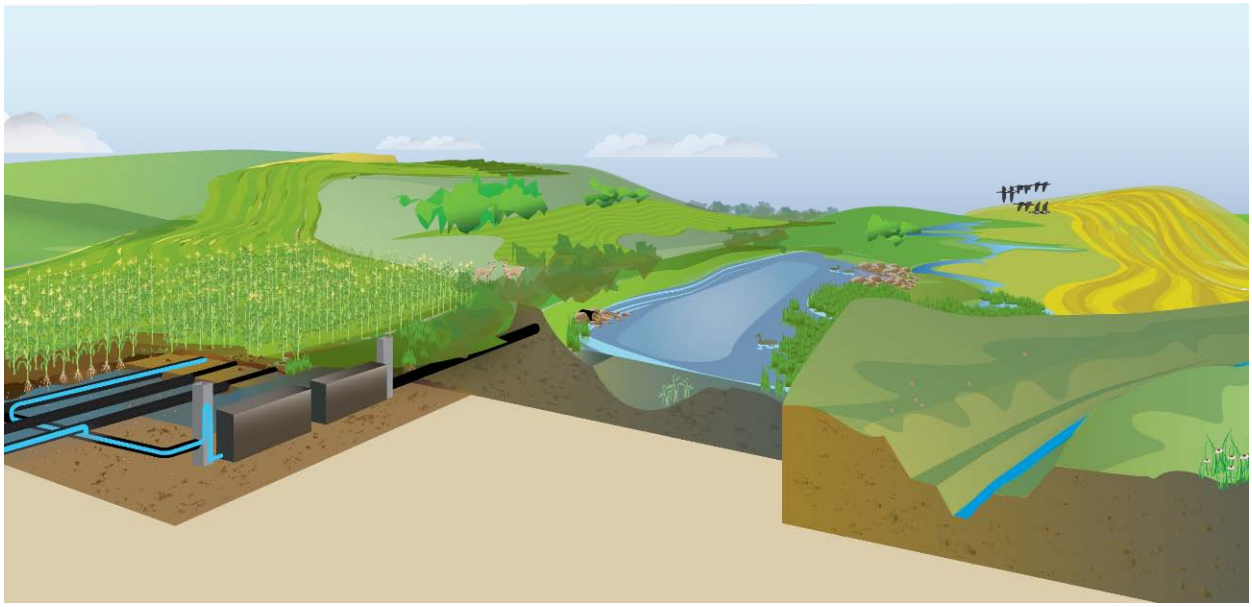
Review of Conservation Drainage Practices and Designs in Minnesota:

Results from Focus Groups with Drainage Professionals around the State



October 18, 2010

Prepared for:

The Drainage Systems Management Education and Stakeholder Feedback Workshops Project; funded by the Minnesota Department of Agriculture, Department of Natural Resources, Pollution Control Agency, and Board of Water and Soil Resources; and University of Minnesota Extension; through EPA 319 grant #C9-97593508-0.

Prepared by:

Ann Lewandowski, University of Minnesota Water Resources Center

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Available online at http://wrc.umn.edu/randpe/agandwq/consdrainage/

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Acronyms used in this document

ACP – Agricultural Conservation Program
MDA – Minnesota Department of Agriculture
PCA – Minnesota Pollution Control Agency
NGO – Non-governmental organization
NRCS – Natural Resources Conservation Service
SWCD – Soil and Water Conservation District
UND – University of North Dakota
USACE – US Army Corps of Engineers, also known as the Corps of Engineers (COE)
USFWS – US Fish and Wildlife Service

Contents

Executive Summary

Focus groups were held around the state in January-February 2010 to listen to people directly involved with designing, installing, and regulating agricultural drainage systems. Participants were separated into three groups: engineers and agency hydrologists, farmers and contractors, and drainage authorities.

Most participants were interested in the topic of conservation drainage and appreciated the importance and complexity of drainage issues. Many were eager to continue the conversation, feeling it was a much-needed discussion about fresh ways to address drainage concerns. However, "conservation drainage" is not a well-established or well-understood term, and some were not comfortable with it.

Many participants emphasized the importance of personal relationships for determining how people respond to drainage issues. They knew and valued those individuals who were skilled at facilitating ongoing communication and productive relationships among the various stakeholders. They also recognized the deep challenges of building good relationships.

Most participants emphasized the site-specific nature of drainage – meaning no one size fits all, the most appropriate strategy depends on the situation, and policies and programs need to be flexible.

Current state of drainage. Each focus group was preceded by a presentation about the current state of knowledge and the growing body of research on the impacts of and design guidelines for alternative drainage system options. Activity is high statewide installing, upgrading, and replacing drainage infrastructure. This infrastructure has a long lifespan, making it especially urgent to design systems now, as they are going in, to meet the multiple goals of ag production, water quality, flood mitigation, and habitat.

