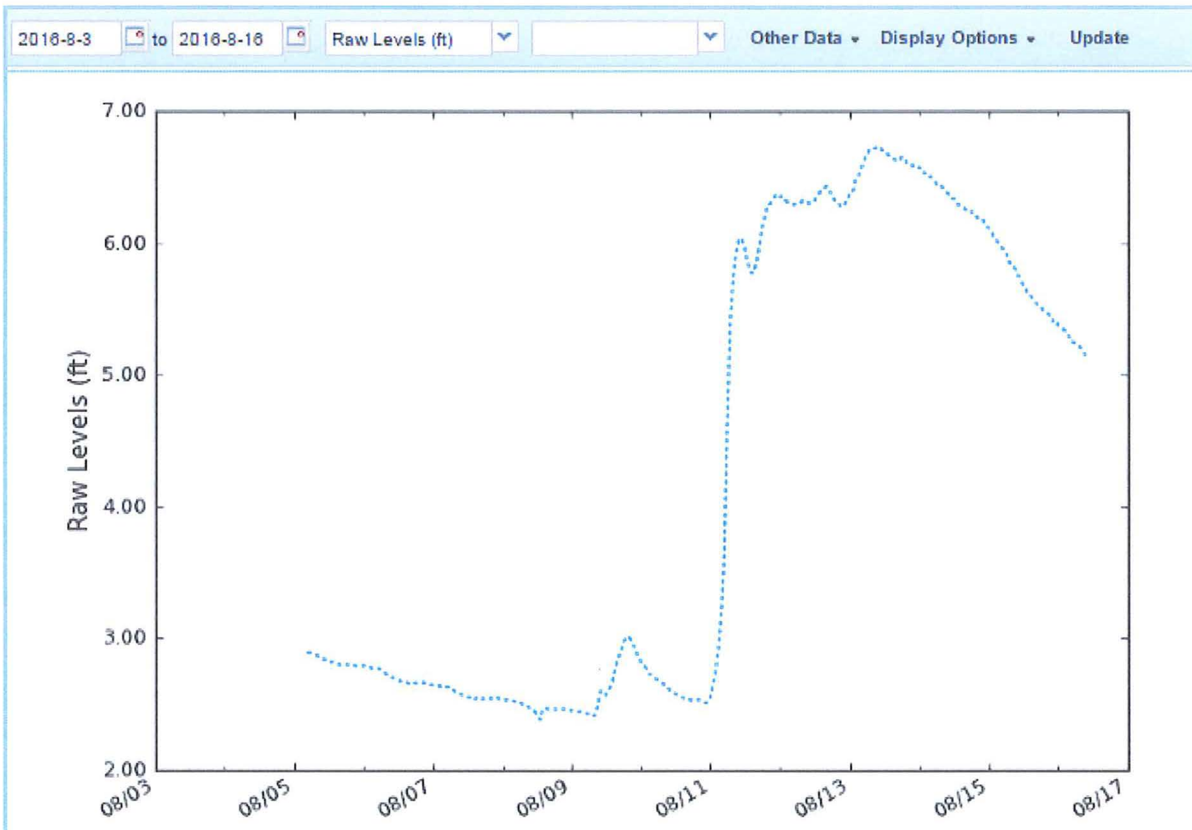
Most Recent Data

Stage: 5.13104 ft at Aug 16, 2016 10:45 CST

Period of Record

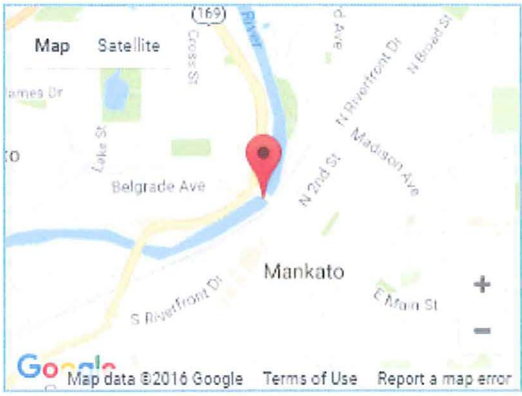
Telemetry data: 2014-09-06 to 2016-08-16

Available data: all telemetry variables



Please note that provisional data are represented by a dashed [····] line.

Site report
Minnesota River at Mankato, MN (28042001)
USGS ID:05325000, NWS AHPS:mnkm5
Provider: USGS



Most Recent Data

Stage: 10.95 ft at Aug 16, 2016 07:30 CST

Flow: 12600 ft^3/sec at Aug 16, 2016 07:30 CST

Period of Record

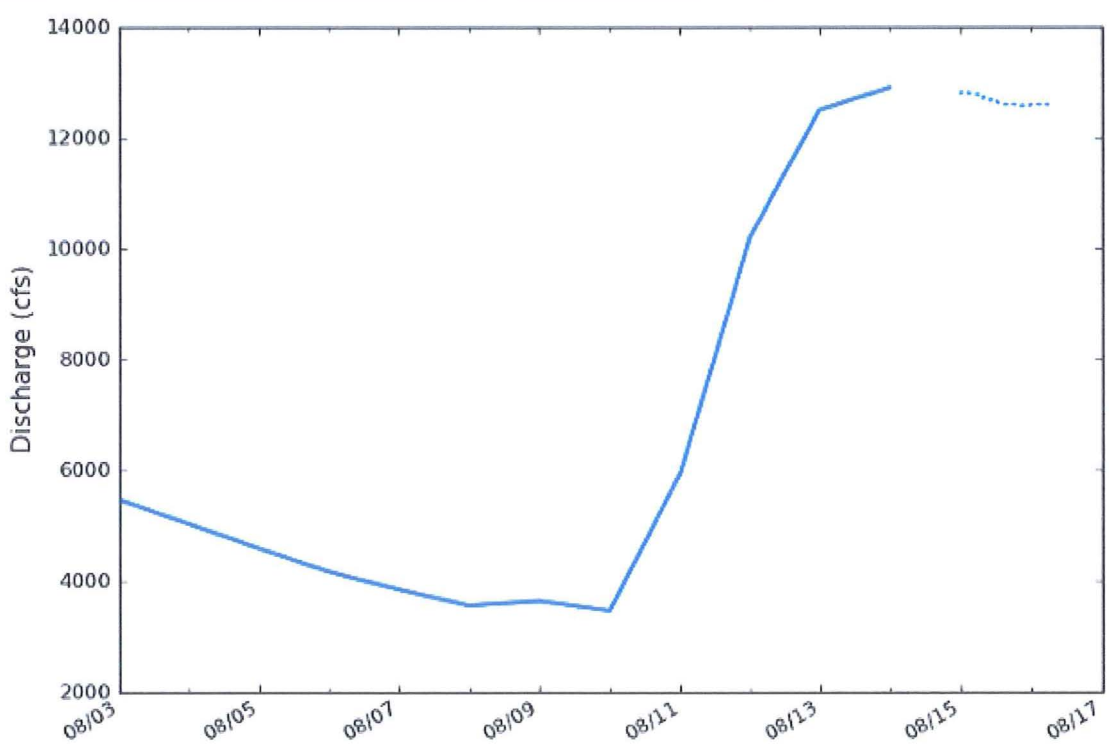
Telemetry data: 2016-08-15 to 2016-08-16

Available data: all telemetry variables

Archive data: 1903-06-01 to 2016-08-14

Available data: daily discharge

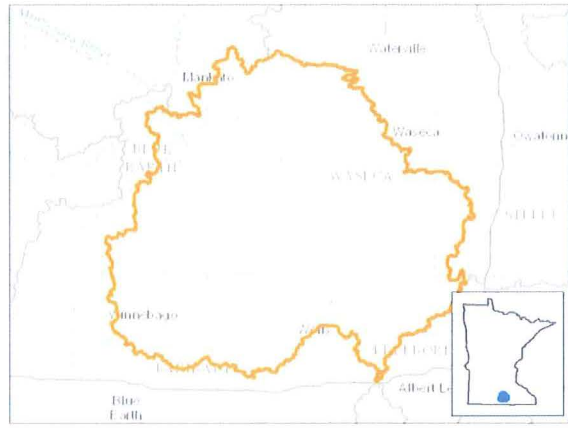
2016-8-3 to 2016-8-16 Discharge (cfs) Other Data Display Options Update



Please note that provisional data are represented by a dashed [----] line.

LeSueur River Watershed

Clean Water Accountability Progress Report

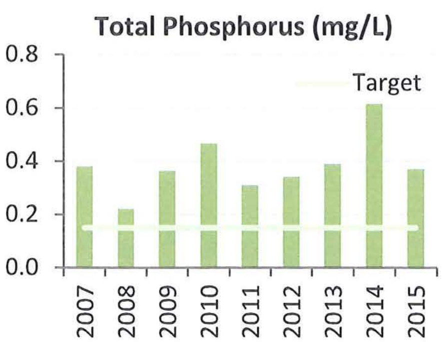


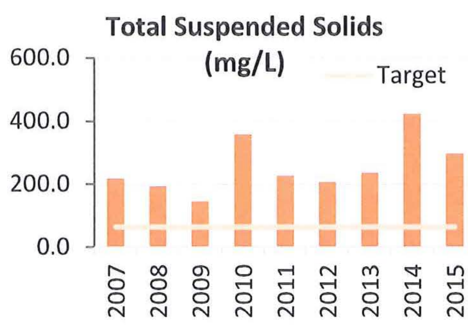
The Le Sueur River major Watershed is located in south central Minnesota and drains approximately 711,000 acres 1,110 square miles into the Le Sueur River. The watershed is largely rural with 82% of the land under agricultural cultivation. The Le Sueur River flows to the Blue Earth River and these waters join the Minnesota River near Mankato.

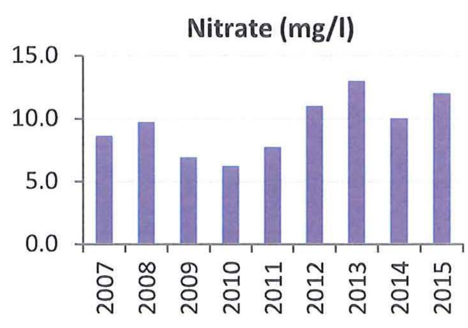
Monitoring and assessment reveals many aquatic life impairments due to low Indices of Biological Integrity (IBI) scores, with fish or macroinvertebrate populations low or dominated by pollution-tolerant species. The Le Sueur River is a major source of both sediment and nutrients to the Minnesota River. Primary stressors identified included: altered hydrology; poor habitat; and high turbidity, nitrate, and phosphorus concentrations; low dissolved oxygen concentrations; and lack of connectivity. Pollutant source contributions are generally dominated by agriculture, reducing pollutant/stressor contributions from agricultural sources is a high priority. To improve and protect water quality conditions, strategies need to be implemented across the watershed and should be customized based on locally-led prioritizing and targeting work.

Water quality measurements

The graphs below show the annual flow weighted mean concentration (FWMC) of total phosphorus (TP), total suspended solids (TSS), and nitrate. FWMCs help to normalize pollutant loads across years with varying precipitation. The target identified for TP and TSS is the water quality standard. There is no surface water quality standard for nitrate.



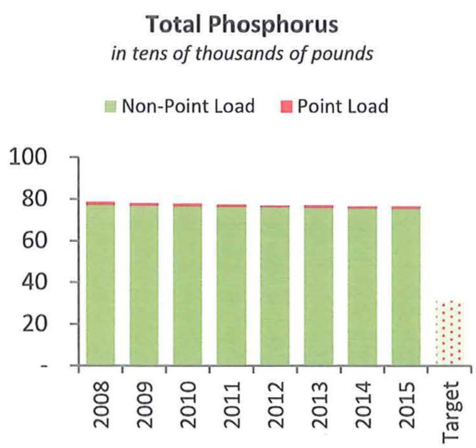


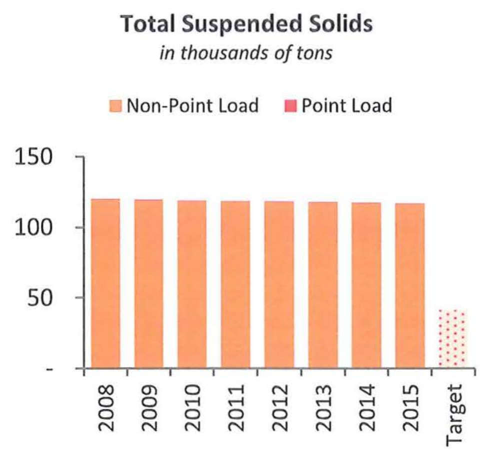


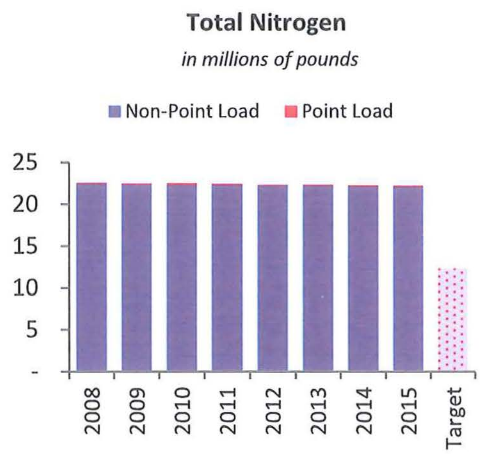
Compared to other watersheds in the state, the LeSueur Watershed exhibits somewhat higher than average water runoff and substantial variability in runoff from year to year. Such high runoff variability may have negative impacts on fish and other stream life. For water quality, the LeSueur River near the mouth has levels of TP and TSS well above targets, indicating very poor conditions and the transport of large pollutant loads. There are no apparent trends in these two indicators; nitrate on the other hand appears to be edging somewhat higher in recent years.

Progress toward load reduction targets, 2008-2015

The Le Sueur River Watershed Restoration and Protection Strategy calls for a minimum 60% reduction in TP, a 65% reduction in sediment, and a 45% reduction in nitrogen, in order to achieve water quality goals. These charts display the annual load reductions for nitrogen, TP and TSS estimated as a result of best management practices (BMPs) reported to U.S. Natural Resources Conservation Service and to the Minnesota Board of Soil and Water Resources, for the period of 2008-2015. These charts do not take into account factors such as land use changes, climate change, or privately funded BMPs. The modeled load for 2008 serves as the baseline load, with the estimated reductions shown relative to that baseline.







Top non-point source BMP activities in the LeSueur River Watershed, 2008 – 2015

BMP Type	Projects	Acres	N reduced (lbs)	P reduced (lbs)	TSS reduced (tons)
Nutrient Management	651	40,215	170,425	3,396	0
Residue & Tillage Management	531	24,808	60,702	12,400	2,636
Cropland Diversity/Seasonal Cover	118	5,585	42,451	1,334	178
Water & Sediment Control Basins	96	1,444	11,057	1,050	206
Permanent Vegetative Cover	68	378	3,057	102	18

Water quality improvement spending in the LeSueur River Watershed, 2008 – 2015

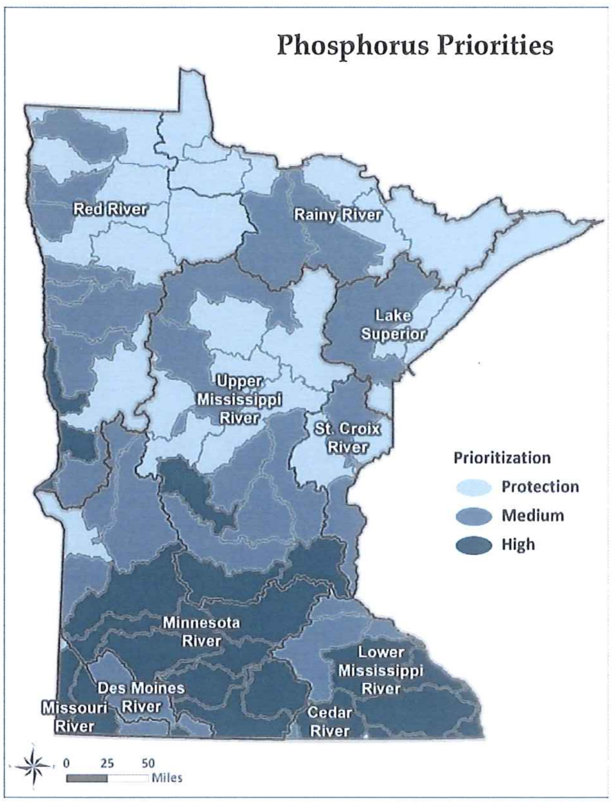
The figures in this report are based on data from several agencies. For details, see: www.pca.state.mn.us/water/clean-water-fund.

Table 3. Priority sources for each major basin

Major basin	Priority phosphorus sources	Priority nitrogen sources
Mississippi River	Cropland runoff, wastewater point sources, and streambank erosion	Agricultural tile drainage and other pathways from cropland
Lake Superior	Nonagricultural rural runoff [a], wastewater point sources, and streambank erosion	Wastewater point sources
Lake Winnipeg	Cropland runoff and nonagricultural rural runoff	Cropland

a. Includes natural land cover types (forests, grasslands, and shrublands) and developed land uses that are outside the boundaries of incorporated urban areas.

Priority watersheds have the highest nutrient yields (loads normalized to area), and also include watersheds with high phosphorus levels in rivers. Figure 5 identifies major watershed priorities.



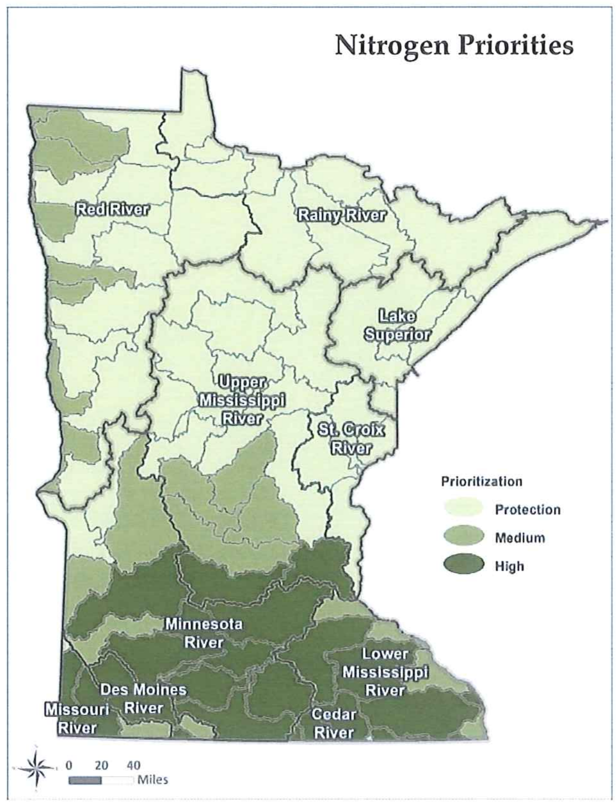
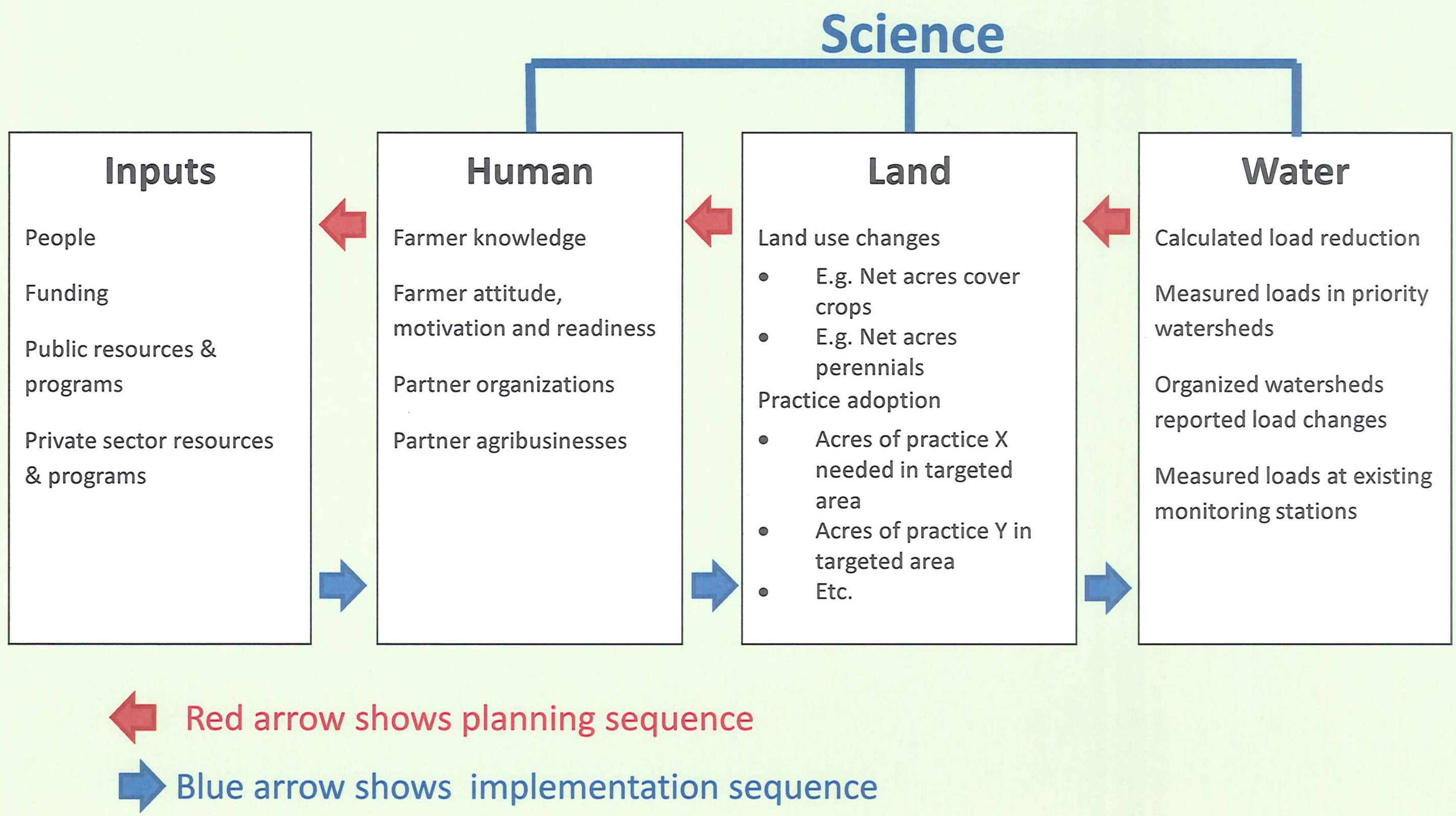
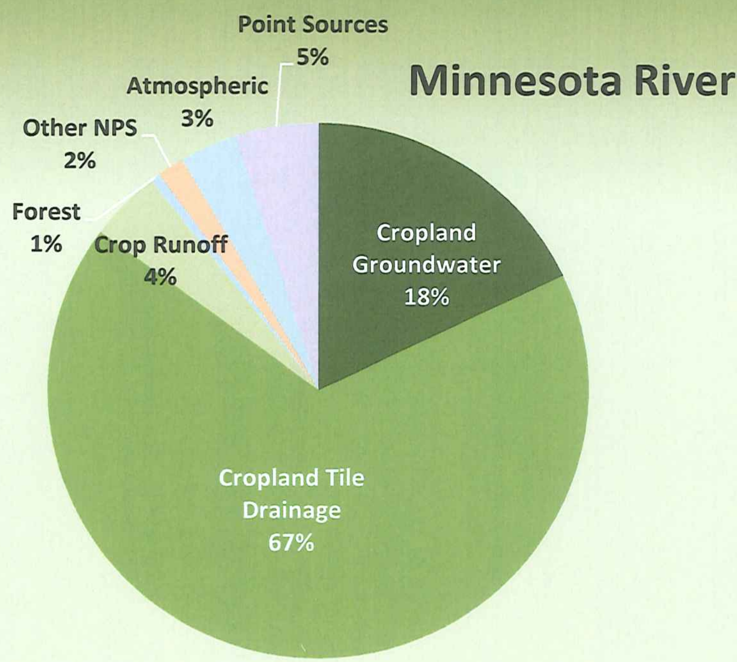


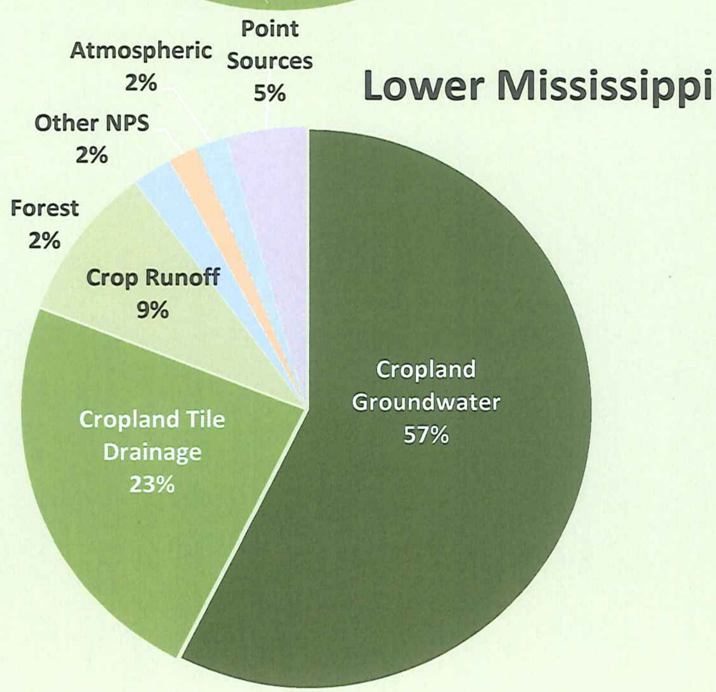
Figure 5. HUC8 watershed priorities.