Impacts. Participants had varied and sometimes conflicting impressions of the impact of drainage. Some of the disagreement came from differences in the frame of reference – i.e., what people were comparing drainage to, and what the scale of impacts were. Most participants wanted more data describing the impacts of various options. Many participants thought that drainage increases peak flow compared to un-drained or less-drained conditions. Many participants pointed out that tile drainage creates a "sponge" effect – the opportunity to store water in the drained portion of the soil profile, and drainage creates the opportunity for water to filter through the soil instead of running off over the surface. Several participants, especially farmer/contractors, emphasized that pattern-tile drainage makes conservation practices possible, including reduced tillage and crop rotations.

Practices and designs. Nearly all participants thought ditch buffers and side inlets were a cost-effective way to reduce sediment loss and ditch maintenance costs and to improve public goodwill. Participants were interested in controlled subsurface drainage, but they raised a lot of questions about its practicality and effectiveness. Water storage was a broad topic that generated mixed impressions. Most participants had limited knowledge of the range of water storage options. Participants wanted more demonstrations of water storage options, woodchip bioreactors, and controlled subsurface drainage.

Of the three groups of participants, the participants who design drainage systems were the most likely to talk about watershed-scale interactions and cumulative effects of drainage. In general, though, participants were not planning drainage activities at a watershed-scale.

Guidelines for action

Based on the "Findings and Conclusions" section of the full report, the authors offer the following guidelines to those involved in agricultural drainage.

- ***Support long-term relationships*** and the individuals who are skilled at building and maintaining productive relationships. "Win-win" options are available, but they can only be implemented with the help of people who can build the necessary trust and collaborations.
- ***Be part of the conversation.*** Hydrology and drainage are complicated. Building widespread understanding is an ongoing process involving both outreach to stakeholders and engagement of diverse groups in dialogue. Leaders and organizers at all levels should promote conversations about drainage in a wide variety of forums. Specifically, workshops and other in-person contact are especially important, but popular news outlets and on-line resources also play a role. Communication is needed both within and between stakeholder groups, including the non-farming public. At the local level, build a better understanding of hydrology and a shared understanding of goals. Carefully structure meetings of diverse stakeholders to support open communication. Be precise in defining terms and be explicit about assumptions when discussing impacts of drainage.
- ***Clarify, delineate, and communicate the roles and responsibilities*** of the various state and local agencies. Landowners and other clients sometimes perceive inequities, inconsistencies, or inefficiencies.
- ***Discuss and clarify who is responsible for costs of managing or mitigating upstream contributions*** to drainage systems. People have different perspectives of when the landowner is responsible and when society (the taxpayer) is responsible.
- ***Examine options for water storage*** on the landscape. This is one key for achieving effective agricultural drainage while minimizing impacts on streams and lakes. Water storage ranges from large-scale impoundments to temporary ponding behind small inlets and even storage in the soil. Cropping practices that increase evapotranspiration are a related water management tool. Each situation offers different opportunities.
- ***Promote watershed-scale views of drainage.*** Approach planning and management from the watershed scale. This may mean reviewing culvert sizing or water storage options across the whole watershed. Or it may mean establishing a county or district-wide schedule for redetermination of benefits so landowners feel that ditches are being managed fairly and with appropriate priorities.
- ***Continue research and demonstrations,*** especially full-scale demonstrations and analyses of costs and benefits. Landowners need to see how a design works before they can adopt it. Use demonstrations to communicate with both farm and non-farm audiences.
- ***Address regional differences.*** The Red River Basin is particularly distinctive, but other regions also have unique physical and institutional features that impact water management.

A. Introduction

A.1. Purpose

The purpose of this study was to gain insight into how drainage professionals around the state think about "conservation drainage" practices. It is a study of the people most directly involved in implementing drainage, with the results intended for use by a broader group of all stakeholders interested in drainage and its impacts. As the Minnesota Department of Agriculture, University of Minnesota, and other organizations plan outreach, research, and water-related projects, this study provides information about the knowledge and perspectives of the people who actually design, install, and regulate agricultural drainage.

A.2. Definitions

In this document, "artificial drainage" refers to modifications to hydrology to improve the trafficability of fields and increase the air available to crop roots. It includes sub-surface drainage tile, shallow field ditches, deep ditches built for the conveyance of drained water, and straightened stream channels. "Drainage" in this document means agricultural systems, not urban storm water systems. "Conservation drainage" is a subset of agricultural drainage approaches, practices and designs.

A.3. Background

Much of the agricultural land in Minnesota was drained 50 to 100-plus years ago. Today, we are at an important point in drainage history. The level of drainage activity is high as landowners and local drainage authorities replace aging infrastructure and enlarge and intensify systems to expand drainage effectiveness. This new infrastructure will have a lifespan of many decades and thus will determine the design of the state's drainage system far into the future. At the same time, research is providing more and more information about the interaction between artificial drainage and water quality and flows.

"Conservation drainage" is a response to a changing climate, cropping systems, and water quality expectations. It is a suite of practices and designs intended to support the needs of agricultural production while addressing water quality and flow issues.