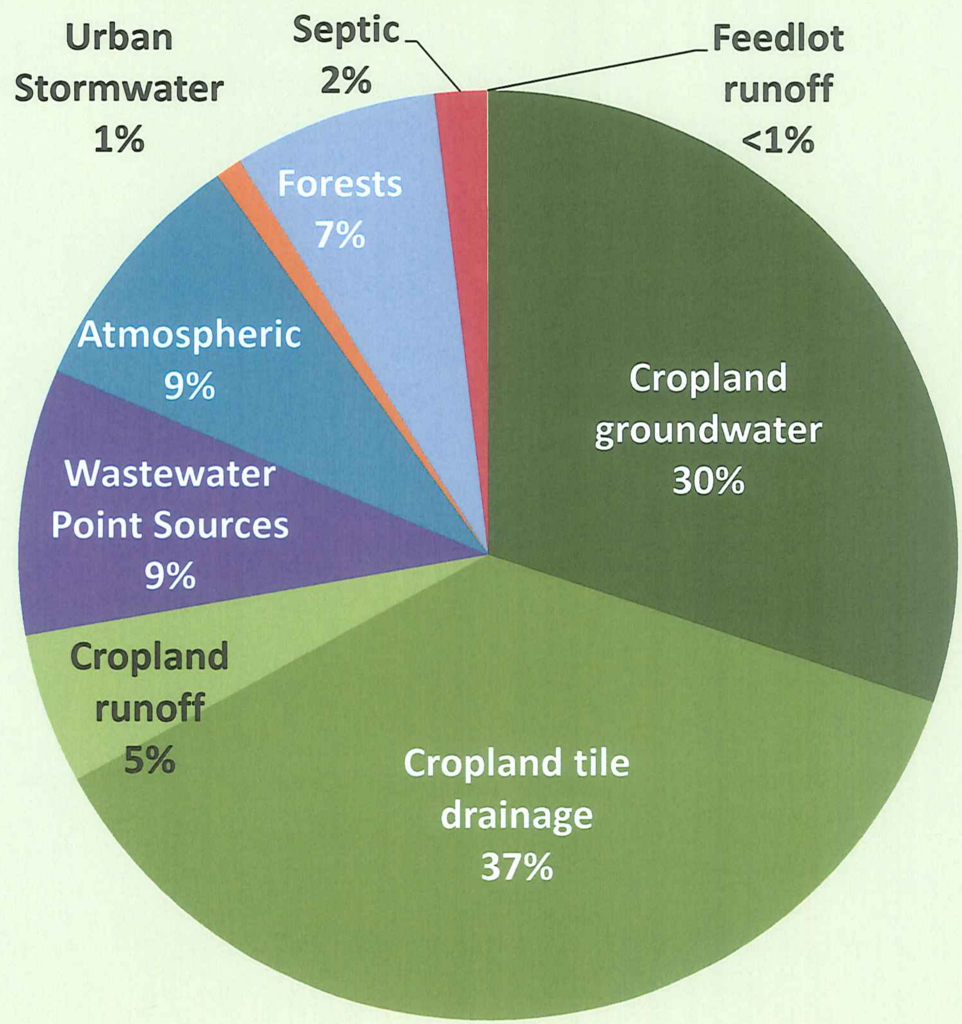
Watershed planning and implementing for desired change in water



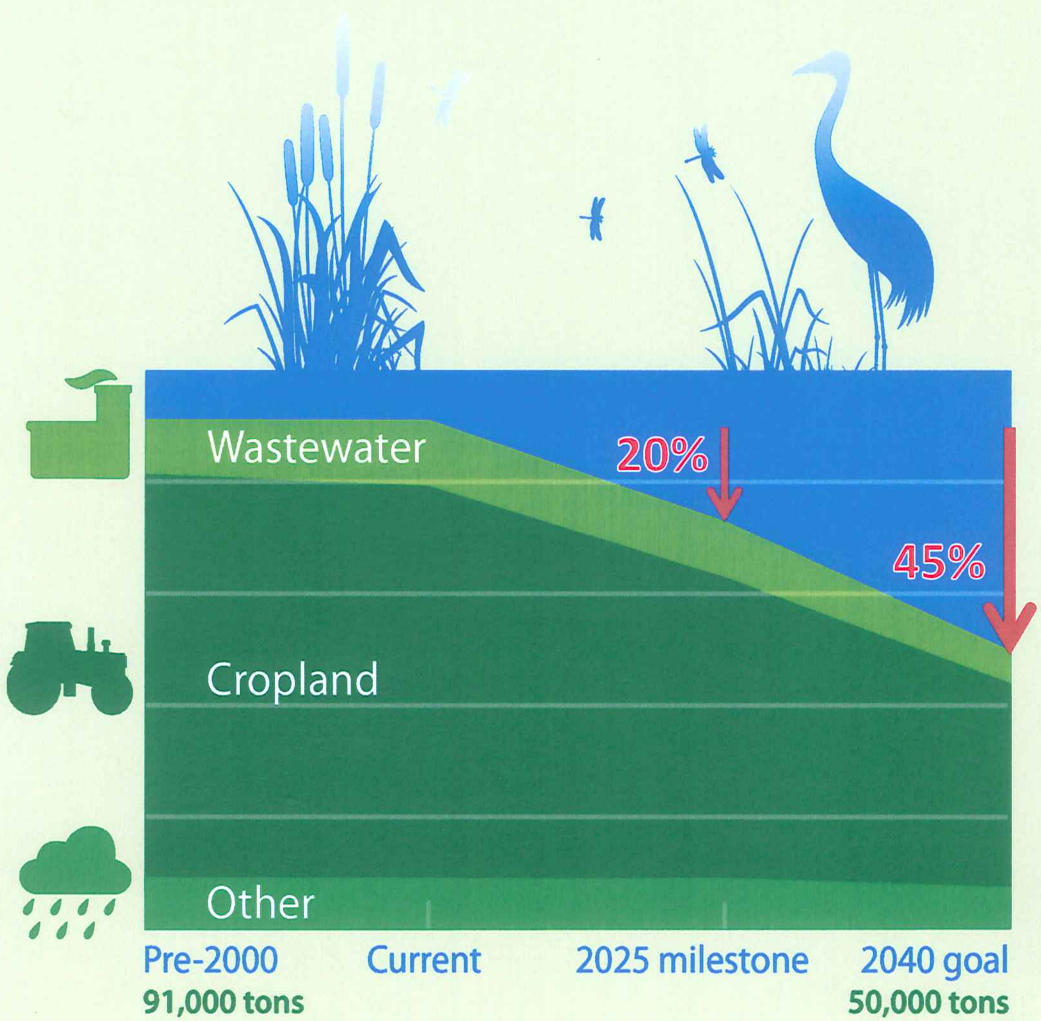
Statewide nitrogen to waters

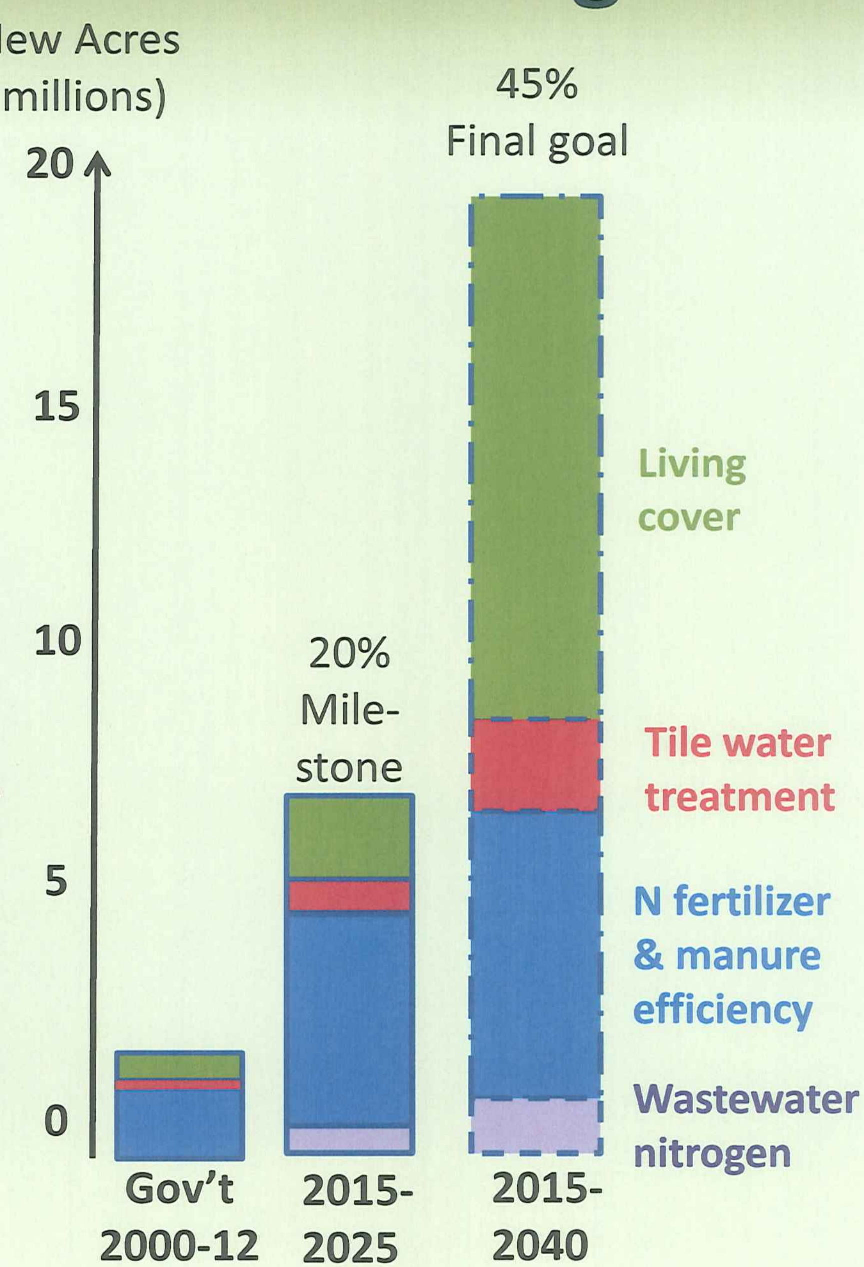






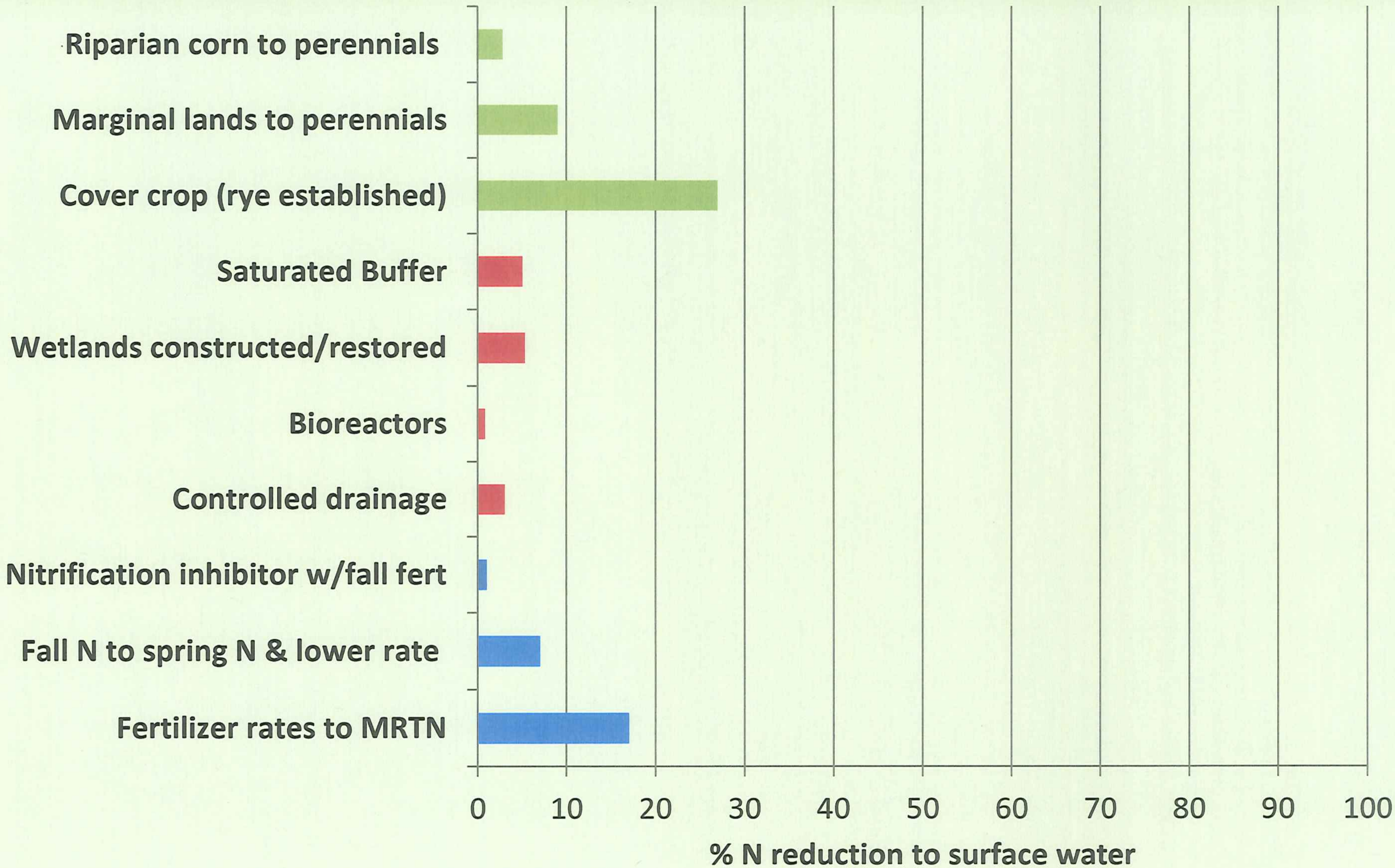
Additional NITROGEN BMPs needed for final goal





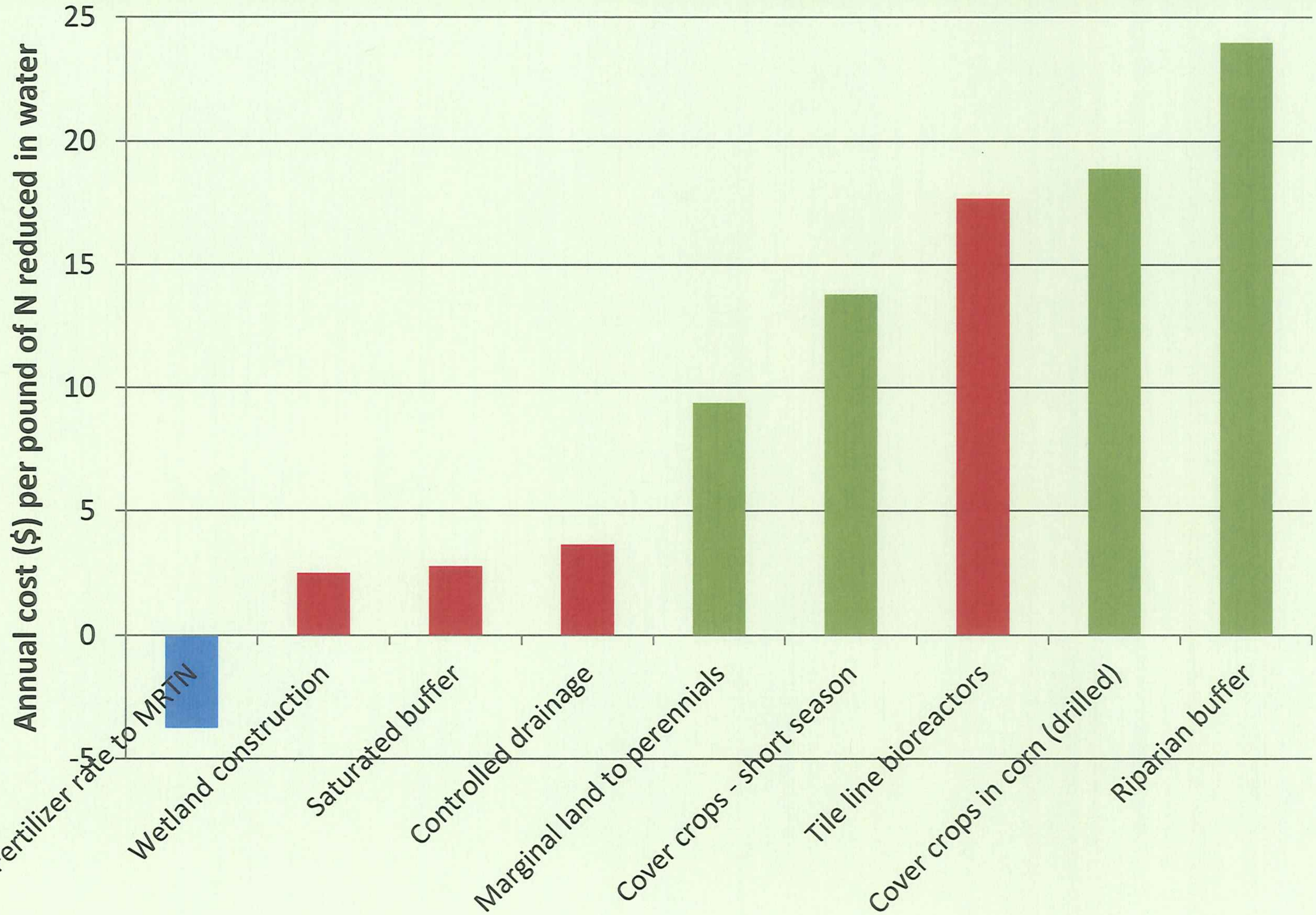
Nitrogen Reduction Potential (Mississippi R.)

if BMPs used on all suitable acres



Cost per pound of N reduced

N-BMP



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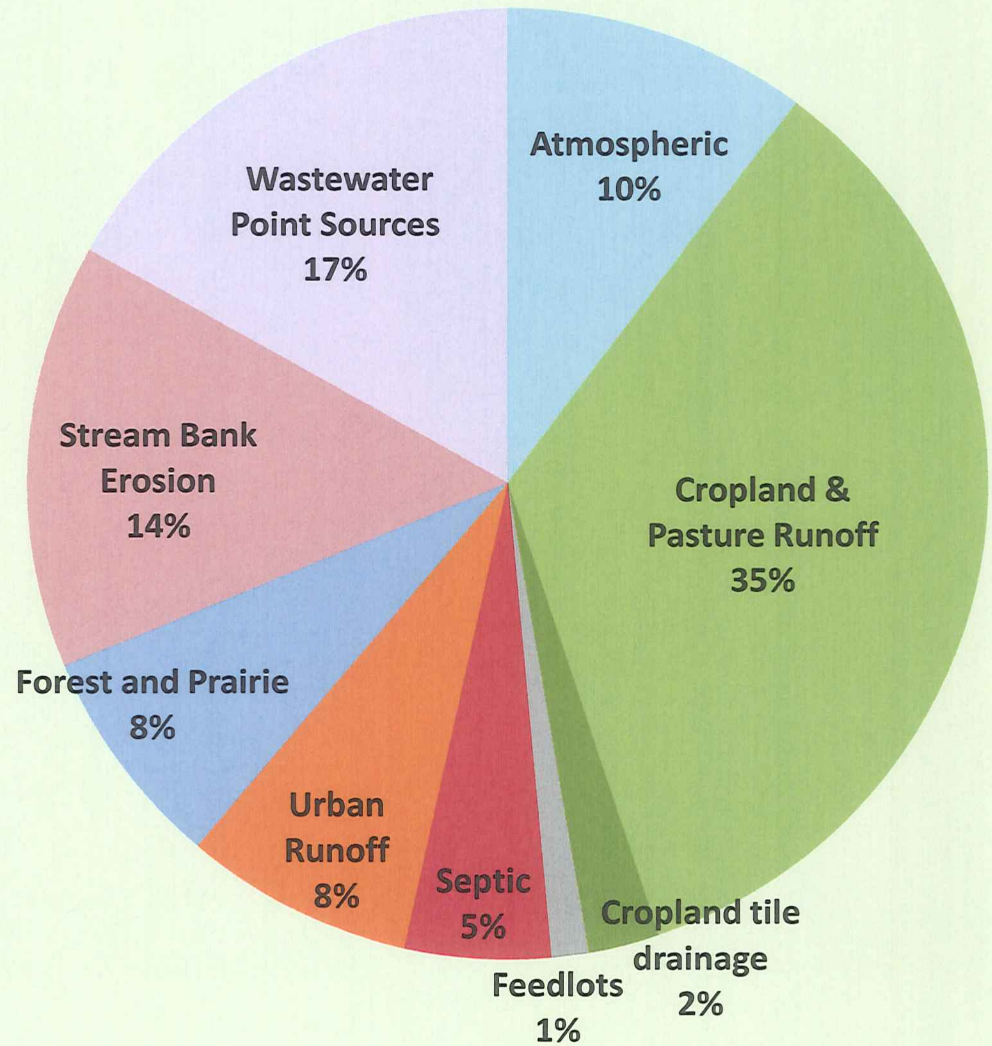
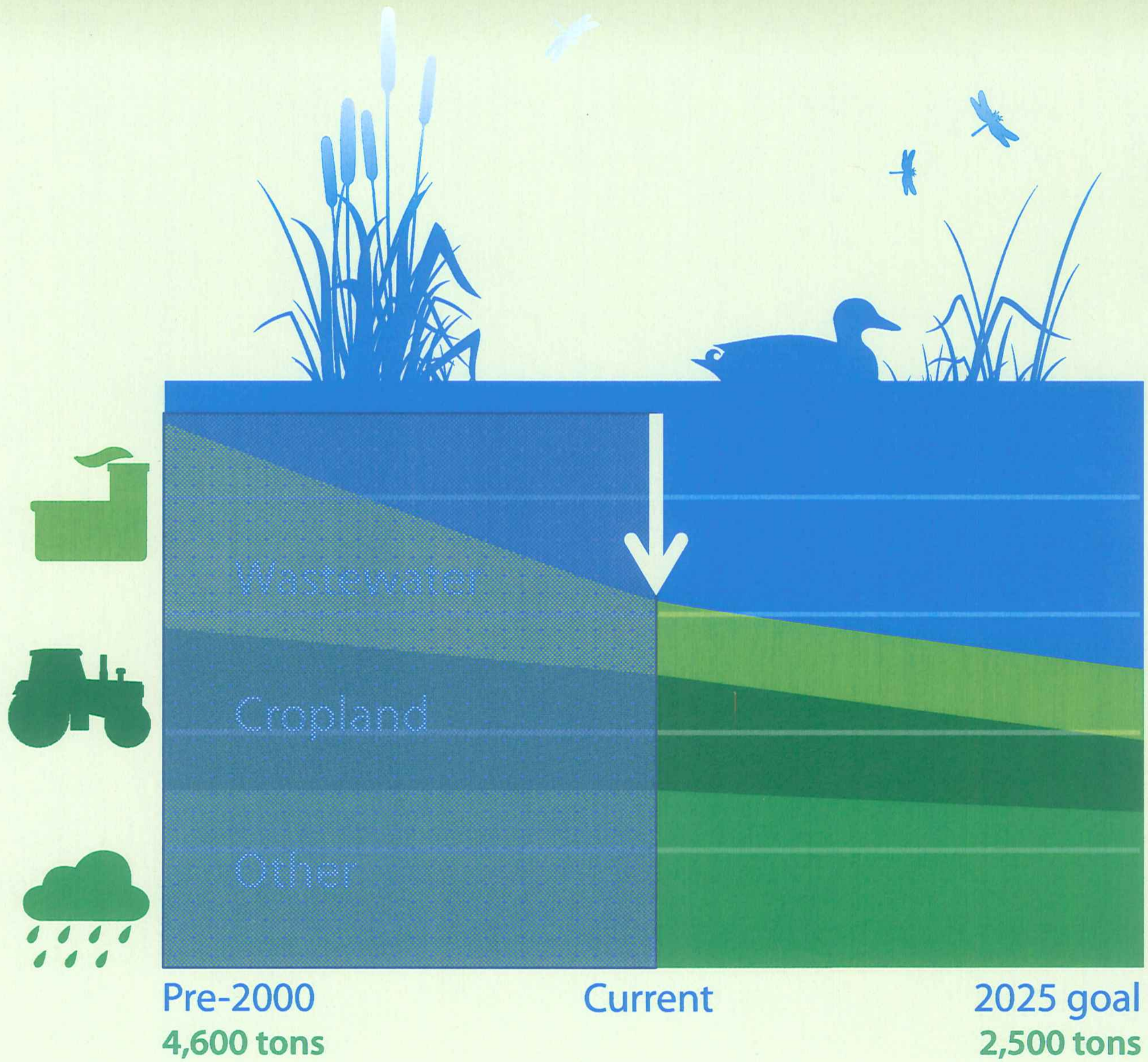
Statewide phosphorus sources to waters