Drainage design – like all agricultural activities – is highly site specific. Control over artificial drainage is widely dispersed among tens of thousands of landowners and about a hundred drainage authorities. Before agencies and researchers promote particular design options, it is important to tap into this wealth of experience, understand the issues faced in the field, and ensure support by the people making public and private drainage decisions. To this end, the goal of this project was to learn what key people around the state think about agricultural drainage and promising new designs and practices.

A.4. Method

Nine focus group sessions were conducted between January 14, 2010 and February 17, 2010 with three stakeholder groups (engineers and agency staff, contractors and farmers, drainage authorities) in three locations (Crookston, Montevideo, Mankato). Each focus group was preceded by a presentation about the current state of research and policy related to drainage.

In addition to the participants, each focus group was attended by a moderator, note taker, and a regional observer who attended all three sessions at one location.

What is a focus group?

A focus group is a qualitative research method to understand how people feel or think about an issue or idea. By using in-depth discussion, a focus group provides more nuanced information than is possible with a questionnaire or other short feedback methods. The ideal size of a focus group is six to eight people. Larger group discussions prevent participants from providing full input. The discussion is led by a moderator who presents carefully developed questions and does not offer opinions or participate in the discussion, except to ask for clarification and further explanation. A critical feature of an effective focus group is to have a relatively homogenous group so individuals feel it is a safe and permissive environment to be open and frank. This is in contrast to learning or problem-solving environments where mixed groups are preferred to build mutual understanding of varied perspectives.

Sites

Three sessions each were held in ***Crookston***, ***Montevideo***, and ***Mankato***. Experience with drainage and priorities differ in the three places due to institutional and geographic variations.

Drainage infrastructure in the ***Red River Basin*** is dominated by surface drainage ditches. People are just beginning to install subsurface systems. Many people have little knowledge about tile drainage, while others are enthusiastic about the potential. The primary concern in the Red River Valley is managing flooding, with water quality as a secondary concern. Both watershed districts and counties administer Chapter 103E drainage systems.

Southern and Western Minnesota drainage professionals have experience in rolling areas as well as flat landscapes such as the Blue Earth basin. Most of their agricultural areas have subsurface drainage systems, though many are intensifying the existing drainage with new or denser pattern tile. Drainage authority is generally held by the counties with a minority of systems administered by watershed districts. People in ***southwestern Minnesota*** have more experience with road impoundments for temporary flood storage than people from other regions.

Participants

Many people have an interest in drainage in Minnesota, but we limited the sessions to stakeholder groups who are most directly involved in implementing ag drainage. A total of 64 people participated; most were key players in ag drainage and were interested in the results of this study. Participants were

divided into three groups. (The number of participants in each group and subgroup are indicated in parentheses.)

- ***Group 1: Technical assistance providers (21)*** – Technical experts, especially private drainage engineers (8), and DNR and BWSR hydrologists and engineers (5) who review engineering plans. Other agricultural drainage technical specialists (8) were included from PCA, MDA, USFWS, NGOs, and NRCS.
- ***Group 2: Contractors and farmers (22)*** – The "front line" people who actually install and use farm-scale drainage technology including tiling contractors (11), farmers (13), agronomic consultants (1), Certified Crop Advisors, and farm managers. (Several people wore multiple "hats".)
- ***Group 3: Drainage authorities (21)*** – The watershed district managers (10) and county commissioners (4) and their drainage administrators (5) who are responsible for permitting and maintaining drainage systems and thus help regulate, influence, manage, and plan county- and watershed-scale drainage systems. Two state agency staff also participated in this group.

To identify participants, several key people familiar with the targeted communities were asked to provide names of potential participants. These lists were divided into sub-pools (e.g. drainage authorities were divided into administrators, managers, and commissioners), and participants were randomly selected from the sub-pools to ensure a mix of perspectives. We avoided having more than one person at each session from any particular organization, agency, or local government unit.

Invitations were generally sent via email, often in combination with a phone call. Participants were offered a $50 incentive and lunch.

Eight of the nine groups had open, frank discussions. However, in one group, participants were not selected as effectively and the discussion was guarded and less open. The dynamic of the group illustrated the challenges of engaging mixed audiences (e.g., conservation and industry professionals) and highlighted the importance of mixing group participants in a way that fosters open and productive communication.

Format

The sessions began with a presentation that defined conservation drainage and described current research data and experiences. Strictly speaking, focus groups are designed to avoid providing information that would influence participants' comments. In this case, we were interested in how people responded to the presentation, we wanted to ensure that everyone started with the same background information, and we wanted to answer the technical questions that otherwise would have arisen during the focus group discussion.

Agenda

10:30 Introductions
10:40 Presentation
12:00 Lunch
12:45 Questionnaire
1:00 Focus group discussion
2:30 Adjourn

After the presentation and lunch, participants completed a questionnaire asking them to rate the various drainage practices, and how they prefer to get information about drainage. Then the 90-minute focus group discussion began. Presenters did not stay for the discussion.

Presentations

Presentors were selected who had expertise in conservation drainage issues and who were respected by their audience and would easily develop a rapport. They were all asked to define the scope of the discussion by explaining what is "conservation drainage", discuss the impacts of drainage at the field and watershed scale, and explain the latest research, policy, and applications of conservation drainage practices.

Presenters

Group 1: Gary Sands

Group 2: Jeff Strock (W, S), or Hans Kandel (RRV)

Group 3: Kurt Deter (all locations) with Kevin Kuehner (W), Ed Hohenstein (S), or Ron Harnack (RRV).

> *"When you have a person from the Netherlands talking about water, you need to listen to him."* Farmer/contractor, Crookston.
>
> *"I needed the peptalk today about keeping laterals as shallow as possible."* (Contractor, in response to Jeff Strock's presentation)

The content presented to Groups 1 and 2 was similar. Speakers addressed:

- History, extent, and impacts of drainage.
- Definition of conservation drainage
- Conservation drainage strategies – technical descriptions of practices, and results from research and demonstrations.

The presentations for Group 3 had much less technical information about individual practices.

- Deter reviewed the components of drainage law that allow authorities to address conservation issues.
- Then Harnack, Hohenstein, or Kuehner described examples of how authorities have incorporated conservation drainage into their planning processes and on-going repair activities.

Detail about the presentations is in the next section. They provide an excellent summary and explanation of conservation drainage. They could provide a foundation for organizing training, definitions, fact sheets, and so on.

Discussion questions

The questions were designed to learn 1) what barriers people perceived to implementing various drainage practices, and 2) how they understood the relationship between drainage practices and water quality and flows.

Sample Discussion Questions

Group 1: Private engineers and agency hydrologists

Q1. Tell us one interesting thing you heard during the presentation.

Q2. Write down three things that you can say definitively about the link between ag drainage and surface water quality or flows.

Q3. *Participants were shown a flip chart with their responses to the questionnaire item "Which two of the following practices would you most recommend?"*
Do you agree with these rankings that you generated? To say it another way, if a researcher or funder or other decision maker were standing here, are these the drainage practices you would tell them to focus on? Why did you recommend these?

Q4. What keeps people from doing more of each of these practices?

Q5. What aspect of hydrology most needs to be improved?

Group 2: Farmers and contractors

Q1. Tell us one interesting thing you heard during the presentation.

Q2. What are the benefits of ag drainage?

Q3. *Participants were shown a flip chart with their responses to the questionnaire item "Which two of the following practices would you most recommend?"*
Do you agree with these rankings that you generated? To say it another way, if a researcher or funder or other decision maker were standing here, are these the drainage practices you would tell them to focus on? Why did you recommend these?

Q4. What keeps people from doing more of each of these practices?

Q5. What would motivate you or the landowners you know to adopt these practices?

Q6. Of the issues presented this morning and discussed this afternoon, what do you want to know more about?

Group 3: County drainage authorities and watershed planners

Q1. Tell us one interesting thing you heard during the presentation.

Q2. Think about the current water plan for your county or watershed. Describe the activities in that plan that relate to the conservation drainage practices listed on the handout.
What role can ag drainage play in addressing water quality and water flow issues?

Q3. Think about the ag drainage system design in your watershed or county. Describe your vision of what that system will do, or look like, in the future.

Q4. Thinking about your vision for your ag drainage system, what needs to happen to make that reality?

B. What is Conservation Drainage?

The information below is based on the presentations given before each of the focus group discussions. See the resources list at the end of this document for further sources of information about conservation drainage.

B.1. History and extent of drainage in Minnesota

Many public drainage ditches and tile systems were installed between1860 and 1920, particularly after 1900. The State Drainage Commission was formed in 1897 and drainage research at U of M started two years later. In 1919, the state created an Office of the State Drainage Commissioner and the University created the Department of Drainage. In 1931, the state transferred duties to the Department of Conservation and in 1947 the state was no longer authorized to construct state ditches. A detailed history of drainage activity and law is in Chapter 2 of the "Minnesota Public Drainage Manual."

1860 – 1920	Many public drainage ditches and tile systems installed (particularly 1900 – 1920)
1897	State Drainage Commission formed
1899	Beginning of drainage research at U of M
1919	Office of the State Drainage Commissioner established
1919	U of M Department of Drainage is created
1931	Drainage duties transferred to the Department of Conservation
1947	State no longer authorized to construct state ditches
1955	Drainage authority shifted from state to local control.

Information about the extent of drainage in Minnesota is incomplete. Based on the DNR's map of surface hydrology, the state has more than 21,000 miles of surface drainage ditches, although several sub-watersheds are not included in that count. Most of the water flowing out of the state flows through the Mississippi and Red Rivers and most of those surface waters at some point pass through artificial drainage features, both surface and subsurface.