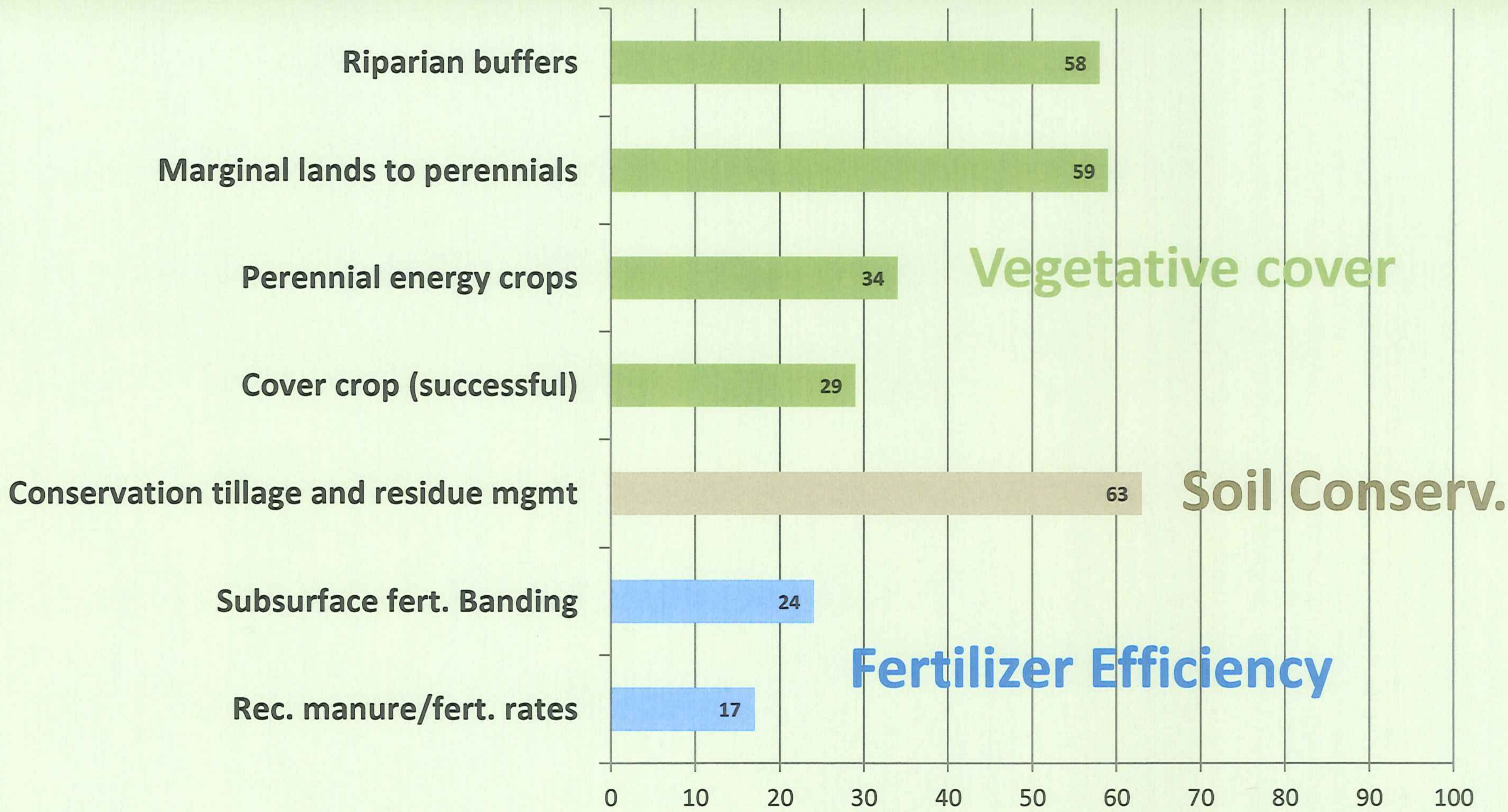


Phosphorus progress - Mississippi River



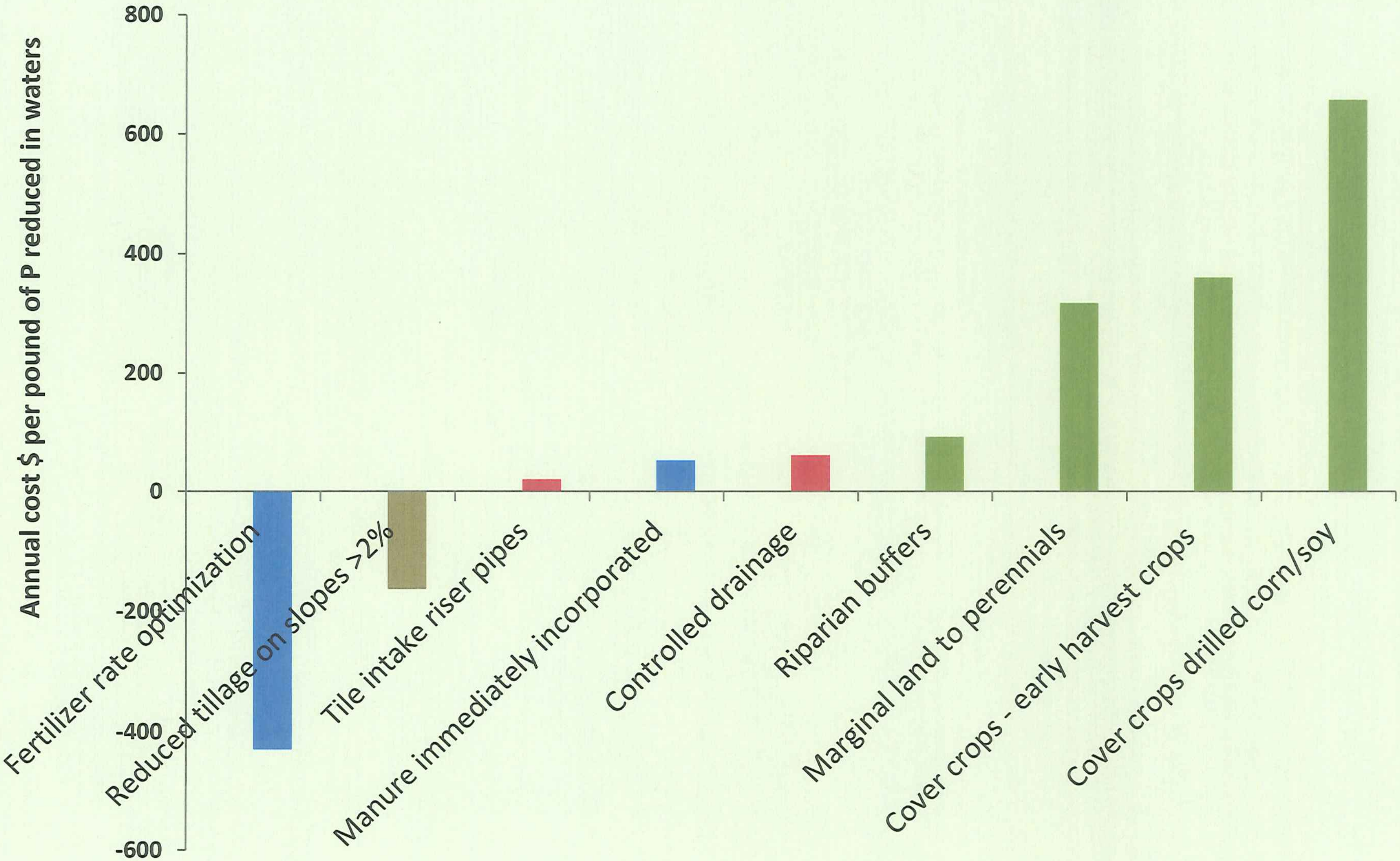
Sector	Load Reduction (MT)
Wastewater	1113
Cropland	356
Septic, open lots & lawn fert.	51
Atmospheric, streambank, other urban	Reduction not quantified

Typical % P reduction – edge of field

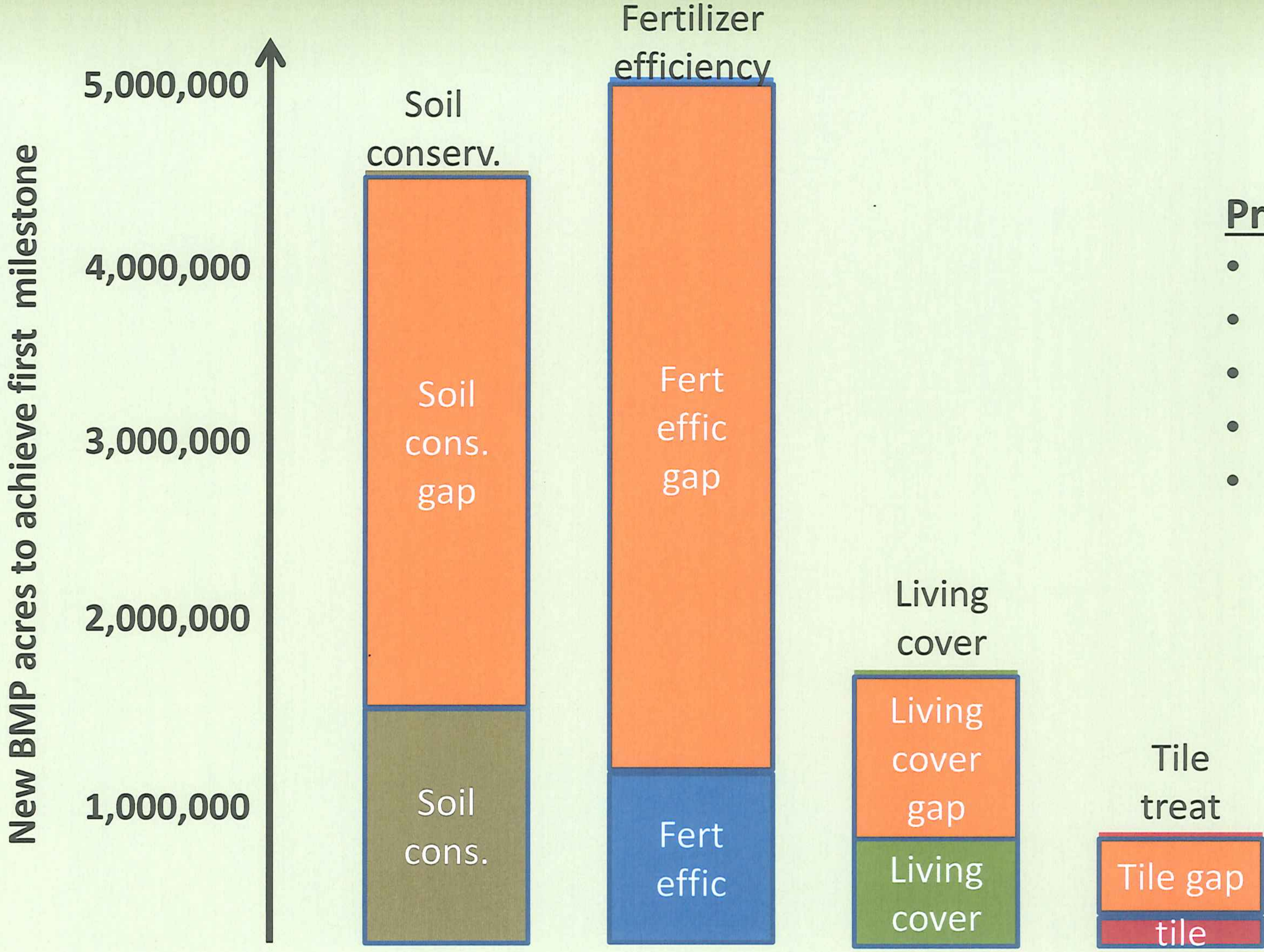


From: Tetra Tech 2013 – based on MN BMP handbook, Iowa Nutrient Strategy

Cost per pound of P reduced



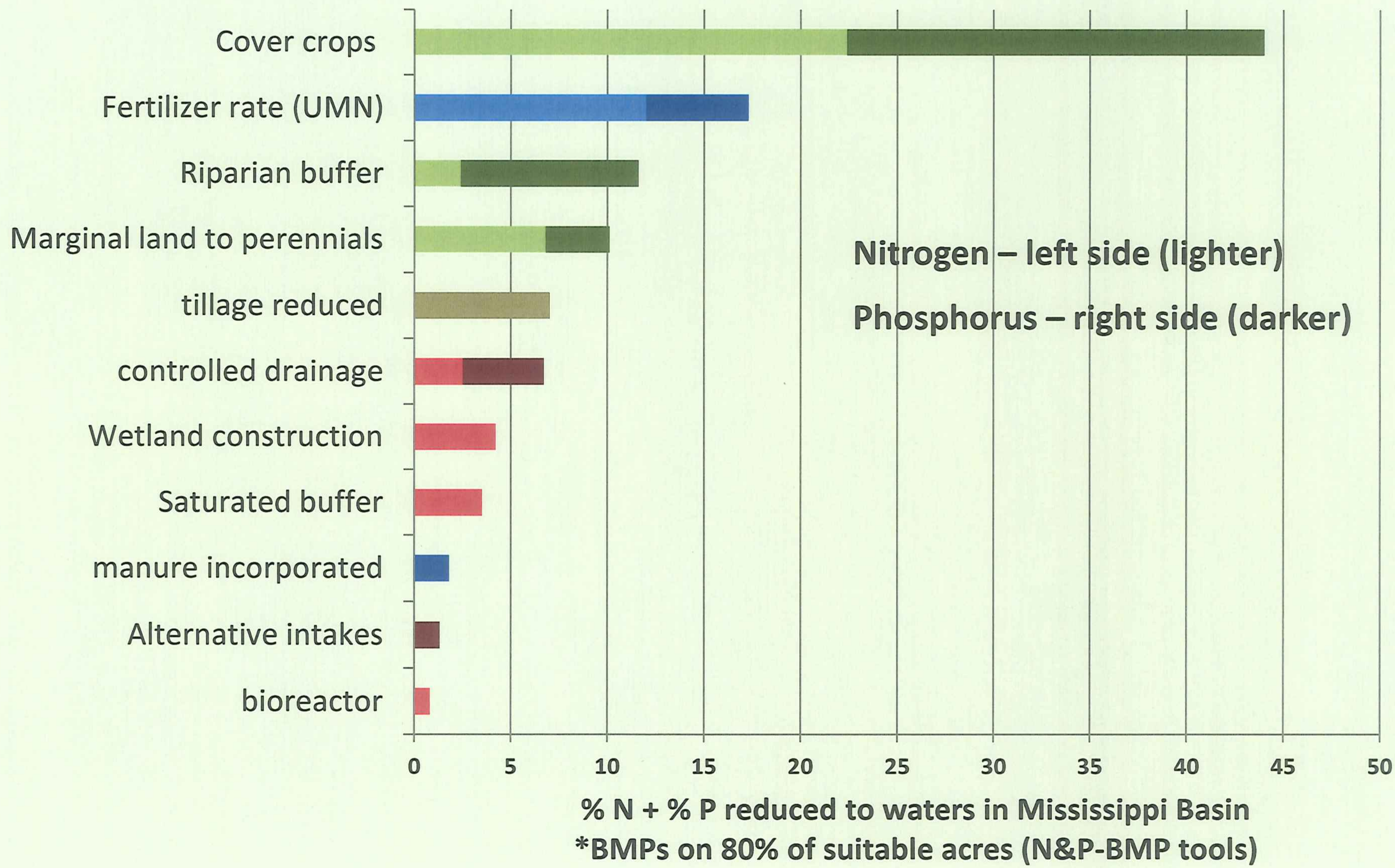
Gap between N&P milestone needs & projected



Projected by 2025:

- NRCS programs
- BWSR programs
- MDA NFMP
- Ag WQ Certific.
- Buffer law

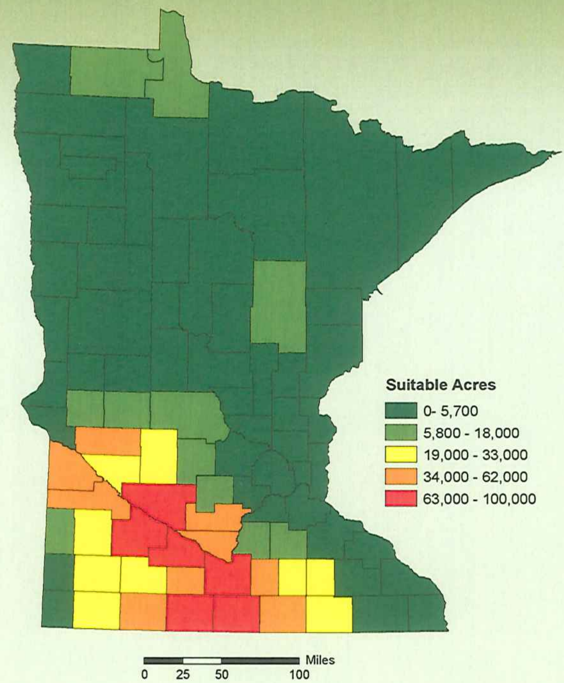
Combined N & P reduction



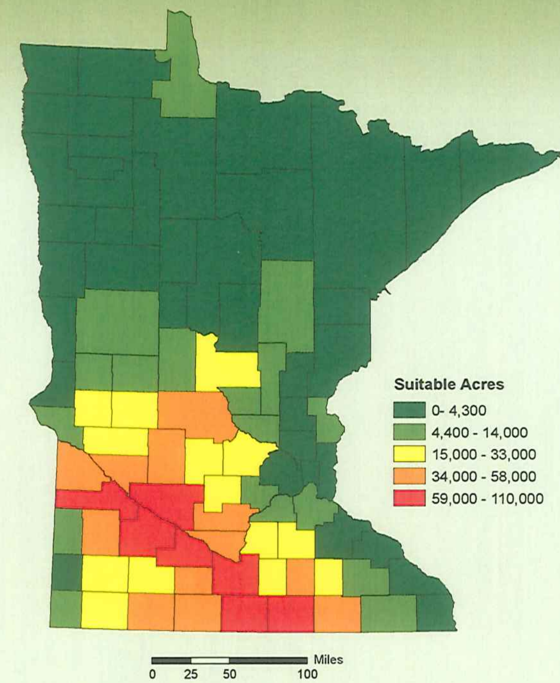
Nutrient Reduction Strategy – N & P

	Soil erosion protection	Fertilizer efficiency	Living Cover on cultivated lands	Drainage Water storage & treatment	Human & Animal waste
Groundwater nitrate		X	X		X
Surface water nitrogen		X	X	X	X
Surface water phosphorus	X	X	X		X
Surface water sediment	X		X	X	
Surface water bacteria	X		X		X

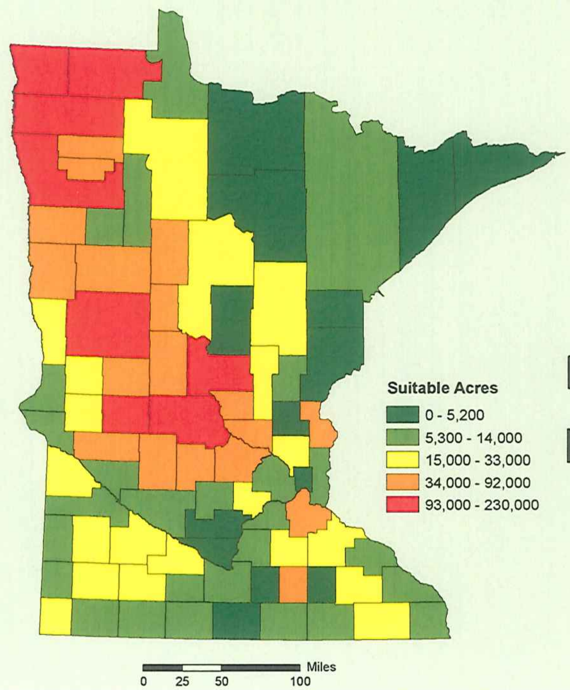
Suitable lands for BMPs



Controlled Drainage

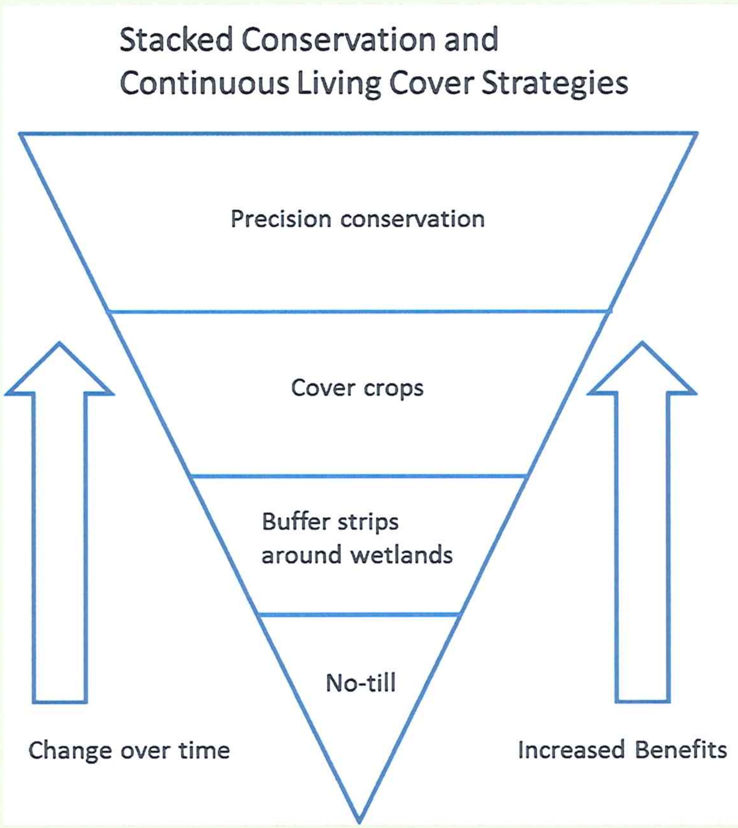


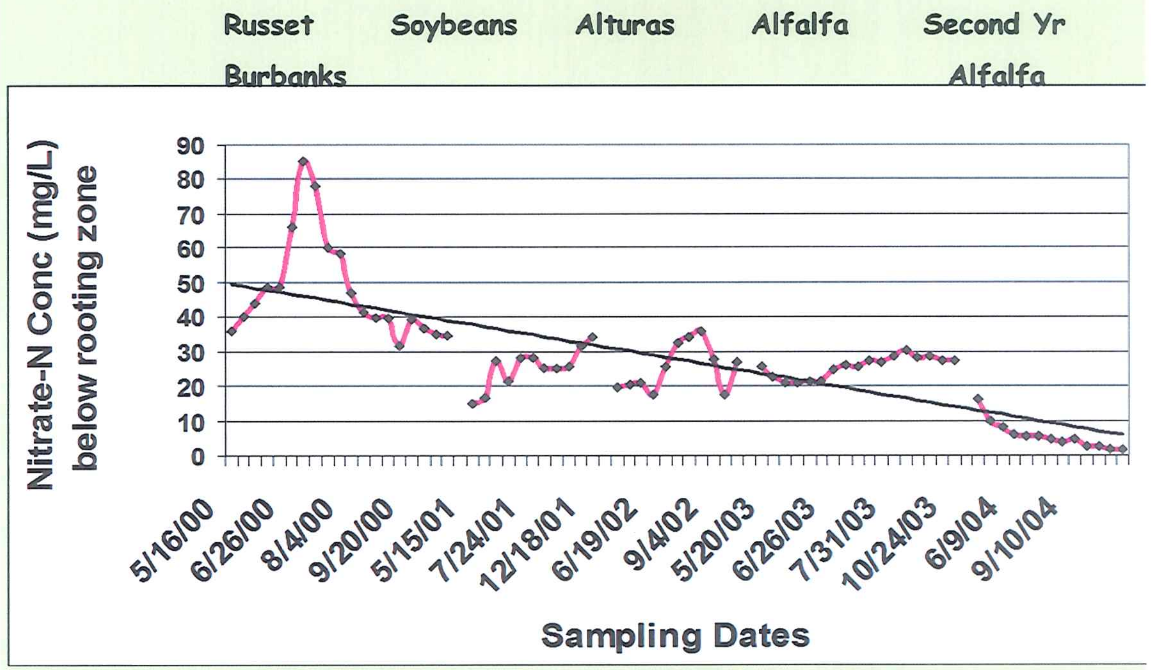
Restorable wetlands for tile waters



Marginal cropland for perennials

Success Stories





Perham Wellhead Protection Area

Tony Thompson – Willow Farm

Stop 4
Mankato

Wastewater reclamation and reuse and other city water programs

MANKATO WASTEWATER TREATMENT PLANT

Focus on Beneficial Reuse

Reclaimed Water:

140,660,000	gallons per year to Mankato Energy Center
214,790,000	gallons per year internal use
426,900	gallons per year irrigate Riverfront Park grand lawn
1,496,000	gallons per year street sweeping, vehicle washing, sod establishment etc.