B.2. Effects of drainage

Artificial drainage makes agriculture possible and profitable across large parts of the state. In many areas, installation of drainage tile still provides a quick and reliable return on investment in the form of a substantial boost in crop productivity and more flexibility in performing field operations.

In addition to the benefits of drainage, there are unintended effects on water quality and hydrology. Blann and others (2009) reviewed the effects on aquatic systems. Some impacts are associated more with surface than with sub-surface drainage. Turbidity, and associated sediment and phosphorus, can be a water quality issue in some surface ditches. Elevated nitrate delivery to surface and ground water can be an issue in sub-surface drainage systems. These contaminants may be a concern in local water bodies as well as in the Gulf of Mexico and Lake Winnipeg.

Artificial drainage also impacts hydrology. Indeed, that is the purpose of drainage.

Our level of understanding and the significance of water quality and hydrologic impacts varies with the situation. Impacts should be described in terms of the following features:

- ***Drainage type*** – Is the impact associated with surface or subsurface systems?
- ***Scale*** – Are the impacts occurring at the edge of the field, in a small watershed, in the larger watershed, or in the basin?
- ***Baseline*** – Is the impact in comparison to pre-settlement conditions, after conversion to agriculture but before extensive agriculture, surface drainage alone, or various types of subsurface designs?

B.3. What is conservation drainage?

Conservation drainage is the use of drainage designs, structures and practices to provide the benefits of drainage while minimizing negative impacts on the environment.

Another way to think about conservation drainage is the Golden Rule of Drainage (attributed to Wayne Skaggs): "Drain only what is necessary for good trafficability and crop growth – and not a drop more".

Gary Sands defined three aspects of conservation drainage:

1. The preservation of soil quality and soil conditions through prudent use/management of artificial drainage.
2. The careful utilization of soil and soil-water resources.
3. The act of preventing or mitigating unwanted and unintended effects of artificial drainage systems.

Conservation drainage includes a variety of strategies, some of which are familiar and others which are under development. Achieving conservation drainage is a process of applying a mix of strategies appropriate to each situation. More information about these strategies is available from UM Extension at http://www.drainageoutlet.umn.edu/.

Field system designs

- Appropriate sizing of culverts and field drainage systems to dampen peak flow
- Controlled subsurface drainage to decrease annual flow

Ditch and system designs

- Woodchip bioreactors on subsurface drainage systems for reducing nutrients and bacteria
- Improving side inlet controls on open ditch systems to reduce erosion, meter flow, and trap sediment
- Buffers along ditches to set back tillage and nutrient and chemical applications, and to help stabilize ditch banks
- Water storage (wetlands, floodwater impoundments, in ditch and off ditch temporary storage, culvert sizing)
- Two-stage ditch channels, and other in-ditch treatments to reduce erosion and nutrient transport

Appropriate sizing of field systems

"Appropriate sizing" means choosing the depth, spacing, and diameter of tile to optimize productivity, cost, and water and nutrients delivered into the drainage system.

Controlled subsurface drainage

Controlled subsurface drainage or drainage water management is a field tile system designed to allow the landowner to control and vary the water table over the course of the year. The water table can be lowered in the spring to allow for timely field operations. After planting, it can be raised somewhat to increase water storage for crop use and to reduce the amount of water and nutrients leaving the field through the tile system. In fall, the water table is lowered again for harvest and tillage.

Woodchip bioreactors

A woodchip bioreactor is an excavated area at the edge of a field filled with wood chips. Water from a tile system is diverted into the excavated area where it is denitrified before continuing through the drainage system.

Side inlets

Side inlets are located adjacent to ditches to control the flow of water from a field into a ditch. They prevent local bank erosion and head cutting of the receiving ditch and create temporary water detention adjacent to the ditch to reduce peak flows and allow sediment to settle.

A related practice is the design of field tile inlets. Perforated risers, rock inlets, and dense pattern tiling may be used to replace open tile inlets.

Ditch buffers

Vegetated buffers along ditches serve as a setback to prevent tillage at the edge of the channel, trap wind-blown sediment, and may slow down surface runoff and trap sediment and nutrients. The result is less sediment in the ditches,reduced maintenance costs for ditches, and improved water quality.

Water storage and culvert sizing

Water storage is an effort to hold water on the landscape and release it slowly to streams in an effort to reduce peak flows and velocities and allow time for denitrification. Water may be metered over a day or two through a reduced-sized side inlet or road culvert, or it may be stored for longer periods in a large impoundment with carefully managed outlets. Storage may be created in ditches and even within the soil profile. Some water storage techniques such as culvert sizing, must be addressed across a subwatershed to ensure that sizing matches upstream and downstream, and that road design can handle the slowed water. An example of guidelines for culvert sizing is a report from the Red River Basin Flood Damage Reduction Work Group Technical and Scientific Advisory Committee, "Culvert Sizing for Flood Damage Reduction" (http://www.rrwmb.org/files/FDRW/TP15.pdf).

Former wetlands have been restored to provide wildlife habitat and storage capacity and to improve upstream drainage function. However, there are often trade-offs between habitat goals and water storage goals.

Two-stage ditch channels

Two-stage ditches are constructed to mimic the function of natural channels. The main channel is narrow – only wide enough to carry low flows. On either side of the main channel are grassed benches and then side slopes built to hold high flow. The narrow main channel may eventually meander between the banks of the high flow channel.

Agronomic practices in conjunction with conservation drainage

While agronomic practices are not drainage practices, per se, they are often part of the same discussion. For example, some cropping systems and cover crops may reduce drainage water by increasing evapotranspiration. Nutrient and manure management practices may be designed to minimize nutrient losses into drainage water.

B.4. Drainage policy

The presentation about drainage policy emphasized a few features of drainage law including the following.

Conservation in drainage law. Law pertinent to public drainage systems is contained in Minnesota Statutes Chapter 103E (https://www.revisor.mn.gov/statutes/?id=103E), with additional information related to watershed districts in Chapter 103D. Several sections in 103E provide authority to address environmental goals. (A definition of public and private systems is in a footnote on page 18.)

103E.011 Subd 5. Use of external sources of funding: The language in this section was added in 2000 to allow drainage authorities to use outside funding for drainage projects for the purposes of water quality improvements or flood control. Previously, only money from assessed landowners could be used. This limited authorities' ability to work with agencies and NGOs to incorporate conservation components into drainage projects.

103E.015 Subd 1. Environmental and land use criteria: Before establishing a drainage project the drainage authority must consider private and public benefits and costs, agricultural land acreage, land use, flooding characteristics, water storage and retention alternatives, effect on water quality, impacts on fish and wildlife resources, shallow groundwater characteristics, and " the overall environmental impact of all the above criteria."

This language has been in the statute since 1973 and gives drainage authorities a means to address flooding and water quality concerns associated with any new project.

103E.021 Subd 1. Spoil banks must be spread and permanent vegetation established: A minimum 1-rod buffer of permanent vegetation must be established along all public drainage ditches when a viewer is appointed to assess the ditch for benefits and damages (such as during establishment, improvements or

redetermination of benefits). The requirement does not apply to private ditches. Where it does apply, not all drainage authorities enforce the requirement consistently.

103E.021 Subd 6. Incremental implementation of vegetated ditch buffer strips and side inlet controls: The incremental addition of side inlets or ditch buffers can be implemented as a repair rather than an improvement. This provision was added in 2008.

Utility approach to drainage fees. This alternative approach to assessments has been discussed by some and was described during the presentation. Currently, drainage assessments are based on the relative dollar value of potential benefits, in particular, the value of crops grown on the land. These fees are assessed to beneficiaries of the system as needed for drainage system costs. Alternatively, some have suggested assessing fees regularly (e.g. annually) based on the amount of water sent into the drainage system. This approach would be comparable to a stormwater utility system.

C. What People Said

The themes in this section emerged from analyzing transcripts of the focus group conversations. Discussions occasionally differed by region, but the more significant variations were by stakeholder group, as noted in the text.

C.1. People are key

Without prompting, participants from every group stressed the importance of relationships – either among landowners, or between landowners and local decision makers, contractors, and agencies.

Local leaders must build relationships. The drainage authorities, in particular, noted that having the right personality at the local level was essential to making projects work. The "right" person is a people-person committed to developing relationships over the long haul and who is respected by farmers as well as other stakeholders.

> *"If you want these projects to happen, staff cuts at the local offices are the worst thing you can do. Farmers see guys from SWCD as the good guys - don't make them the enforcement officers. If farmers see them as enforcers, you'll lose that education access point."* (Drainage authority, Mankato)

> *"It's the one-on-one approach. It's not the meeting, or the flyer. . . . For a farmer, they want to talk about a project over a cup of coffee, with the understanding that he may not do anything for two, three years."* (Drainage authority, Mankato)

> *"Too bad we don't have a test that we can give people. Sometimes our technicians waste too much time trying to talk to people who will never change their minds. They nod their heads but deep down you know they'll never change their minds. "* (Drainage authority, Mankato)

Show that it fits with working farmland. The challenge of earning the respect of farmers was underscored by the farmer/contractor groups when they expressed their distrust of some government institutions and individuals. Policy and programs directly impact their land and livelihood, so they will be skeptical until it is proven that a problem exists, that the proposal will have the desired effects for both the environment and production, and that it meshes with their observations and understanding of their land.

> *"If we can show that certain techniques are appropriate for certain areas, we can make that decision much better than any authority can make it for us."* (Farmer/contractor, Mankato)

> *"I see a lot of agencies that hold the cost-share dollars, but they have people with anti-ag attitudes that are administering those dollars. So the dollars don't get spent, they get spent on administration, and they don't hit the ground."* (Drainage authority, Montevideo)

> *"If we can do it without government dollars, I am much happier than if some politician is trying to make a name for themselves. Get out of our way, we are Americans, we can build this country, and we can make it great. And we can make it clean. But when they want to micromanage us, it just adds more fuel."* (Farmer/contractor, Montevideo)

Neighbors are influential. Engineers and farmer/contractors discussed how neighbors listen to one another.