Biosolids: 885 dry tons applied annually to agricultural land as fertilizer. Beneficial nitrogen and phosphorus are applied at agronomic rates

Methane: 6.5 million cubic feet produced per year, used for energy supply to the facility for process and building heat

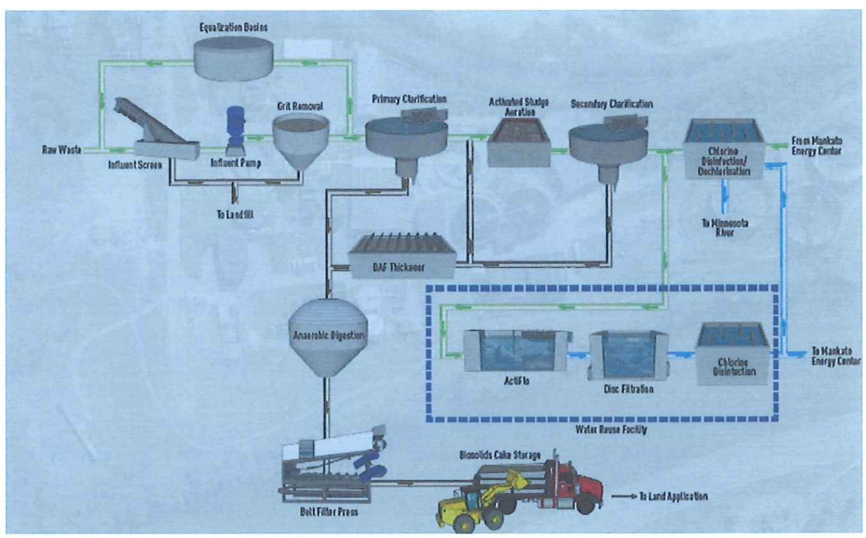
Partnerships

Regional Facility: Wastewater services to the communities of Mankato, North Mankato, Madison Lake, Eagle Lake, South Bend Township, Lake Washington Sanitary District, and Skyline

Calpine: City partnered with Calpine to build the $22 million Water Reclamation Facility, supplying reclaimed water for electrical production and other uses while reducing Mankato's phosphorus discharge levels to 0.35 mg/l

Minnesota River Watershed: Phosphorus credit trading with municipal and industrial facilities in the Minnesota River watershed

MPCA: Mankato is a Delegated Pretreatment Authority, regulating 9 Significant Industrial Users and 8 Categorical Industrial Users within our service area. Worked with the MPCA and MSU-M on a grant to study alternative methods to achieve very low phosphorus levels.



National Biosolids Partnership (NBP): Mankato participates in the NBP which advances environmentally sound biosolids management practices. This program is operated by the Water Environment Federation in collaboration with the National Association of Clean Water Agencies with support from the EPA. This EMS-based, third party audited certification program requires participating organizations to go beyond regulatory requirements.

Regional Municipal Separate Storm Sewer System (MS4) Group: Mankato, with a current MS4 program in place, has reached out to the surrounding townships, cities, counties and other government agencies to form a regional group. While currently in the development stage it will allow these entities to consolidate resources with us and participate in varying degrees as they work towards their compliance date.

Mt. Simon Users Group: Mankato joins surrounding major water consumers in funding and monitoring the resiliency of the significant Mt. Simon Aquifer.

Facility Plan

Mankato is currently working on a Facility Plan for the Wastewater Treatment Plant which will evaluate the current condition and capacity of the facility. Aging infrastructure will be evaluated to determine if rehabilitation or replacement is more economical. Regional residential, industrial and commercial growth projections will be used to determine future capacity needs. Future regulations will be considered for process planning. Alternative processes will be evaluated and the financial impact to our regional communities will be determined.

Water Challenges Facing Mankato:

Aging infrastructure: The Wastewater Treatment Plant was originally built in the 1950's with subsequent major expansions. Segments of the original structures remain in use but are in need of replacement. While the facility will tune in the needs we anticipate the needs will be nearly $25 million. The distribution and collection systems have portions that are over 100 years old which contribute to line loss on the water side and infiltration on the collection side as well as increasing staff time for line repairs.

Increasing Regulations: The NPDES permit for the Wastewater Treatment Plant has expired. Proposed regulations include an interpretation of the new River Eutrophication Standard which would reduce our allowed phosphorus discharge by 21%. The ramifications of this are increased treatment costs, reduced growth potential and reduction/elimination of our phosphorus credit trading with small cities and industries.

Inflow and Infiltration (I&I): While providing wastewater services to our surrounding communities there are some, Madison Lake and Eagle Lake in particular, that have above normal I&I. These increased flows to the treatment facility during high flow events uses up capacity needed for future growth. Mankato has requested funding from the legislature for the investigation and solution to these issues in our surrounding areas. Mankato recently spent $5.5 million on lining one force main to reduce I&I

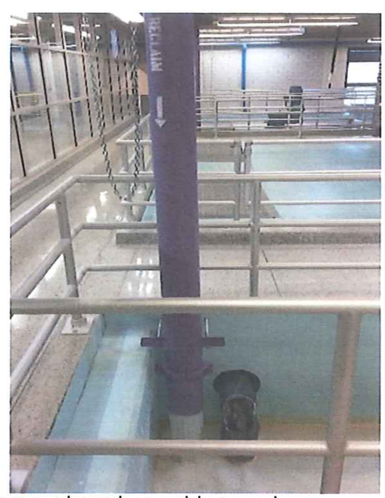
Storm Water Management:

- **Agricultural Runoff into the city:** Over 3,500 square miles of land drain through the city of Mankato which can and has overwhelmed our storm water infrastructure and natural drainage ways causing flooding and damage to residential properties
- **River bank Stabilization:** Non-point source runoff from high rainfall events causes increased flows to the local streams and rivers. For Mankato the increased flows have undercut the banks of the Blue Earth River threatening the integrity of the land surrounding one of our major wells.
- **Ravine stabilization:** Increased flows through our city has caused destabilization of the numerous ravine areas spread throughout the city
- **Upgrades to the flood control system:** Subsequent to severe and damaging floods in 1951 and 1965 a levee system was constructed along the Minnesota and Blue Earth Rivers passing through the Mankato/North Mankato/South Bend Township area. Mankato has 5 aging pumping stations in this system which need to be brought up to code and be provided with redundant electrical service.

Water Supply Sustainability:

- **Source Water Protection for Ranney wells:** Two of Mankato's main supply wells are considered ground water under the influence of surface water. These wells are approximately 60 feet deep with laterals extending out under the Minnesota and Blue Earth Rivers. Spring runoff from non-point sources have elevated the concentration of nitrates into both rivers. During these periods Mankato's pumping capacity is limited in order to protect our residents from elevated levels in our drinking water. This past spring one well had to be taken out of service and another reduced to ½ capacity to maintain acceptable levels.
- **Competition for groundwater:** Mankato has focused on maximizing the water draw from the shallower, more sustainable wells and minimizing the draw from the centuries old aquifers. There is concern about the considerable amount of water drawn for once-pass cooling water by non-municipal users

Funding: The magnitude of current and future needs is of concern. We anticipate the Wastewater Facility Plan will identify $25 million in needs. The recent legislative funding request identified an additional $28 million. We anticipate conducting a Facility Plan for the Water Treatment Plant in the next year which will also identify future needs in that area.



Water Conservation in Mankato

PFA Funded Water Treatment Plant Reclaim Water Project:
In March, 2016 a project was completed to return membrane rinse water back to the head of the Water Treatment Plant. This Minnesota Department of Health approved project will save approximately <u>182,500,000 gallons</u> of water each year. Not only does it save by reducing the amount of water taken from our wells it also reduces the amount of water going through our collection system and Wastewater Treatment Plant thereby increasing capacity for us and our regional users.

Water Supply Plan: The new plan currently in development will focus on reducing industrial and commercial water usage by 15% over the next 10 years

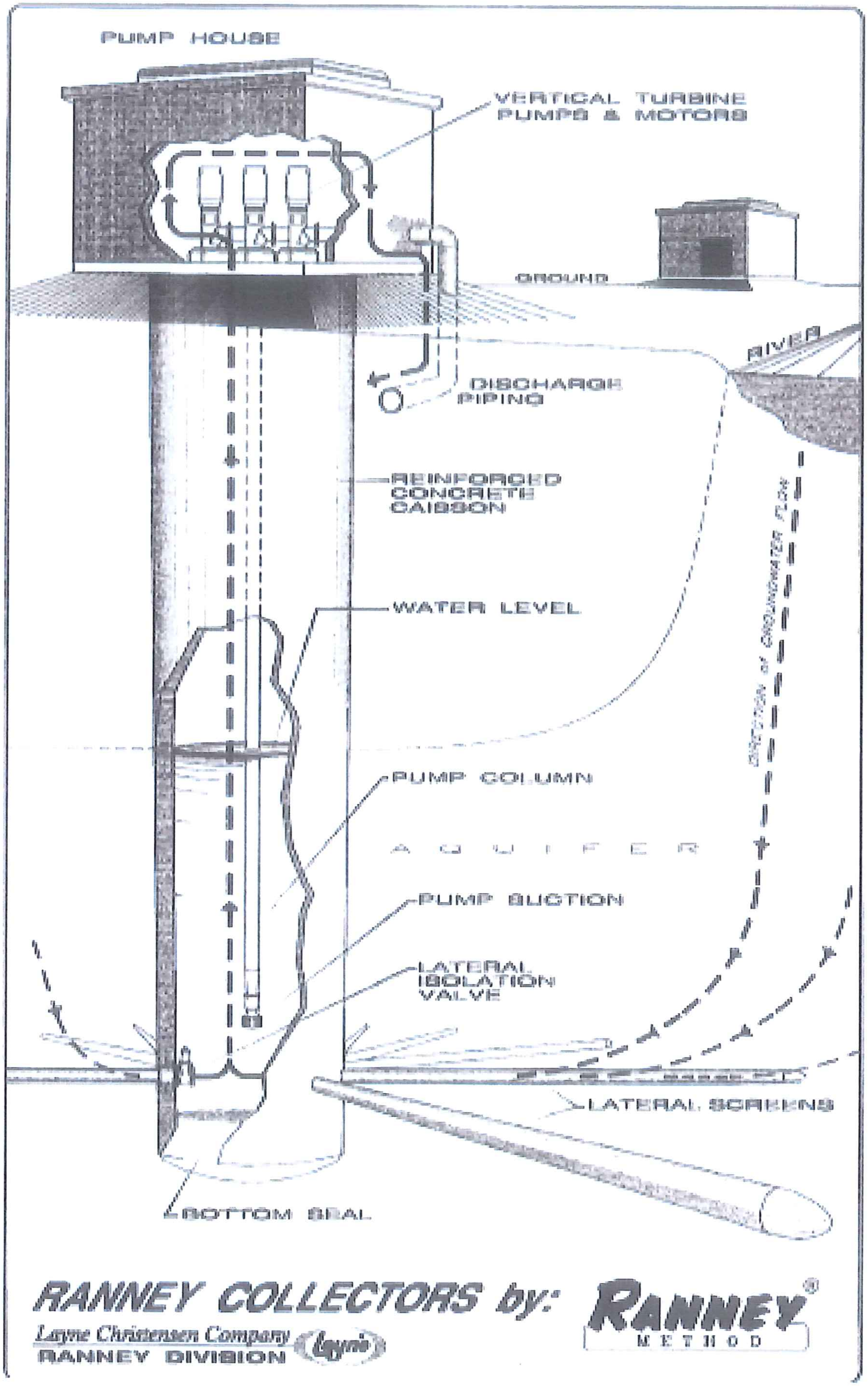
Year Round Even/Odd Watering Days: The City has put mandatory even/odd day watering into effect year round to decrease the peak demand days which maintains the plant capacity

Individual metering to mobile home communities, apartments: The city has begun a program to upfront the cost to install individual water meters to each unit. Residents will have the tools to visualize their water consumption and reduce it.

Water loss detection program: The city has a continuous leak detection program. Through this program we have been able to reduce our water line loss to 8.5% which is below the DNR goal of 10%. We have also been able to reduce our residential per capita daily consumption to 50 gallons which is below the DNR goal of 75

Public education: The City is using a variety of methods to keep our customers informed of the ways they have to conserve water; text messages, Tweets, electronic newspapers, mailings, web site and multi-media announcements among them

Land of Memories Park


PUMP HOUSE
VERTICAL TURBINE PUMPS & MOTORS
GROUND
RIVER
DISCHARGE PIPING
REINFORCED CONCRETE CAISSON
WATER LEVEL
DIRECTION of GROUNDWATER FLOW
PUMP COLUMN
A Q U I F E R
PUMP SUCTION
LATERAL ISOLATION VALVE
LATERAL SCREENS
BOTTOM SEAL
RANNEY COLLECTORS by:
RANNEY METHOD
Layne Christensen Company
RANNEY DIVISION

Preserve water

Mankato's lawn watering conservation program:

Conserving water is the most cost effective way to avoid future problems. Mankato's lawn watering conservation program deliberately encourages reduction of water usage to ensure stable delivery and minimize peak demand times. The lawn watering conservation program applies to everyone watering lawns using city of Mankato water. Since water is a valuable resource, it's important to conserve water and reduce water usage. Doing so helps efficiently use the area's groundwater resources and ensures an adequate water supply for residents, business and other organizations.

When to water

Watering is limited to every other day between 6 p.m. to 11 a.m. (avoid watering during the day from 11 a.m. to 6 p.m.)

Know your watering days

- odd-numbered street addresses may water on odd-numbered days (1, 3, 5, 7, 9)
- even-numbered street addresses may water on even-numbered days (0, 2, 4, 6, 8)
- multiple-unit complexes may water based on the lowest-numbered complex address. For example, if the lowest number of the complex is 1, it is an odd-numbered watering day; if it is 2, it is an even-numbered watered day.

Exceptions

- new landscaping, sod or seed within 30 days of being installed (with a city permit)*
- gardens and flower beds (with a hand-held hose)
- children's water toys (must be attended)
- washing vehicles

New landscaping, sod, or seed permits are available online at http://tinyurl.com/mankatowaterconservation or call 311, or 507-387-8600.*

Avoid a fee

Help us, help you. Conserve water and reduce water usage to benefit the environment and avoid the following fees:

First notice	warning
Second notice	$50
Third notice	$100
Fourth notice	disconnection of irrigation meter or outdoor spigots

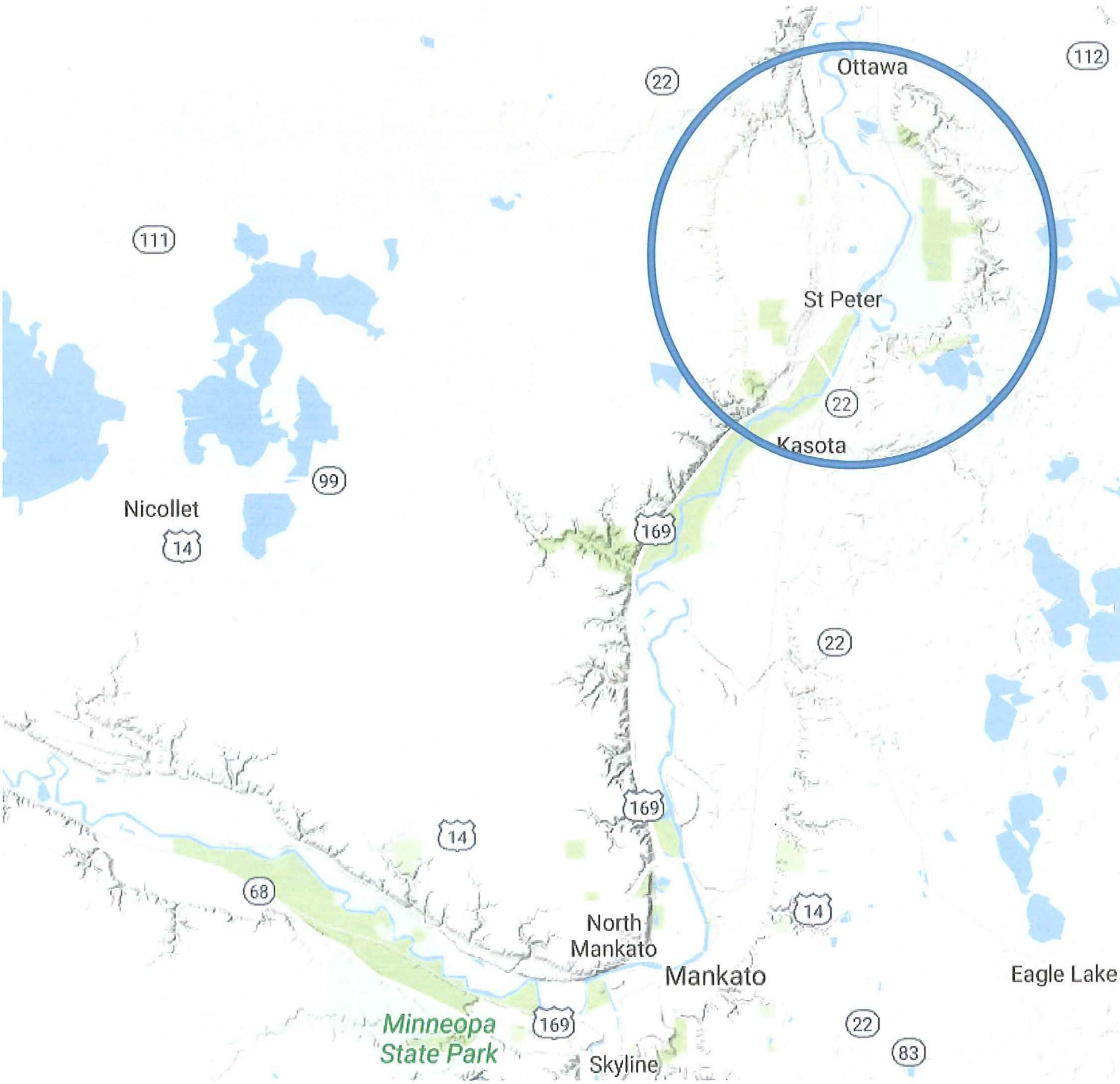
For more information contact staff at 311 or 507-387-8600.

Stops 5 & 6
St Peter

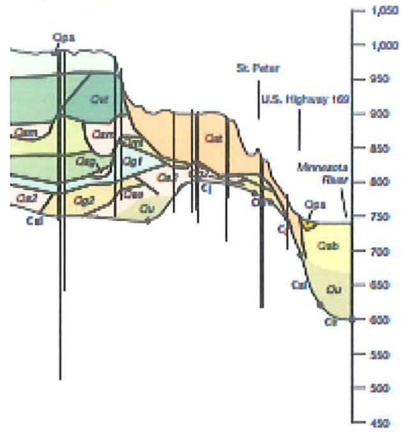
Drinking water protection and treatment

St Peter Geology Explains Aquifer Vulnerability to Contamination

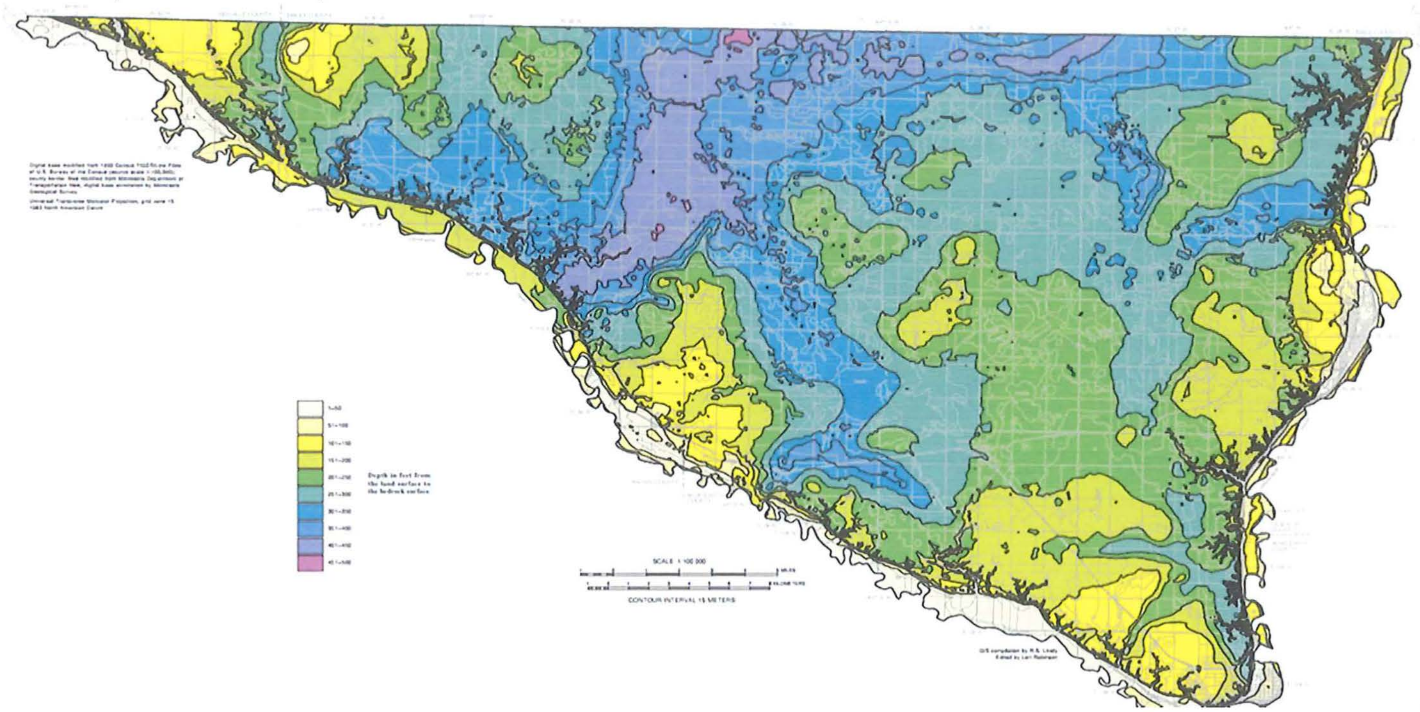
Glacial River Warren gouged a deep and wide path within which the Minnesota River flows today. This map shows that the channel is wider from Mankato to Ottawa and, due to the widening, glacial sands and gravels could settle out along this reach. As River Warren shrunk and the water level lowered, the deposits formed a series of terraces. St Peter is constructed above those terrace deposits. As you drive from MN 169 westward, you climb those terrace "benches". The blue circle shows that River Warren carved a "bowl" or depression where St Peter is located today.