> *"There is peer pressure in drainage, if it's an issue of capacity. But I don't know if it relates to water quality."* (Farmer/contractor, Mankato)
>
> *"Pick out one or two 'kingpins' who are paying attention: who keep things current, do things right, they keep everything current. The neighborhood watches what they do."* (Engineer/agency, Mankato)

The farmer/contractor groups discussed the reality of family feuds among landowners. Some disagreements go back generations and can block cooperation. Some drainage authorities noted that when a local government representative alienates a farmer, such as during a redetermination, the effect may be long lasting. "Bad blood", in whatever form, can stop a project that objectively is a win-win for the players.

> *"If there are two families with a long-standing feud, 90% chance it has to do with somebody dumping water on somebody else. "* (Farmer/contractor, Mankato)
>
> *"All it takes is one person standing in the way to prevent a project, you can put hours and hours into a project, it's often not the dollar amounts, but personal beliefs or family ideas that pose problems in moving projects forward."* (Drainage authority, Mankato)

Decision-makers must be fair. To do their work, commissioners and board members need to be viewed as objective and fair and they need to be courageous.

> *"The minute you become a strong advocate instead of a decision-maker, you've lost your credibility. That's the key. Focus on that you have to make that decision based on the facts. If I lose my objectivity, I've effectively denuded my ability to continue to exist in a controversial arena."* (Drainage authority, Montevideo)
>
> *"In our watershed project, we can't have joint meetings with some of these other watershed groups, because we can't afford to have that perception of our group (as an objective entity)."* (Drainage authority, Montevideo)
>
> Regarding redetermination: *"Once things have been done successfully, they're going to catch on. . . ." "But it takes a commissioner with guts to do it." "If the board is not willing to be courageous, [the redetermination] won't happen." "It all comes down to fairness. You just make that case over and over again, that you are trying to be fair. If people are benefitting, it's only fair that they pay their share."* (Drainage authority, Montevideo)
>
> *"We still have individuals who are afraid to do things because they won't get re-elected. But if you're afraid, you shouldn't be in the business."* (Drainage authority, Montevideo)

Everyone needs to be committed to respectful communication. Several groups expressed the sentiment that communication and relationship building – by all stakeholders – is essential because of the need to meet multiple goals: agricultural production, water quality, flood mitigation, and wildlife habitat.

> *"Given the funding climate, the economic climate we live in, we can't settle for a one-win solution. We can't settle for just flood control; we can't settle for just water quality; we can't settle for just wildlife. We need to figure out solutions that provide wins for all the parties involved. And that's going to require communication not just among agencies and farmers."* (Drainage authority, Montevideo)
>
> *"The one impediment has been the inability to communicate on a non-emotional level. The minute emotion is present, logic is gone. Rational thinking is gone and solutions are not possible at that point. . . . I would respectfully request and expect that in whatever media and whatever outcomes that come from this, that you **emphasize relationship building, communication, and those connections**; so that we have people, first of all, agreeing that we can find solutions, and agreeing that we're going to be part of the solution rather than*

being a problem. Otherwise, all of the good work goes for naught." (Drainage authority, Montevideo)

"We all know we have issues. Problem is, we have to figure out how to work together to fix some of these issues. I'm really glad that this discussion is starting." (Drainage authority, Montevideo)

"If there's ways to broaden industry engagement beyond controlled drainage into some of these other areas. . . and by industry I mean broadly beyond just the drainage contract industry, but also commodity industry reps." (Drainage authority, Mankato)

Participants also expressed the serious challenges to communication.

"Nobody trusts anybody. We don't trust the agencies; the agencies don't trust the counties; the counties don't trust the watersheds. We're still miles apart from sitting down." (Drainage authority, Crookston)

"The only way you're going to get this to go is to communicate with the people, not against the people. We have farmers that would love to come to a hearing, but half the people there are agency people, and they don't want to say anything. You got three or four DNR people, MPCA, all these agencies – they just feel alienated." (Drainage authority, Montevideo)

Communicate with the non-agricultural community. The farmer/contractor groups wanted the urban decision-makers and general public to understand more about farming.