The geologic atlas for Nicollet County includes cross-sections that show how complicated those quaternary deposits are and how thick they are within the St Peter depression.



Within the St Peter depression, the depth to bedrock varies from 1 to 150 feet (the purple section indicates there had been deeper erosion there).



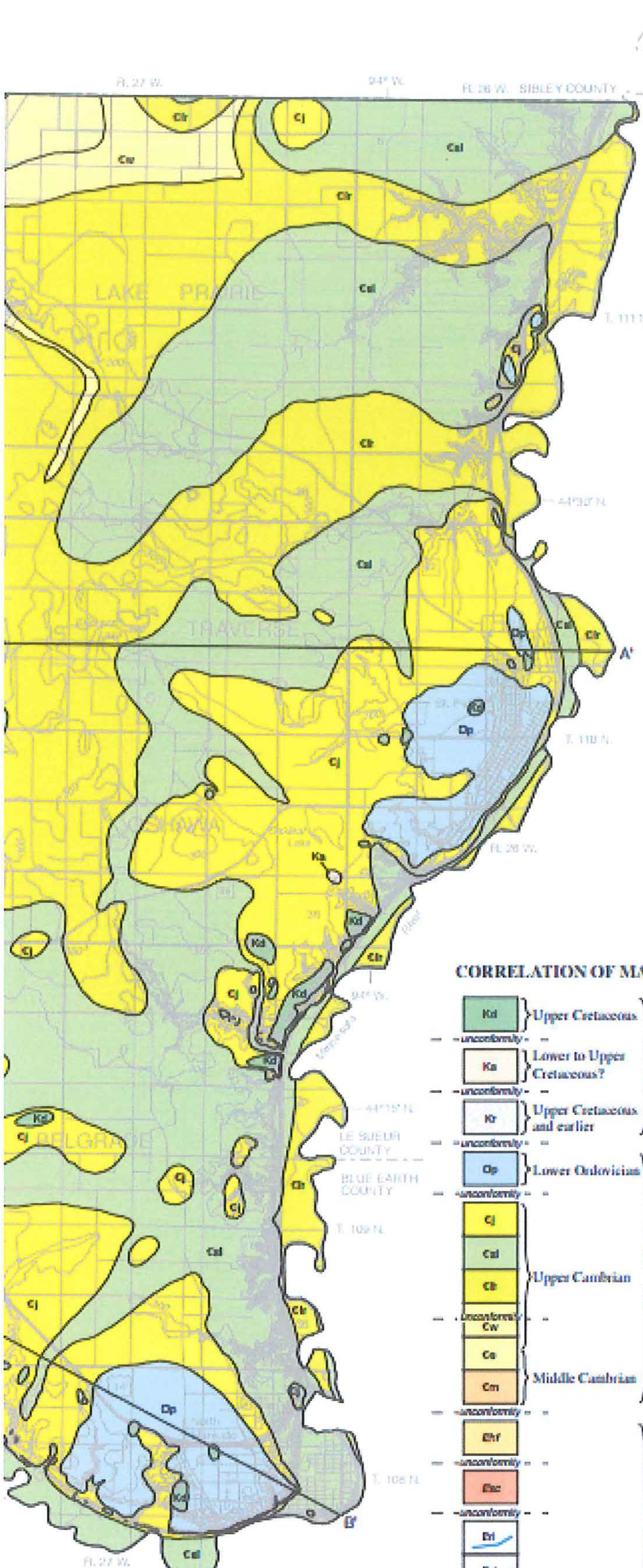
The following figure shows the layers of sedimentary bedrock (primarily sandstone and limestone) that are beneath the surficial sands and gravels. The City of St Peter has drilled three wells into the Jordan formation (these are the most susceptible to contamination), 3 into the Tunnel City-Wonewoc formation (formerly called the Franconia-Ironton-Galesville formation), and 3 into the Mt Simon formation.

BEDROCK GEOLOGY

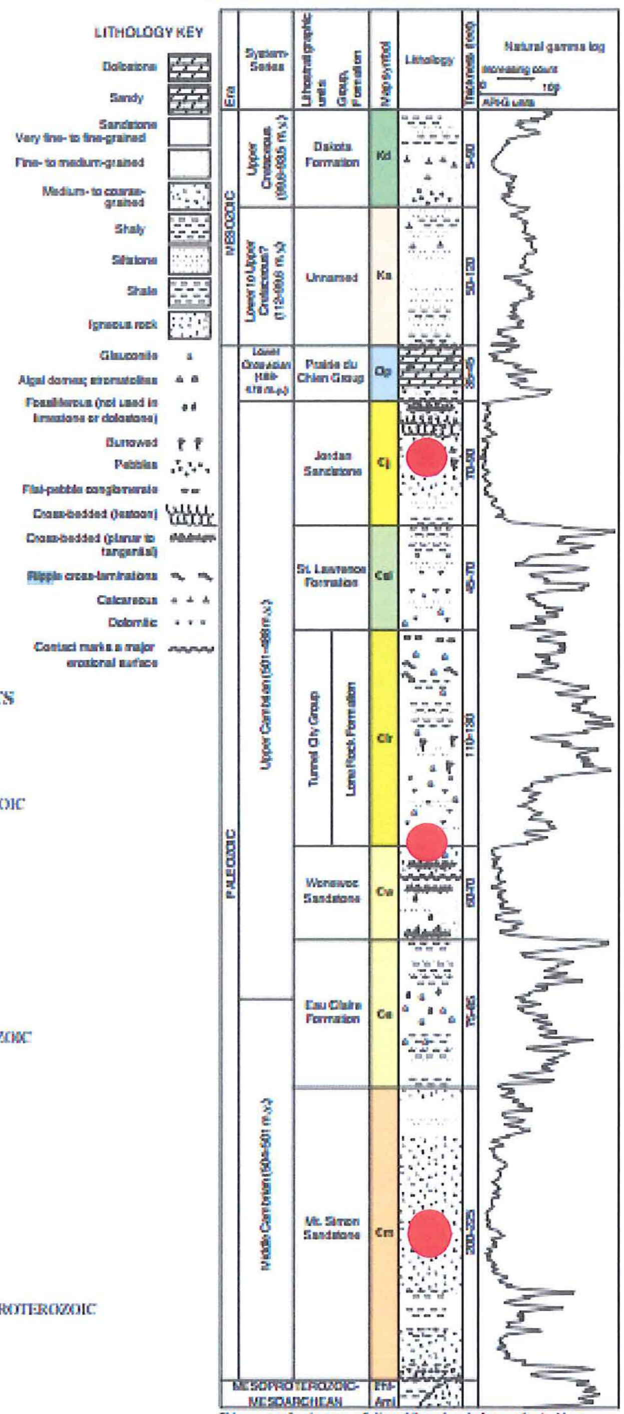
By

John H. Mossler and V.W. Chandler

2012

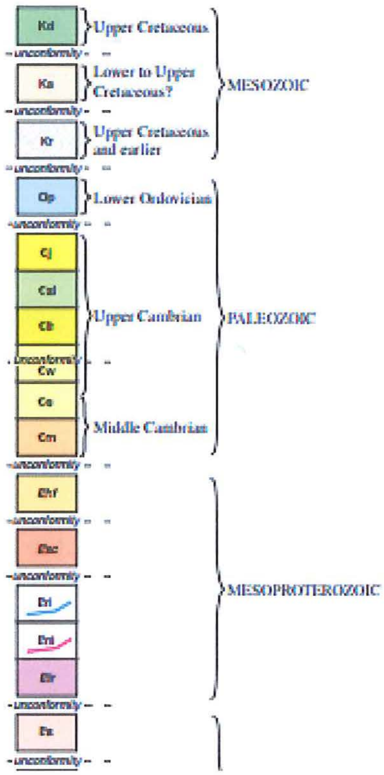


STRATIGRAPHIC COLUMN

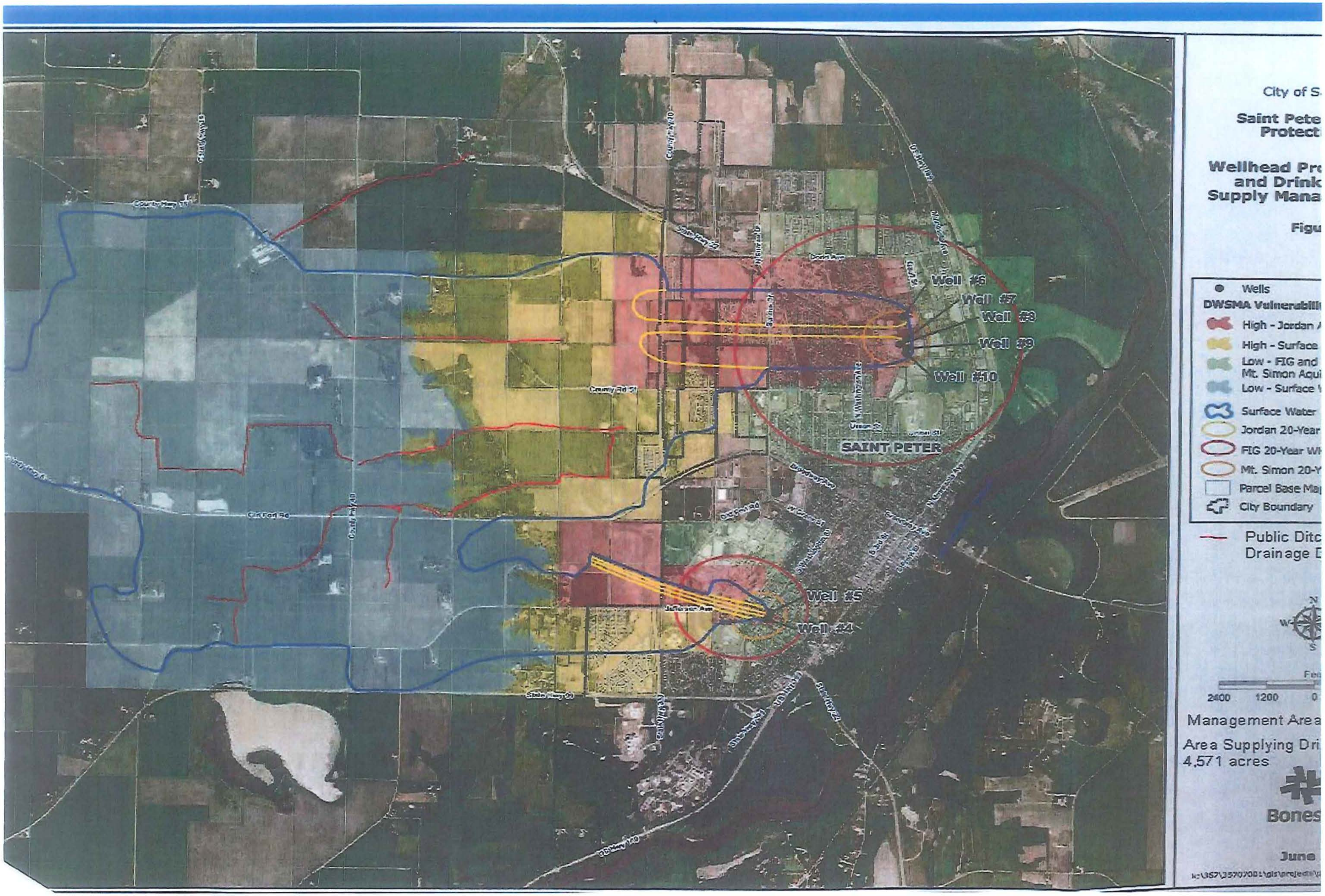


This gamma log is a compilation of three borehole geophysical logs collected from water wells in Nicollet County; unique numbers 208868, 232487, and 529254.

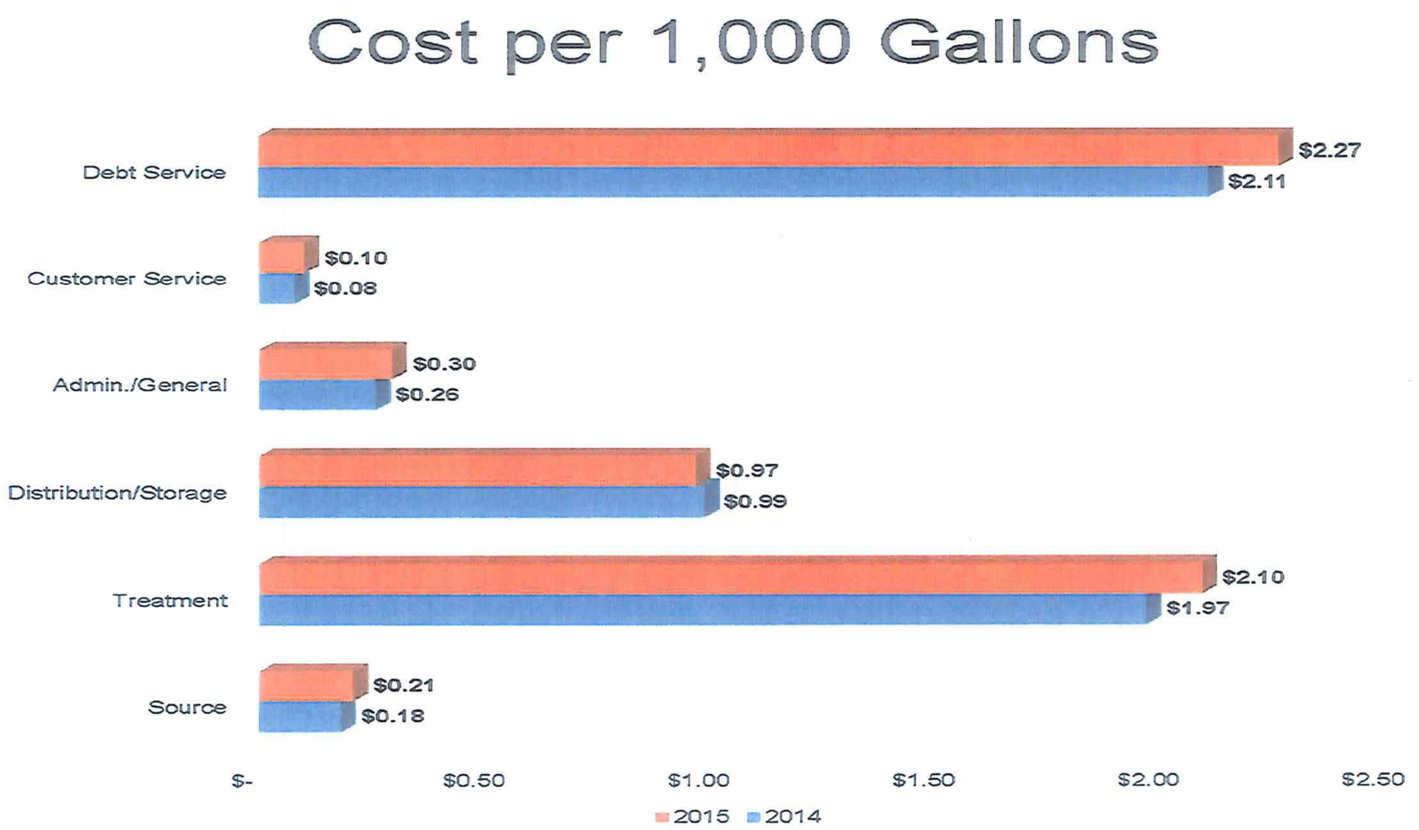
CORRELATION OF MAP UNITS



The green public ditch in the upland area west of (Co Rd 40) drains into a ravine that then enters a smaller ditch that eventually drains into a wetland area (in the red circle) that the City believes is a focused recharge point for the Jordan aquifer. The field south of the wetland is the location for the new school and city park, currently under construction.

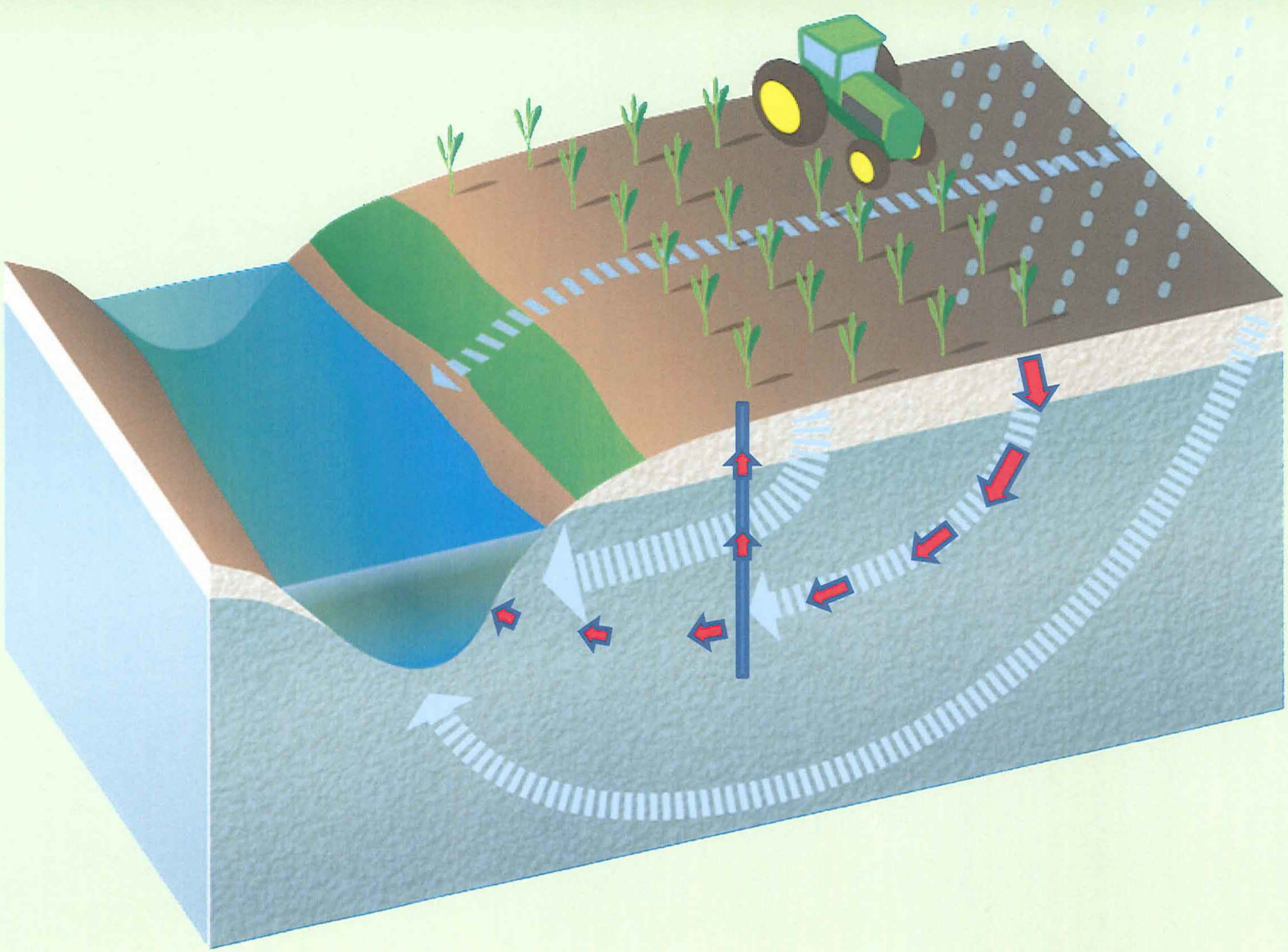

City of S
Saint Pete
Protect
Wellhead Pr
and Drink
Supply Mana
Figu
Wells
DWSMA Vulnerabili
High - Jordan A
High - Surface
Low - FIG and
Mt. Simon Aqui
Low - Surface
Surface Water
Jordan 20-Year
FIG 20-Year W
Mt. Simon 20-Y
Parcel Base Ma
City Boundary
Public Ditc
Drainage D
Well #6
Well #7
Well #8
Well #9
Well #10
Well #5
Well #4
SAINT PETER
2400
1200
Management Area
Area Supplying Dri
4,571 acres
Bones
June

COST PER 1,000 GALLONS

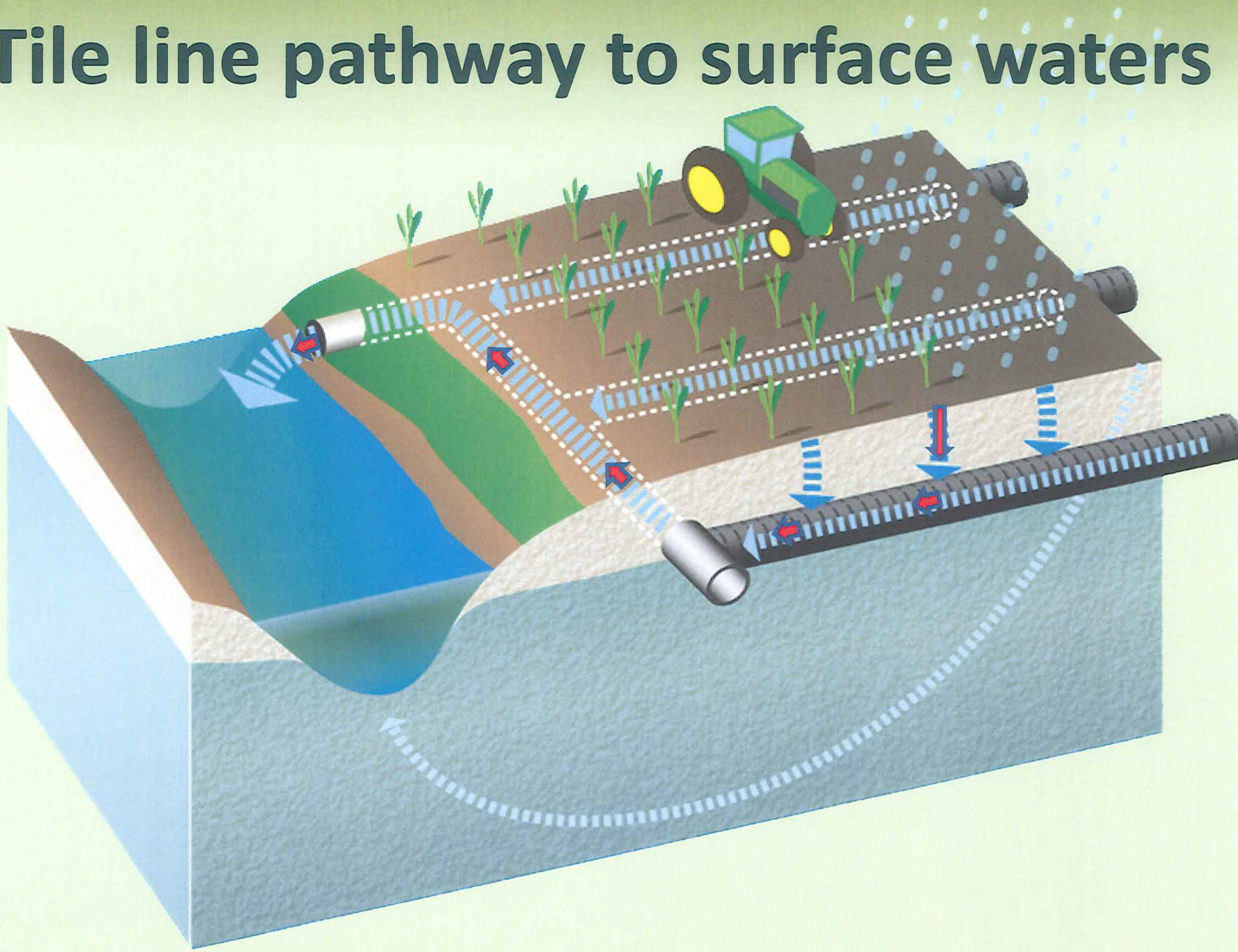


19

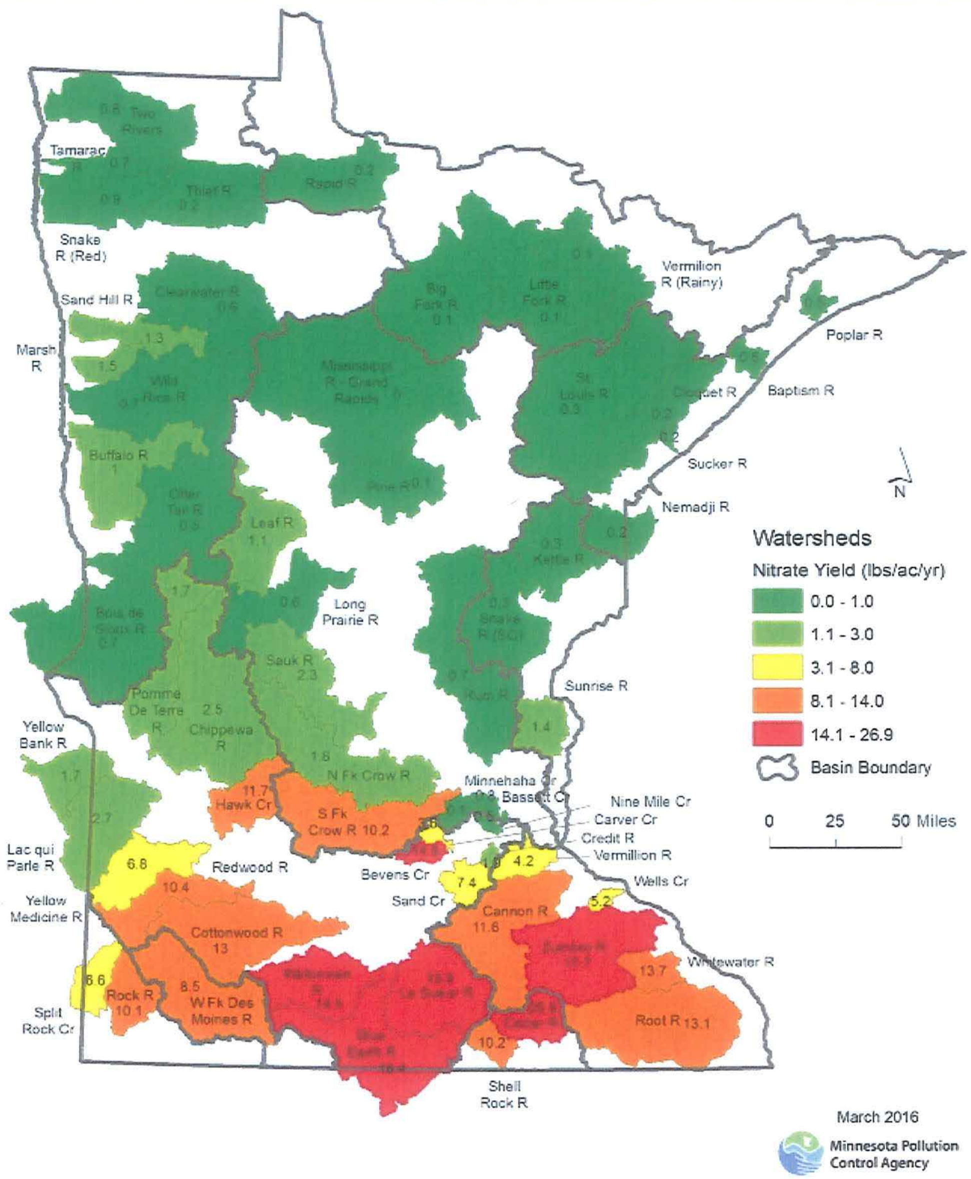
1. Cropland nitrate into well water



Tile line pathway to surface waters



Nitrate - lbs/acre/year (2009-13 avg)



Excerpted from the Minnesota Nitrogen Fertilizer Management Plan (March 2015, MN Department of Agriculture, Pesticide and Fertilizer Management Division)

Figure 23. Mitigation levels based on nitrate levels and BMP adoption

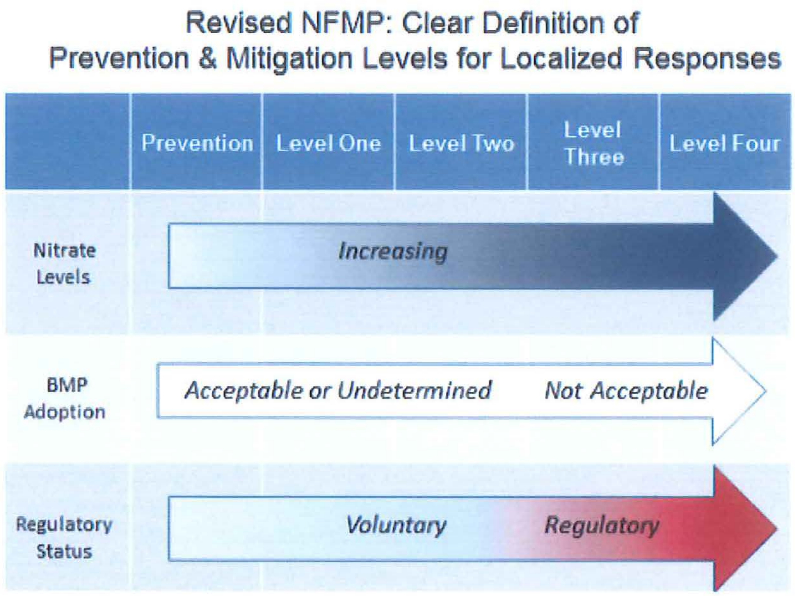
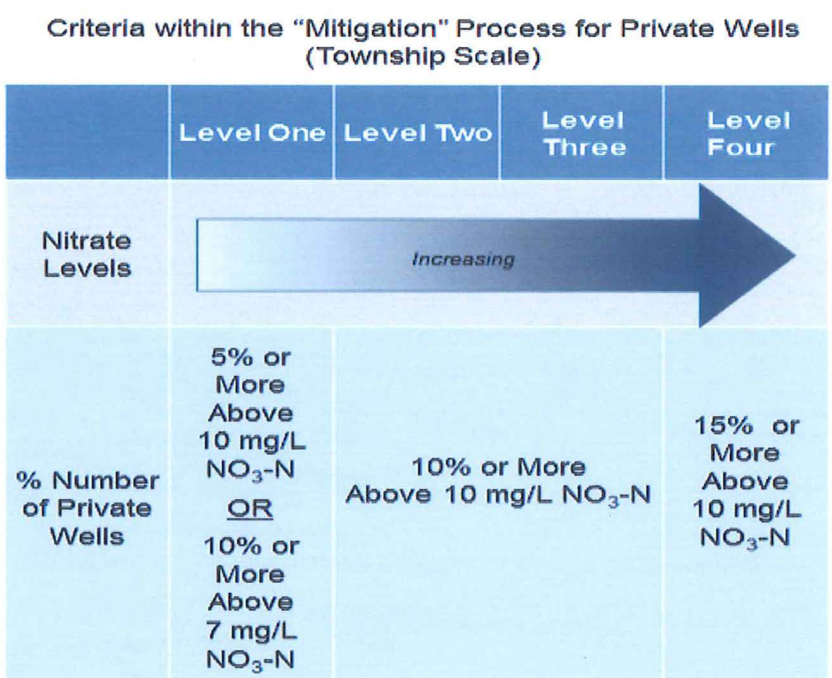
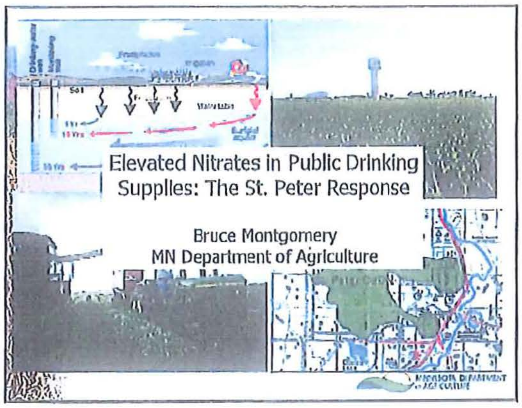


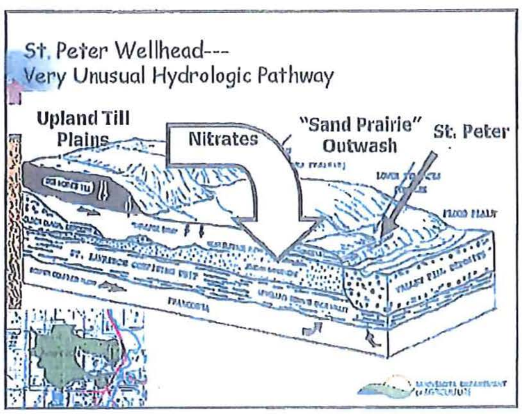
Figure 24. Mitigation process for private wells

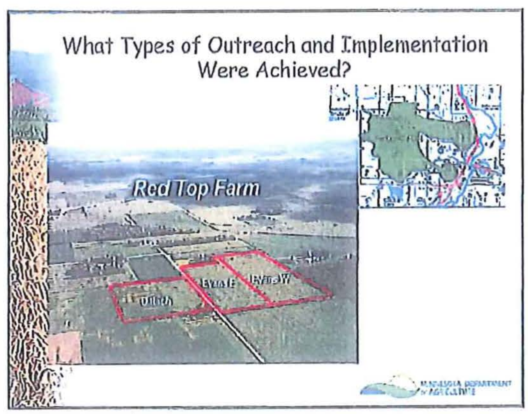


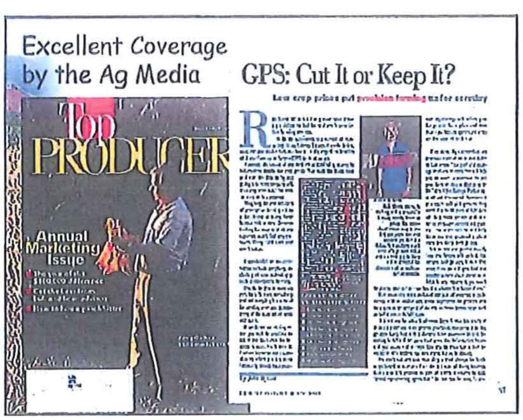
Rules must be written and adopted to implement this plan and these mitigation steps. According to MDA staff, they are in the process of writing the Statement of Need and Reasonableness at this time and expect to have the rule adopted in 2018.

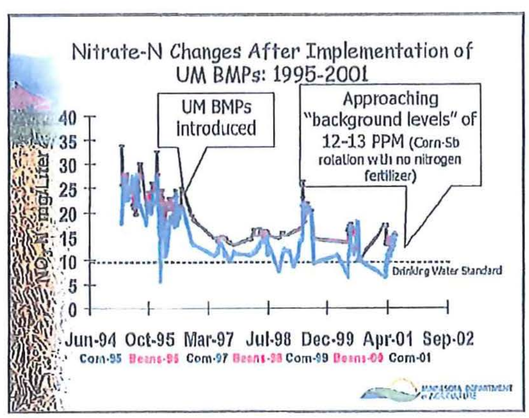

Elevated Nitrates in Public Drinking Supplies: The St. Peter Response
Bruce Montgomery
MN Department of Agriculture


Many Important Players............
Brown-Nicollet Environmental Health
• Minnesota Extension Service
• Pollution Control Agency
• Department of Agriculture
• Department of Health
• Rob Meyer-Red Top Farms


St. Peter Wellhead---
Very Unusual Hydrologic Pathway
Upland Till Plains
Nitrates
"Sand Prairie" Outwash
St. Peter


What Types of Outreach and Implementation Were Achieved?
Red Top Farm


Excellent Coverage by the Ag Media
Top Producer
Annual Marketing Issue
GPS: Cut It or Keep It?


Nitrate-N Changes After Implementation of UM BMPs: 1995-2001
UM BMPs Introduced
Approaching "background levels" of 12-13 PPM (Corn-Sb rotation with no nitrogen fertilizer)
Drinking Water Standard
40
35
30
25
20
15
10
5
0
Jun-94 Oct-95 Mar-97 Jul-98 Dec-99 Apr-01 Sep-02
Corn-95 Beans-96 Corn-97 Beans-98 Corn-99 Beans-00 Corn-01

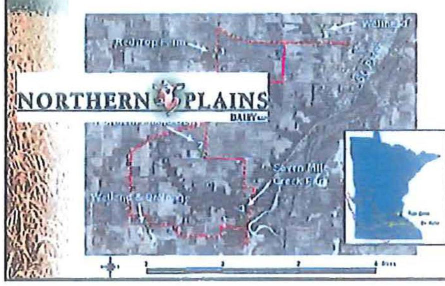
Red Top Farm

Confirmed many findings from the University of Minnesota Research and Outreach Centers including;

1. Expect to see 25-30% of the annual water balance leave the system via the sub-surface tile drainage;
2. Expect to see about 75% of the drainage occur in April, May and early June;
3. Even with BMPs fully adopted in C-Sb cropping systems across southern MN, it will be extremely difficult to keep NO3-N concentrations below 12-15 PPM and annual N losses less than 10-20 lb/A.

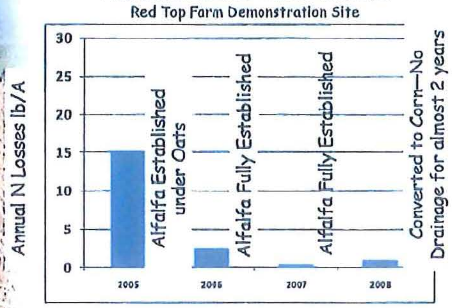
A New Player Arrives in 2003

St. Peter/Seven Mile Creek Watershed Field Tour



Annual N Losses Under Alfalfa

Red Top Farm Demonstration Site



St. Peter Case: What Worked?

- Development of the first "edge of field" monitoring site (Red Top);
- Red Top confirmed many earlier findings conducted by the UM on a research scale;
- Red Top provided a place to conduct meaningful localized "research";
- Wellhead issues helped move along the concept of Nutrient BMP Insurance and eventually the Nutrient Management Initiative;
- FANMAP clearly identified key issues;
-

St. Peter Case: Painful Lessons in the Promotional Aspects

- Early promotional campaigns (mainly via mail outs & news letters) were extremely ineffective;
- Many producers were not aware of the wellhead program until after 5-7 years into the campaign;
- Nothing replaces "one-on-one" technical assistance;
- It took years for the BNC staff to gain credibility with the farming community;
- Adoption periods can require years. Extremely difficult to carry out due to funding issues and/or lack of qualified personal to get the job done.

St. Peter Case: Possible solutions but could not be implemented

- Due to the recharge characteristics of the St. Peter wellhead, this is a still very fixable system;
- The BMP Insurance program could have quickly insured that area producers were using UM recommended rates. However, the public water suppliers must have 99.9% certainly that they can provide safe drinking water;
- Northern Plains Dairy can buy and ship South Dakota alfalfa cheaper than local producers can provide. Our wetter summers creates problems with drying and baling. We need an organization such as a RC&D to serve as a broker to make something like this happen.

Historical Overview of St. Peter Activities for Addressing Elevated Nitrates

Compiled by Larry Gunderson, MDA (August 2016)

Introduction

The Minnesota Department of Agriculture (MDA) was part of a group of interested parties convened to address nitrate in the City of St. Peter's drinking water. Local farmers, county and SWCD staff, U of M Extension, city water planners, agricultural professionals, the Minnesota Department of Health (MDH), the Minnesota Pollution Control Agency (MPCA) and others came together to assess the problems and develop responses. This was one of the state's first attempts to address nitrate in groundwater. Other "firsts" in the project included edge of field demonstrations, accelerated well testing, advisory groups and field days.

Nitrate-nitrogen levels are frequently elevated in the Jordan aquifer near St. Peter due to unique hydrogeologic conditions. Just west of town, a sand terrace overlies the Jordan aquifer with no protective confining layer present where groundwater recharge is relatively rapid. Age-dating studies show that water from the Jordan aquifer near St Peter averages 10 to 20 years in age. Agricultural ditches on the higher upland till plain to the west of the sand terrace are fed by field tiles that drain farmland on clay-rich soils. Water from the ditches flows eastward toward the Minnesota River, but actually infiltrates in the sand terrace, providing a significant source of poor quality, nitrate-rich recharge to the Jordan aquifer. This includes the City of St. Peter's wells pumping from the Jordan.

A Brief History of Efforts to Address Nitrates in the St Peter Area:

1988-1990

Brown-Nicollet Community Health Services was concerned about nitrate levels in private wells. A **township testing project** offered well testing to private well owners.

1990-1992

Brown-Nicollet Community Health Services received an MPCA **Clean Water Partnership diagnostic study grant**. Cottonwood County was added as a partner since wells in that area exceeded the 10 mg/L nitrate-nitrogen Health Risk Limit. Results from the Jordan aquifer generally had nitrate-nitrogen levels exceeding 7 mg/L; 14 out of 26 wells had nitrate-nitrogen levels above 10 mg/L.

1993-1998

MPCA **Clean Water Partnership implementation grant** funding was used to delineate St Peter's Drinking Water Supply Management Area (DWSMA) and to educating farmers in the DWSMA on nitrogen management practices.

Combining information about geologic formations in the area with well boring and pumping-rate data from private wells of various depths, the MDH defined groundwater flow boundaries in the area and determined the location of the groundwater recharge area. Both the flow boundary and the recharge area are important factors because the Jordan aquifer is cut by the Minnesota River in this area and is subject to variable groundwater flow conditions based on the amount of local precipitation. For example, relatively flat hydraulic gradients have been measured in years of relatively dry to normal precipitation, whereas a ten-fold increase in gradients was noted during the flood season of 1993.

With that perspective, the city entered into the wellhead protection process by delineating the DWSMA, which includes the minor watershed west of the city where crop production is the dominant land use.

This was one of the first attempts to use a Farm Nutrient Management Assessment Program (FANMAP) survey to help guide a wellhead protection effort. Results found that: 1) most of the nitrogen was applied to corn; 2) nitrogen applications to corn exceeded U of M recommendations by 10-15%; 3) nitrogen applications to unmanured corn were approximately equal to U of M recommendations; and 4) nitrogen applications to manured corn substantially exceeded the U of M recommendations. This information was used to develop the educational approach used in the project.

Educational programming included: on-farm nitrogen demonstrations; free manure testing to provide farmers with nutrient levels in manure; and field days in cooperation with the U of M and local crop advisors to demonstrate appropriate nitrogen management practices. Nitrogen rate demonstrations on urban lawns and associated educational events provided similar information to St. Peter residents.

1995-2008

In 1995, the **Red Top Farm** became a demonstration site for field-scale BMPs and water quality and quantity monitoring of subsurface drainage. Farmers Rob and Jan Meyer wanted to know what was coming out of the tile lines. The initial design included an 80 acre field with two separate subsurface drainage systems. It was eventually expanded to three fields. This allowed the MDA to compare crop yield and water quality resulting from different crops and nutrient rates. The site has hosted many educational field days, has been featured in numerous agricultural magazines and newspaper articles, and allowed opportunities for education and outreach at various meetings. Long-term data has proven to be instrumental in understanding water quality from field scale drainage under different management strategies.

2000-2003

In partnership with a local crop advisor and U of M, MDA undertook **on-farm nitrogen rate demonstrations** to determine economically optimum nitrogen rates at the field level. From 2000-2003, 15 corn farmers participated in a nitrogen validation project within the St. Peter Wellhead Protection Area. Annual nitrogen application rates of 0, 60, 90, 120, and 150 pounds per acre were replicated three times at each site. Results from the study demonstrated that U of M nitrogen rate recommendations were adequate for the growing conditions during those years and applying more than 120 pounds per acre of nitrogen on corn-soybean rotation could increase economic and environmental risk.

2005-2007

An MDA-led **Conservation Innovation Grant to demonstrate conservation drainage practices,** including bioreactors, installing tile at 3' depth vs. 4' depth, and controlled drainage, occurred on a 160 acre farm near a public drainage ditch in the wellhead protection area. Information gathered from the project was used to help inform conservation drainage practice standards by NRCS.

A McKnight Foundation grant was utilized during this same period to demonstrate the practice of out-letting public and private sub-surface drainage tiles into **restored wetlands** for nitrate removal. Nearly 60 acres of wetlands were restored in the adjacent Seven Mile Creek Watershed. A site in the St. Peter Wellhead Protection Area was also planned, but the landowner was not willing to take land out of production.

2011

The City of St. Peter received a **Source Water Protection Implementation Grant** through the MDH to provide payments to farmers in the City of St. Peter's 4,600 acre DWSMA who were willing to implement new and/or additional nitrogen management practices. Cooperating farmers received a payment to make changes in their standard nitrogen application rates or cropping rotations.

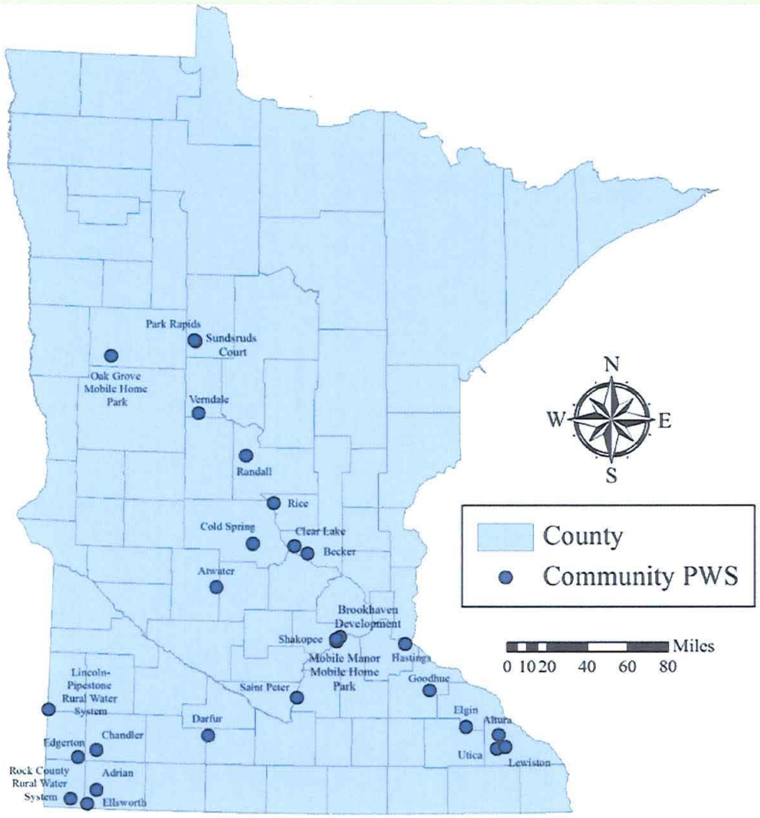
Nitrate Contamination and Community Public Water Supply Systems

The table below lists community public water supply systems (PWS) with nitrate in their source water equal to or greater than the federal Maximum Contaminant Level (MCL) of 10 mg/L, and actions taken to provide drinking water that meets that federal standard. The table includes cost estimates based on the number of households served by the PWS.

Community PWS with source groundwater above 10 mg/L (January 1, 2011 to current)	Population (2013)	Past and Potential Future Actions	Estimated Capital Cost per Household (2013 dollars)
Adrian	1209	Wells sealed and treatment plant built.	$3,300
Brookhaven Development, Shakopee	45	Potential future new well.	$3,300
Chandler	270	Potential future hookup to LPRWS*.	Unknown
Clear Lake	525	Treatment plant to be replaced.	$7,600
Cold Spring	4,053	Potential new wells.	$1,100
Edgerton	1,189	Treatment plant built.	$3,400
Ellsworth	463	Well sealed and treatment plant built.	$3,500
Hastings	22,335	Treatment plant built.	$410
Leota	209	Interconnect to LPRWS* installed.	Unknown
Lincoln-Pipestone Rural Water System	12,271	Potential blending wells and treatment plant improvements.	$170
Park Rapids	3,709	Wells sealed, new well constructed, and treatment plant built.	$3,000
Rock County Rural Water System	2,256	Transmission main built to blend wells.	$44
Saint Peter	11,196	Treatment plant built.	$1,600
Shakopee	37,076	Transmission main built to blend wells.	$7
Sundsruds Court, Menagha	40	Treatment installed.	$430

*LPRWS = Lincoln Pipestone Rural Water System

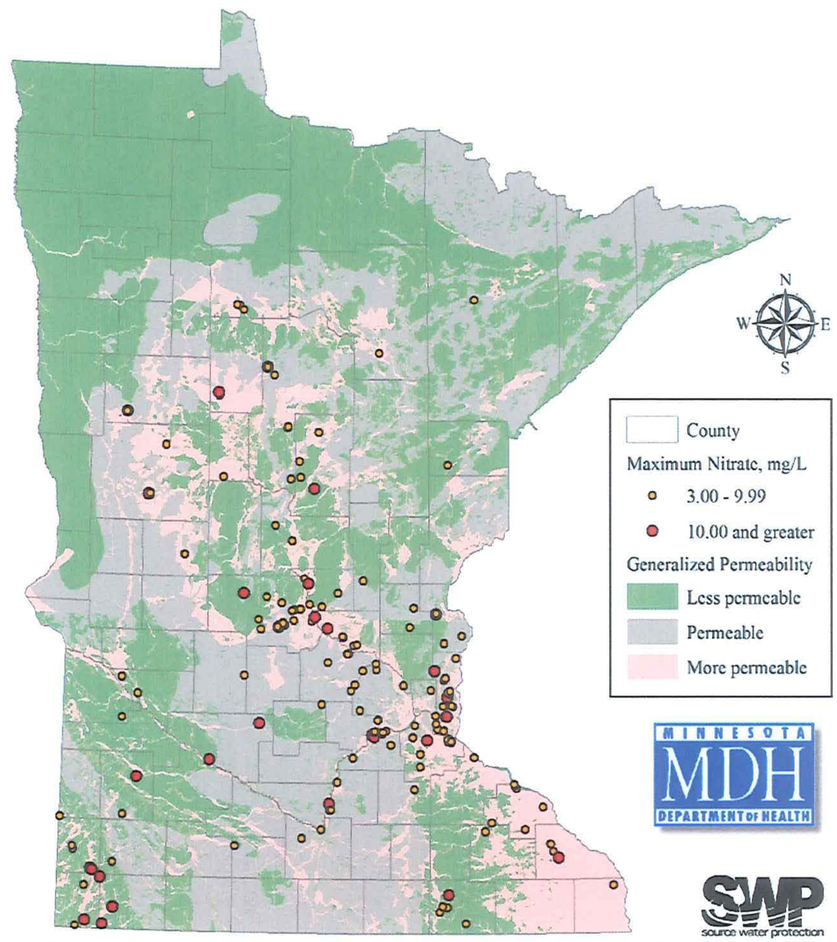
Public wells high in nitrate



Blue dots show locations for 27 community PWS (groundwater) systems currently monitored quarterly for exceeding 5 mg/L nitrate.

Map prepared in May 2013 by Minnesota Department of Health

Prepared by Minnesota Department of Health, July 2013



Stop 7
7 Mile Creek Watershed (SW of St Peter)

Multi-benefit drainage management

GREAT RIVER GREENING

RESTORING LAND, WATER AND WONDER

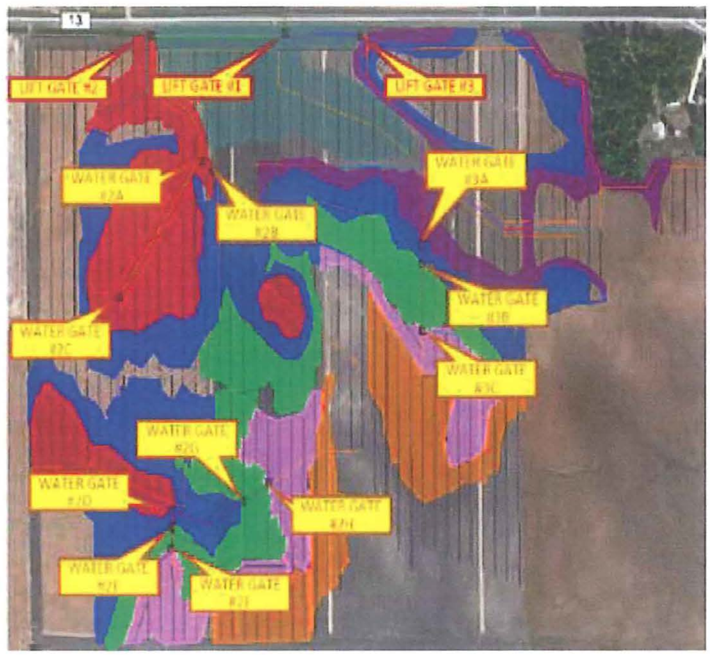
Case Study: Farm Drainage for the Future

Agricultural Watersheds Advisory Committee - Sept, 2015

The Seven Mile Creek Watershed Partnership, led by Great River Greening and Nicollet SWCD, seeks out and seizes opportunities to improve water quality in ways that maintain or even improve agricultural productivity, preserve Nicollet County's rural character, a strengthen our community. We aren't the experts on farming, but we know them. This case sudy is an illustration of our **our approach in practice:**

Locally-led and Community-based

Three neighbors got to talking at a fall 2014 field day and came forward with this project wanting to "do what's right" for future generations – two water quality inlets.



Exceptional Partnerships

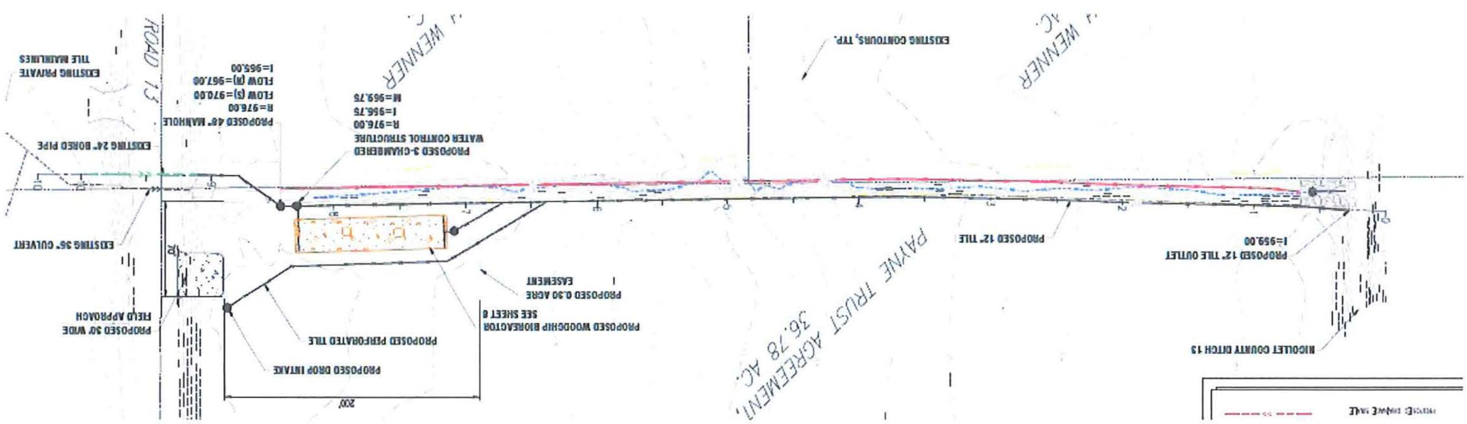
Willing and savvy landowners, creative agricultural engineers, and just the right amount of zeal from the Watershed Program turned two water quality inlets into this integrated drainage water management project.

Lean, Nimble, Effective

Or in this case: Calm, responsive, and persistent.

Harnessing Resources and Expertise

Landowners, Trusted Advisors (Caesar Larson Tiling and Air Row Surveying), AgriDrain Corporation & Ecosystem Services Exchange, The New Agricultural Bioeconomy Project (UMN), Gustavus Adolphus College.



Great River Greening works throughout Minnesota to empower and assist local communities in restoring and conserving the land and water that enrich our lives.

In Nicollet County: Nicollet SWCD | 424 South Minnesota Ave. | St. Peter, MN 56082 | phone: 507/931.2550 ext. 117
In the Metro area: 35 West Water Street Suite 201, Saint Paul, MN 55107 | Phone: 651-665-9500 | Fax: 651-665-9409
GreatRiverGreening.org

Case Study: Farm Drainage for the Future
Agricultural Watersheds Advisory Committee - Sept, 2015

Summary:

A land purchase by a strip till farmer necessitated a new drainage tile system. Along with two neighbors (through whose land any drainage improvements will flow), the farmer approached the Watershed Program to collaborate on a project that will ultimately:

- Improve the farm's productivity
- Reduce pollutants in Seven Mile Creek like sediment, phosphorus, and nitrate
- Address the root cause of sediment pollution by reducing the overall volume as well as peak flows of water drained
- Make the farm more resilient to climate change
- Help others to adopt similar farm- and water-friendly practices by providing a local example of how these ideas and technologies work right here in Nicollet County

The Opportunity:
One hundred thirty acres of minimally drained farmland was purchased in early 2014. A pattern-tile system was planned, requiring a new outlet across a blacktop road, through a private ditch along a property line, and into a county ditch. The private ditch channel has eroded significantly over the years, contributing sediment to Seven Mile Creek.

The Solution:
Finding a way to provide farmers with adequate drainage while minimizing the downstream impacts of tiling projects is critical to solving Seven Mile Creek's water quality challenges. This project provides a drainage system of the future – one that takes advantage of the best new technology and ideas in agricultural drainage water management.

- Ninety-five acres of a flexible controlled drainage system
- Woodchip bioreactor on a quarter acre of Neighbor 1's field
- Grass waterway to convey surface water
- Stable outlet and short-term retention basin at the downstream end of the grass waterway, stopping an active washout in Neighbor 2's field
- Plant community that includes a native mix as well as an example planting of prairie cordgrass – a grass being investigated for its potential as a perennial biomass cash crop

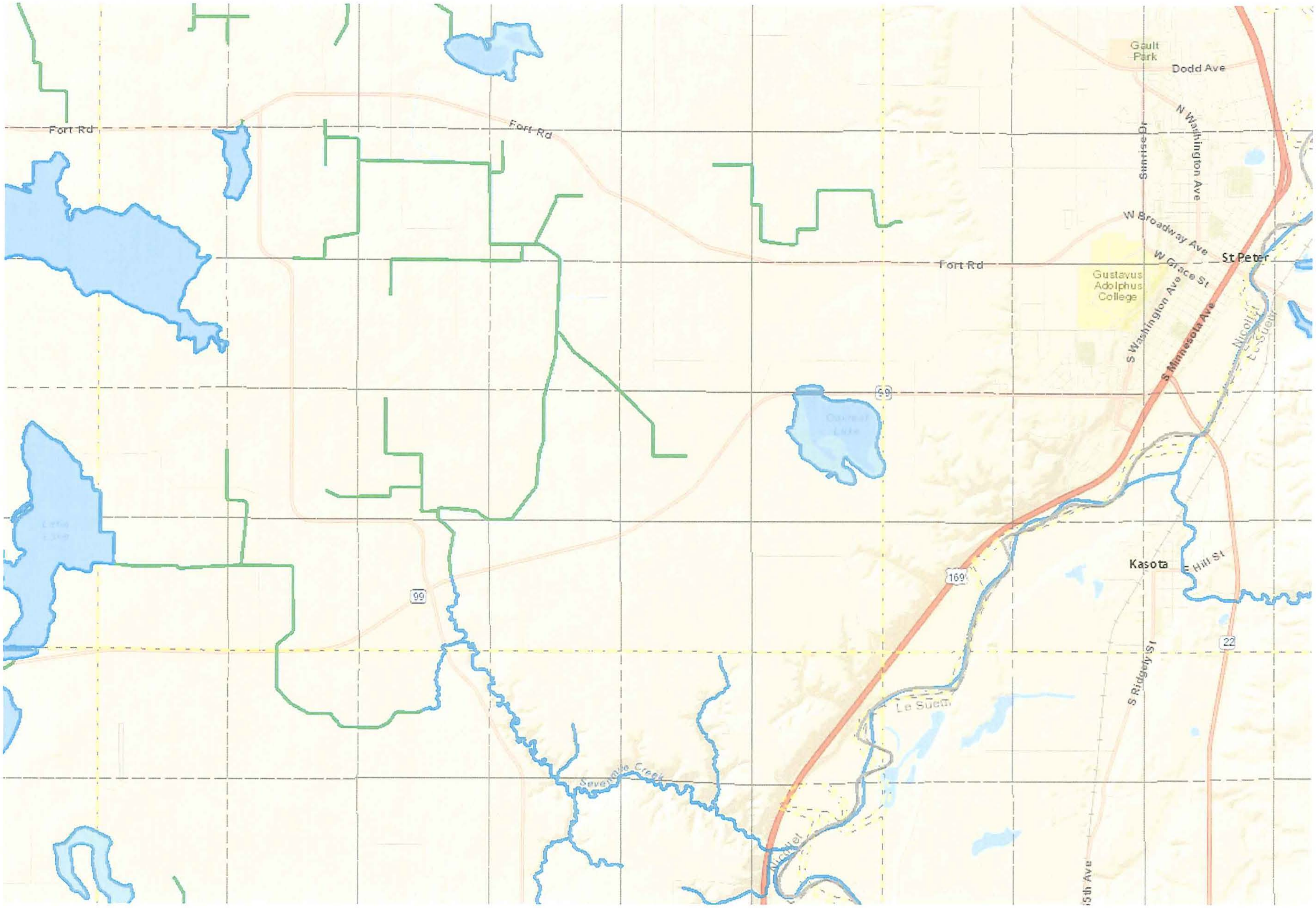
Great River Greening works throughout Minnesota to empower and assist local communities in restoring and conserving the land and water that enrich our lives.

In Nicollet County: Nicollet SWCD | 424 South Minnesota Ave. | St. Peter, MN 56082 | phone: 507/931.2550 ext. 117
In the Metro area: 35 West Water Street Suite 201, Saint Paul, MN 55107 | Phone: 651-665-9500 | Fax: 651-665-9409 |
GreatRiverGreening.org

DNR Buffer Map for Nicollet County

Green: ditches (16.5' buffers) & blue: public waters (30' buffers), unless other requirements apply or alternative practices provide the same water quality benefit

Ditches in the Seven Mile Creek Watershed Area



Stop 8
Blakely

Ravine collapses and restoration and inspiring conservation

WATER QUALITY PROJECT FACT SHEET
BLAKELEY TRAIL RAVINE STABILIZATION

Why did SWMO choose this Project?

The Blakeley Trail Ravine Stabilization project was chosen because soil erosion threatened local county roads and the Minnesota River's water quality. The cost to remove excess sediment and maintain roads over time was significant. The primary goal of this project was to reduce maintenance costs while improving Minnesota River's water quality.

Several structures were installed to slow down water, which reduces soil erosion: a five-foot deep retention basin around an acre in size will hold water from large rain events. Riprap lined channels will lock in soil. Six check dams will slow water flowing down the ravine channels.

During project construction two large storms totaling 14" of rain fell over a ten day period. This amount of rainfall caused major damage to the project and the surrounding area. Because of the damage, a retaining wall was not constructed to protect County Road 60. However, all other project goals were met regardless of the damage from both storm events.

The project was a collective effort with the Board of Water and Soil Resources, Scott Watershed Management Organization and Scott County Highway Department. Funding was also provided to the project from the Clean Water Land and Legacy Act.

QUICK FACTS

Major River Basin: Minnesota River

Water Bodies Affected: Minnesota River

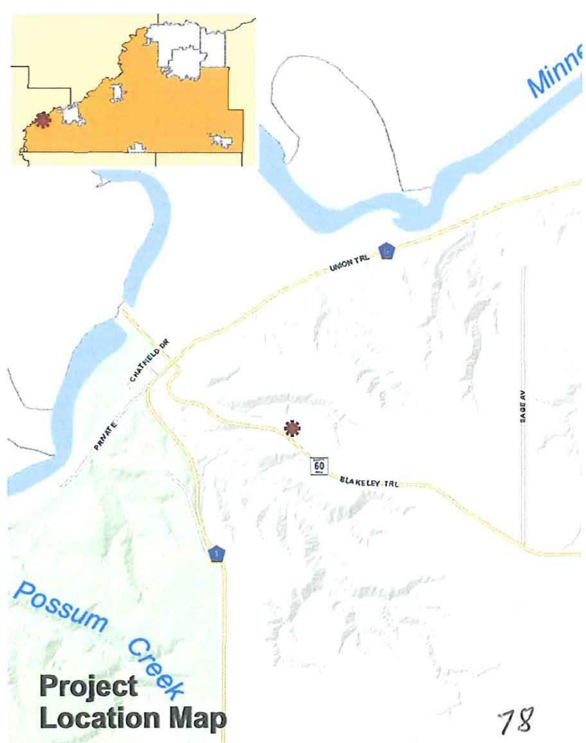
Project Goals:

1. Protect County Road 60
2. Reduce erosion to the Minnesota River
3. Improve water quality

Timeline: Spring 2014 - Fall 2014

Costs: $870,000

Project Designs and Management by: Scott County WMO, Scott County Hwy Department and Barr Engineering

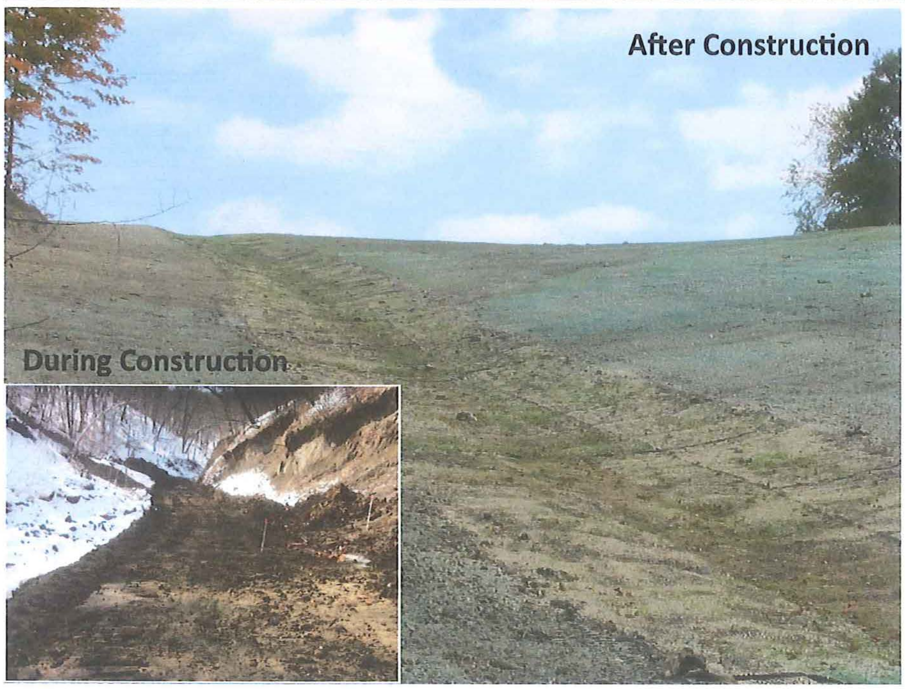


Project Location Map

WATER QUALITY PROJECT FACT SHEET
BLAKELEY TRAIL RAVINE STABILIZATION

Photos

Above: Retention pond at upstream ravine head.
Left: Construction limits showing aerial photography in 2013 and 2015.



MAJOR OUTCOMES

- A foundation for rebuilding County Road 60
- Improved downstream water quality and wildlife habitat
- Reduction of future maintenance costs on County Roads
- Protection of downstream private land and public infrastructure

⇒ Visit our website for more information on previously constructed or upcoming projects
http://www.scottcountymn.gov

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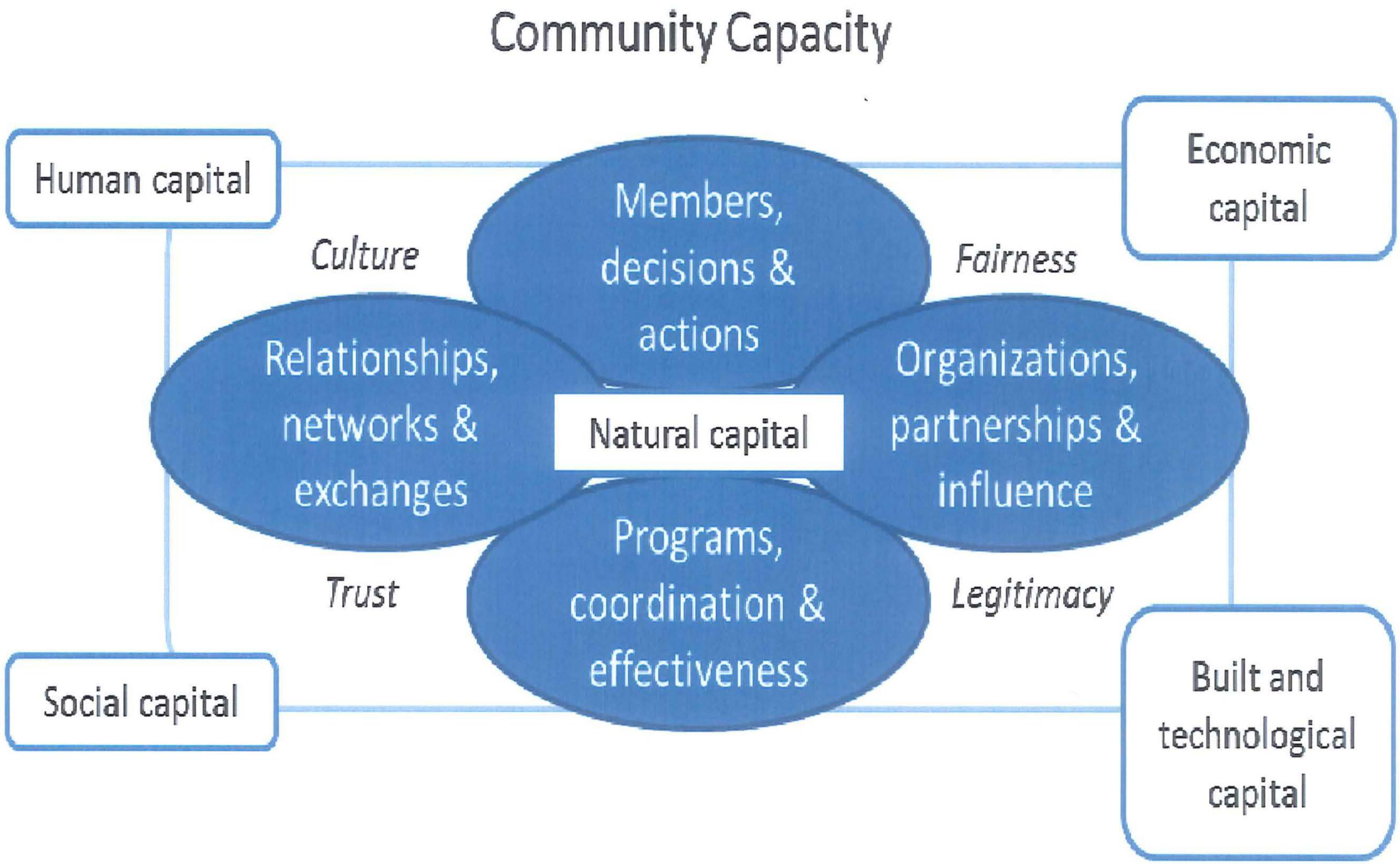
SCOTT WATERSHED MANAGEMENT ORGANIZATION (SWMO)
200 Fourth Avenue West Shakopee, MN 55379 * 952-496-8475 * http://www.co.scott.mn.us/wmo



Creating conservation momentum through community capacity-building (Adapted from Davenport & Seekamp 2013)

Excerpt from forthcoming book: Inspiring Action for Nonpoint Source Pollution Control: A Manual for Water Resource Protection by Paul Nelson, Mae Davenport and Troy Kuphal

Table ____. Simple, Complicated and Complex Problems (adapted from Getting to Maybe: How the World Has Changed by Westley, Zimmerman and Patton, 2007)

SIMPLE	COMPLICATED	COMPLEX
Baking a Cake	**~~Sending a Rocket to the Moon~~ Building a Waste Water Treatment Plant**	**~~Raising a Child~~ Managing Non-point Source Pollution**
The recipe is essential	Rigid protocols or formulas needed	Rigid protocols have a limited application or are counter productive
Recipes are tested to assure easy replication	~~Sending one rocket~~ Building one plant increases the likelihood that the next will also be a success	~~Raising one child~~ Watershed management in one community provides experience but is no guarantee of success with the next
No particular expertise is required, but experience increases success rate	High levels of expertise and training in a variety of fields are necessary for success	Expertise helps but only when balanced with responsiveness to the particular ~~child~~ watershed
A good recipe produces nearly the same cake every time	Key elements of each ~~rocket~~ plant MUST be identical to succeed	Every ~~child~~ watershed is unique and must be understood as ~~an individual~~ a community
The best recipes give good results every time	There is a high degree of certainty of outcome	Uncertainty of outcome remains
A good recipe notes the quantity and nature of the "parts" needed and specifies the order in which to combine them but there is room for experimentation	Success depends on a blueprint that directs both the development of separate parts and specifies the exact relationship in which to assemble them	Can't separate the parts from the whole: essence exists in the relationship between different people, difference experiences, different moments in time

Our Work

Land & Water Treatment

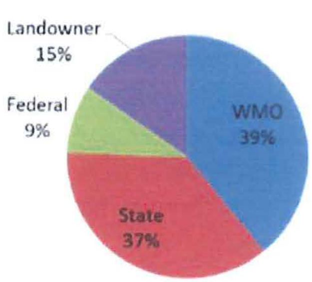
Technical Assistance & Cost Share Program (TACS)

CLEAN WATER LAND & LEGACY AMENDMENT

The WMO Cost Share program had a successful ninth year. Practices approved increased from the previous year in part because the disastrous rain events of 2014 created a backlog and increased demand. Established together with the Scott Soil & Water Conservation District (SWCD) in 2006, the programs goal is to help improve surface and ground water quality throughout Scott County. Through the cooperation of local, State, and Federal agencies, landowners and municipalities are eligible for programs which provide educational, technical, and financial assistance to execute various conservation practices. Funds are matched with other programs when feasible to maximize cost share dollars. In 2015, the practices in the adjoining table were authorized to improve water quality within the Scott WMO.

A total of 111 projects including 15 Grade Stabilizations, 13 Grassed or Lined Waterways, and 44 Water & Sediment Control Basins were approved. The total value of these including Scott WMO, landowner, state, and federal shares is $880,000. An additional $351,000 was spent on staffing to provide the necessary technical assistance. Distribution of the cost share is shown in the below graph.

2015 TACS Program Funding (Staffing and Practices - $1,231,310)



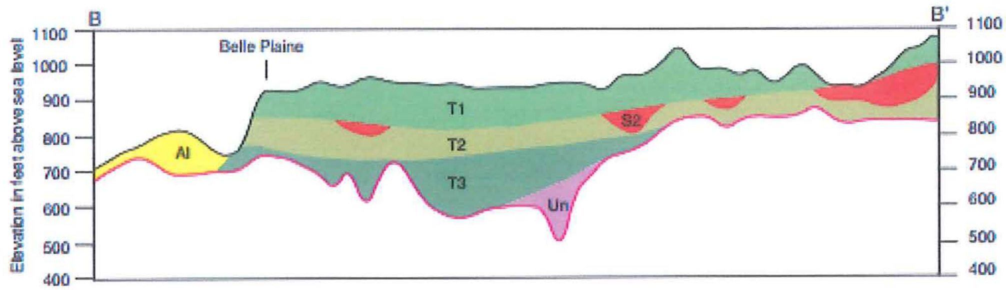
The state share came from a combination of the state cost share program, Clean Water Funds from BWSR, disaster relief funds from BWSR, and a Clean Water Partnership grant from the MPCA. Federal dollars came from USEPA Section 319 grants from the MPCA, and from the NRCS EQIP and CRP programs.

Scott WMO 2015 Cost Share/Incentive Program Summary

Practice	Projects
Grass Filter Strips	1
Grade Stabilization	15
Grassed or Lined Waterway	13
Native Grasses	11
Rain Gardens	4
Riparian Forest Buffer	1
Riparian Herbaceous Cover	1
Stormwater Runoff Control	4
Streambank & Lakeshore Stabilization	8
Terrace	4
Water & Sediment Control Basin	44
Well Decommissioning	5
TOTALS	111

Excerpts from the Scott County Geologic Atlas

Stratigraphy of the Quaternary surficial units (lots of sands and gravels):



DESCRIPTION OF STRATIGRAPHIC UNITS

- **Al** — **Alluvium**—Silty clay loam to gravelly sand, deposited in modern river channels and along terraces adjacent to the Minnesota River valley.
- **S1 / S2 / S3** — **Outwash** (undifferentiated)—Sand, gravelly sand, and cobble gravel, moderately to poorly sorted; crossbedded to flatbedded; interbedded in places with unsorted sediments (till, cobbles, and boulders).
- **T1** — **Gray till** (northwest provenance, Wisconsin age)—Sandy loam to clay loam, pebbly, unsorted, with scattered cobbles and rare boulders; characteristic gray shale clasts generally compose from about 25 to greater than 50 percent of the very coarse (1-2 mm) sand fraction; includes rare lenses of stratified sediment. Likely contains deposits from more than one ice advance.
- **T2** — **Mixed till** (mixed provenance, Wisconsin age)—Loam to sandy loam, pebbly, unsorted, with cobbles and boulders; generally less than 25 percent shale in the very coarse (1-2 mm) sand fraction. Inclusions of reddish-brown sediment indicate mixing with Superior provenance sediment. Likely contains deposits from more than one ice advance from different directions.
- **T3** — **Gray till** (northwest provenance, pre-Wisconsin age)—Loam, pebbly, unsorted, with cobbles and rare boulders. Includes lenses of sorted sand and gravel in places.
- **Un** — **Unknown deposits** (unknown provenance, unknown age).

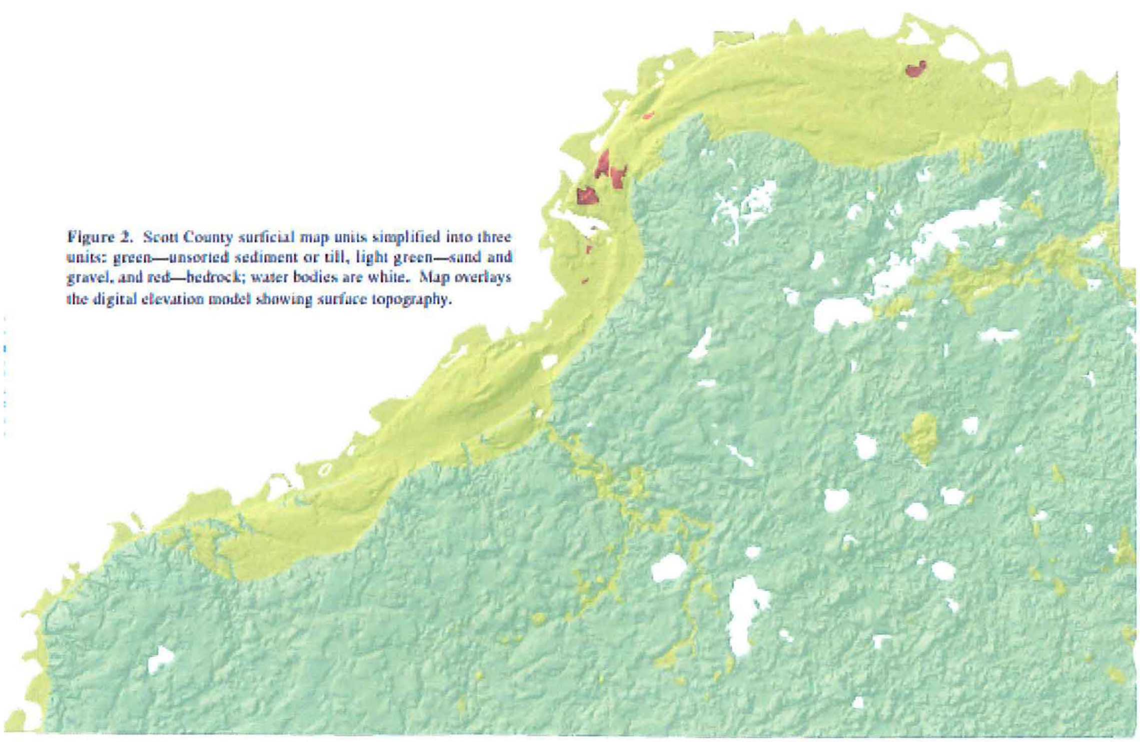
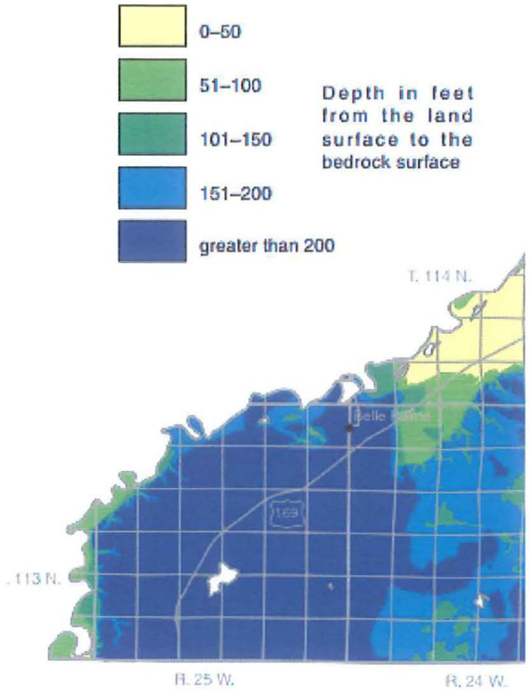


Figure 2. Scott County surficial map units simplified into three units: green—unsorted sediment or till, light green—sand and gravel, and red—bedrock; water bodies are white. Map overlays the digital elevation model showing surface topography.

In the Blakeley area (just south of Belle Plaine), the depth to bedrock ranges from 101 ft to over 200 ft.



Because the overlying surficial units have a high sand and gravel content, they are very permeable, so water can infiltrate from the land surface to a depth of 10 ft in hours to weeks.

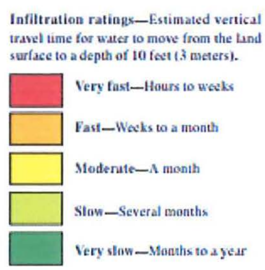
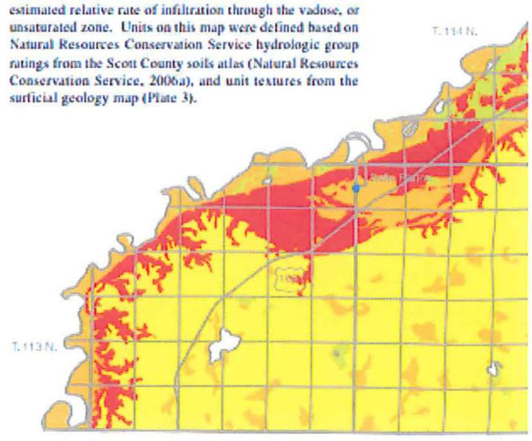


Figure 7. Surface infiltration map. This map shows the estimated relative rate of infiltration through the vadose, or unsaturated zone. Units on this map were defined based on Natural Resources Conservation Service hydrologic group ratings from the Scott County soils atlas (Natural Resources Conservation Service, 2006a), and unit textures from the surficial geology map (Plate 3).



Stormwater Magazine (Forester News) May 2016 Issue

Stabilizing Hillsides and Creek Bottoms: Turf reinforcement mats for a variety of soil types

David C. Richardson • March 22, 2016

Credit: REEL NEET EROSION CONTROL
With drains installed, crews lay down the first course of R45.

The rolling landscape of Scott County, MN, is rural but not particularly remote. "That area is farm country, and the Minnesota River goes through the entire area. On the top of the bluffs it's farmland, but at the river, the elevation drops about 200 feet in 800 feet," says Paul Nelson, environmental services program manager for Scott County. The scene is typical for the Minnesota River Valley; as the river winds through the 30-square-mile Blakeley Township, he says, "Parts of it are up on old glacial deposits, and some of it in ravines where glacial rivers cut through drop 200 to 300 feet in a mile or less. There are lots of eroding ravines."

According to Jake Balk, Scott County's Highway Division program manager, "There's a 15% grade on the roads—the ravines are steeper than that. Water flows through these ravines at 20 to 30 feet per second during storms." And the local geology primes the soil for massive erosion. "There's 10 feet of clay on top of everything, and under that is clean sand. So once the water breaks through the clay it gets into that sand and really starts to wash," says Balk. Highlighting the pernicious erosive potential in the area, says Nelson, there is essentially no bedrock substrate present to tie into to enhance stability of the surface soil.

Contemplating a Threat

Erosion at Blakeley Trail ravine was threatening infrastructure along County Highway 61, while sediments released during the erosive process contributed to degradation of the Minnesota River. Scott County's Environmental Services Department, along with the Scott County Highway Division, set out to find a remedy and undertook a stabilization project to shore up the slope of the ravine.

The project had multiple goals, ranging from protecting County Highway 61 running along the ravine, as well as other infrastructure from slides, to reducing the volume of sediments flowing into the Minnesota River where the creek emptied. The river had already been listed as impaired for high turbidity.

With plans for a retention basin at the top of the ravine to slow the water down, stabilization of the slopes, and a series of check dams at the bottom, construction began on the Blakeley Trail Ravine Stabilization project. In the spring of 2014, while work was underway, disaster struck in the form of unprecedented rainstorms. News accounts report flooding and damage across the entire midwestern United States during the mid-June storm, but Nelson says the Twin Cities region, including Scott County, seem to have borne the brunt of the storm's fury.

Credit: BARR ENGINEERING
Rebuilt slope in Scott County

Balk agrees: "We got 14 inches of rain in 16 hours." Runoff from agricultural lands up on the bluffs, he says, carried huge volumes of sediments and dumped them on the lower-lying landscapes, including the roadways and communities like Blakeley Township.

Averting Catastrophe
Ravines all over the county began to collapse, including the project at Blakeley Ravine Trail. That project, at the time stripped of vegetative cover for anticipated construction, was nearly wiped out. But worse than that, slides had taken out all three road access routes to Blakeley Township itself, potentially leaving the farm community of fewer than 100 residents marooned in the face of rising waters.

"We had to move quick," says Balk. A hurried evacuation in the rain, along a single lane of what was left of the collapsing road, shuttled the residents out of harm's way. Balk says that in all, the storm resulted in at least 110 different landslides. In its aftermath, he notes, "We moved 80,000 cubic yards of clay, mud, sand, and gravel from roadways." Attention quickly veered from the multiple potential benefits of the Blakeley Ravine Trail repair project to the singular goal of getting emergency repairs done to restore the lifeline and livelihoods of Blakeley Township residents cut off from their homes by landslides on County Road 1.

Barr Engineering was tasked with the daunting repair job. Steve Klein, vice president and senior civil engineer with Barr, had a long track record of success with Profile Products' Futerra turf reinforcement mats (TRMs). When Profile introduced the GreenArmor System in 2007, Klein began specifying it whenever a situation needed quick germination and extra holding power. With "vertical fill planned for the site to a depth of 50 to 100 feet," says Klein, the mat selected would need to be able to withstand any intrinsic settlement and movement that might occur on the newly reconstructed slope. In addition, the initial problem that resulted in the landslides remained. "The landscape was steep and we had the potential for high-velocity flows due to concentrated runoff coming off of the bluff into the tributaries."

Klein says he considers Futerra TRMs to be "the most stout" of the TRM class, but at the same time, he says, "They still allow good growth and offer the advantage that tackifier can be applied directly." The GreenArmor System consists of a Futerra TRM infilled with hydraulic mulch, Flexterra High Performance-Flexible Growth Medium (HP-FGM). The combination offers a technologically advanced solution with quick installation to protect high-discharge waterways.

However, Klein notes that one of the keys to success in any TRM application is careful installation. He visited the Blakeley Township site during construction to confirm that crews and contractors had used the recommended techniques. "When protecting an area for concentrated flows, where you have a swale going down a hill, the first row of that material needs to go right up the flow line of that swale, and then subsequent rows of that material are overlapped in a shingled fashion on top of that." He says he has on occasion been called in on projects where TRMs have failed to help the owners figure out what went wrong. He observes that in these cases, "Inevitably, the contractor started from the uphill side and started laying the TRM material down shingled in the reverse order of the way it would normally be shingled, so it didn't act as shingled product. As a result, water got under it and allowed it to scour beneath it, and it ultimately failed."

Klein also recommends a double-seeding technique, with one application of seed going down before the mats are run out and a second seeding on top of the mat, applied with the hydromulch. "Seed is a very inexpensive component" of a project, he says, and therefore a little extra seeding is an economical way to obtain extra holding power for a TRM application. "Double seeding works extremely well," he says.

Credit: BARR ENGINEERING
TRMs and Flexterra hold the slope in place.

According to Balk, repairs to County Road 1 required 9,000 tons of riprap at the bottom of the channel along with Profile Products' TRM, sheet piling, and subsurface drains to keep the water moving away from the slope. "We used a turf reinforcement mat with Flexterra, which has worked fantastic to date. We got five inches of rain last week and we haven't seen any damage. The water's staying on top of the Flexterra, and the vegetation looks great," Balk said several months after the installation.

After completing the road repairs, allowing township residents to return to their regular lives, crews returned to revive the stabilization project on Blakeley Ravine Trail.

Klein and Adam Popenhagen, Profile's market development manager, designed a GreenArmor System consisting of 20,000 square yards of Futerra R45 High Performance-Turf Reinforcement Mat (HP-TRM) infilled with Flexterra HP-FGM. J&L Larson, a contractor from Lakeville, MN, completed the installation in fall 2014 with a quick-germinating dormant seed mix provided by Ramy Turf Products of Mankato, MN.

Thanks to a mild winter and the durability of the GreenArmor System, spring vegetation quickly emerged and turf restoration is happening quickly. Scott County officials and Barr Engineering could not be happier with the results to date.

Reviewing the results at Blakeley Ravine Trail, Balk says, "It looks fantastic. The foliage is two-and-a-half feet tall. There's no undermining underneath the mat. I think the key is that about every 75 feet we tucked an 18-inch overlap into the ground so if any water started eroding under the mat, it can only make it 75 feet before it would hit a wall of TRM and have to come back up to the surface. So if water were to get under the TRM for any reason, it couldn't erode the dirt for very long before it would be forced back on top of the mat."

Our Work

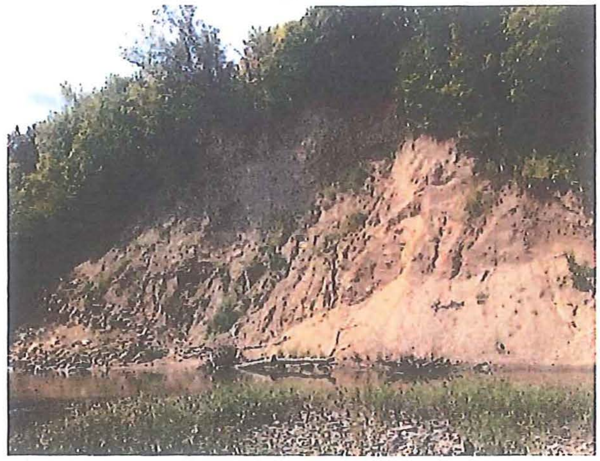
Land & Water Treatment

Capital Improvement Projects

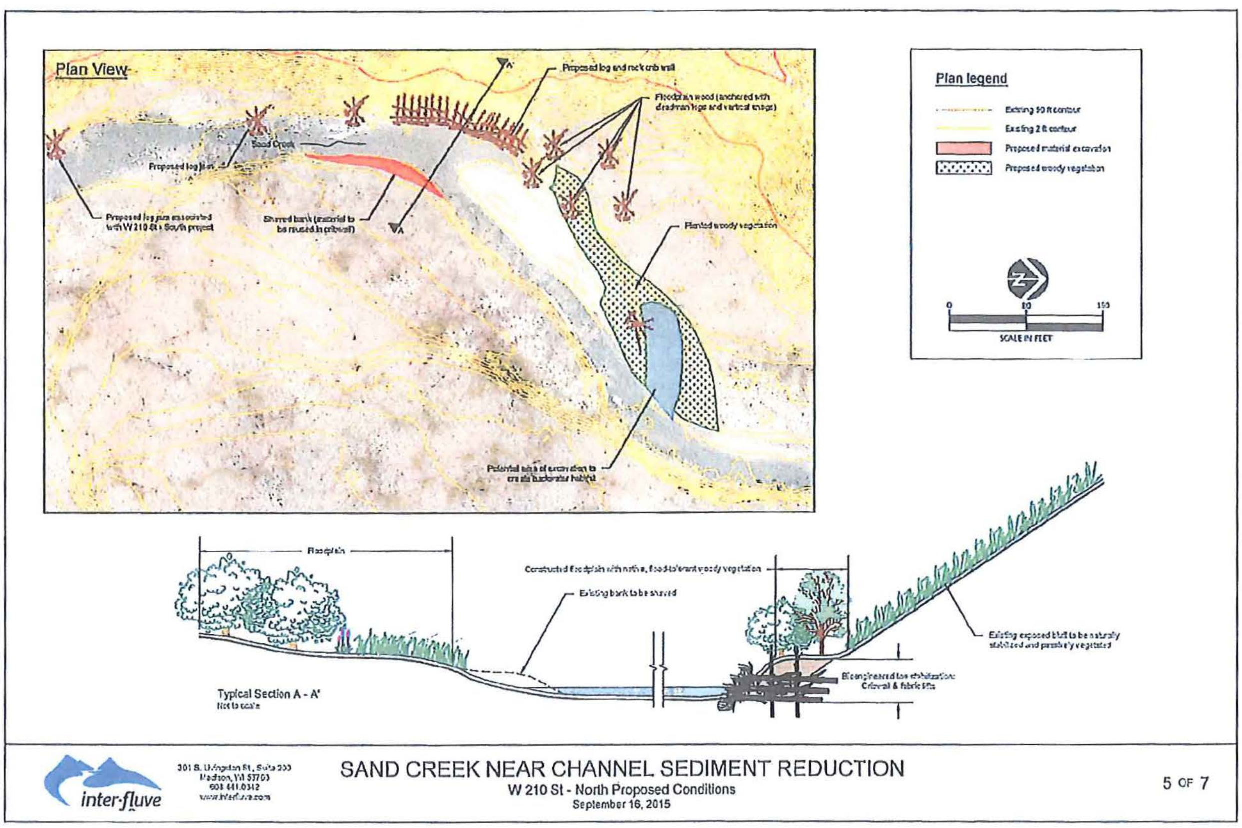
Near Channel Sediment

A feasibility study was completed in 2015 reviewing the highest sediment producing and erosive sites along the middle Sand Creek and Picha Creek watersheds. These areas were known to produce high amounts of sediment. A desktop analysis followed by several field investigations narrowed down the potential sites to pursue for stabilization to six sites. These six sites were selected based on the estimated soil savings and erosion reduction.

Construction to stabilize three of the six sites is planned for 2016. An estimated 10,051 cubic yards of sediment will be saved throughout the practice's life expectancy by stabilizing these three sites.



Streambank erosion at one of the project sites



Concept plan for stabilizing the erosion

1980

Scott County, MN

Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed. This is not a legal Map Scale

1990

Scott County, MN

Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed. This is not a legal

Map Scale

2000

Scott County, MN

Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed. This is not a legal

Map Scale

2008

Scott County, MN

Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed. This is not a legal

Map Scale

2015

Scott County, MN

Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed. This is not a legal

Map Scale