"We fight the perception of the public who has never seen a combine before." (Farmer/contractor, Montevideo)

"Best way to spend dollars would be to do a PR program and educate people how drainage cleans up water, how buffer strips do some good, to improve public perceptions of what we already have been doing." (Farmer/contractor, Montevideo)

"They say tile is flooding us. But if the field level of water is this high and its flooding in Fargo, our tile lines ain't doing nothing for that. Water in the tile lines aren't even flowing." "But if you get one reporter out there takes a picture of a pump while their house is flooded. . . What they don't realize is that pump works all winter - that's water that's not going down the river in the spring time." "All around education is what's needed. There's a lot of ignorance out there." (Farmer/contractors, Crookston)

"I don't think the reality of this whole drainage thing has set in to Joe Farmer, but we have to be as proactive as we can and start thinking smart about drainage, because without drainage we're in trouble. There are fewer and fewer of us, and more and more people in the Metro who don't have a clue what we're doing. They're making more rules about what we're going to do, how we can drain, or whether we can keep our drainage. We need to be terribly proactive to protect drainage." (Farmer/contractor, Mankato)

C.2. Responsibility and fairness are important

There was some disagreement about who is responsible for soil and water. Several groups (two of the engineer/agency groups in particular) repeatedly discussed landowner responsibilities. Many participants felt that landowners, including those with private[1] ditches, should be responsible for buffers

[1] "Private ditches" are constructed and maintained completely by a landowner or by multiple landowners under private agreement. "Public ditches" are governed by Minnesota Statute, Chapter 103E, managed by a drainage authority, and owned by the landowners and beneficiaries of the ditch.

and side inlets to the extent necessary to keep sediment out of ditches. Many of these participants had observed the increased maintenance requirements of unprotected ditches.

There was not as much consensus about responsibilities for water. Some participants said each landowner has a responsibility to control their own water—to hold back or limit the rate of water leaving their land. They should be paid if they are asked to store other people's water, such as for flood mitigation, but they should be responsible for not dumping their own water on downstream neighbors. There wasn't agreement about whether "dumping on downstream neighbors" was a growing concern.

Another participant went a bit further to argue that drainage benefits the farmer, but it also creates social costs, therefore the costs should be internalized to agriculture so they pay the full cost of drainage. One suggestion for internalizing costs was to add a surcharge to every foot of drain tile with proceeds going towards water storage systems. Another suggestion was to make viewing fairer by giving greater consideration to costs to downstream areas and benefits to people further removed from the ditch.

Another common perspective heard in most groups was that if farmers are generating societal benefits, then society should pay. We can meet the multiple goals of drainage, but not on the backs of any one group.

> *"Farmers aren't expected to produce food just because they have the land and give it to us out of the goodness of their heart. But they use their lands to produce things. . . . they could produce more water quality, more wildlife, but I don't think they buy into the notion that they're obligated to do that because they own land. We should explore policy approaches of paying for ecosystem services, and if farmers are doing a good job of storing water, they should get rewarded."* (Engineer/agency, Mankato)

Fairness is important. Two of the drainage authority groups emphasized the importance of maintaining objectivity and applying rules fairly. As commissioners and managers, they need to keep track of the interests of the landowner, downstream landowners, and environmental interests without being an advocate for one or another. They are responsible to make sure that people who benefit are paying their fair share, and for guarding the perception of their objectivity.

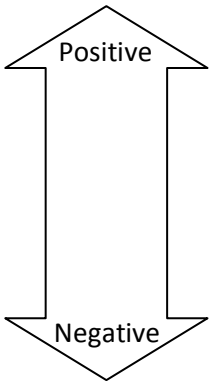
Some don't see wetland regulation as fair. Two groups questioned the process and fairness of viewing and re-viewing wetlands, asking why an area would be considered a wetland now if it wasn't before. Some contractors said they will not go to the NRCS to clarify the boundary of a single wetland because then the landowner's entire farm must be reviewed and they run the risk of identifying new "farmed wetlands[2]."

Targeting cost-share is fair. When some groups were asked whether it was fair to target incentives to some landowners over others, no one thought targeting cost-share was bad. It is better to target practices where they will have a water quality impact; if someone's land is worth more than is a neighbor's land for water quality program incentives, "that's just the way it is."

[2] "Farmed wetlands" or FWs are potholes and other manipulated areas that are cropped, but are often wet enough to still be wetlands subject to Swampbuster and CWA Section 404.

C.3. Impacts of agricultural drainage are complex

Participants' views of the impact of agricultural drainage ranged along a continuum, with most people falling in the middle:



- Ag drainage improves water quality.
- Ag drainage has had no impact on water quality and flood risk.
- Ag drainage is not to blame for all the flooding problems. Precipitation and other factors are more important drivers.
- Ag drainage is sometimes done badly or inappropriately, but isn't all bad.
- Ag drainage is a necessary evil, but we can reduce its negative impacts.
- Ag drainage is inherently bad for water quality and flooding.

Often people were confused by conflicting or incomplete information. Differences of opinion often arose when people were describing different situations.

The impacts of drainage were discussed most in the engineer/agency groups (e.g. following questions about what is known about drainage and aspects of hydrology (See Q2 and Q5, page 10)), and least in the farmer/contractor groups. Thus, most of the statements below reflect the discussions in the engineer/agency groups.

Management matters. Many participants expressed frustration or apprehension with the implementation of practices. The usefulness of impoundments, in particular, got mixed reviews, with participants saying they will not meet flood or water quality goals if they are designed or managed incorrectly. Similarly, controlled subsurface drainage will add to spring flooding if the water levels are not drawn down over the winter to provide room for spring runoff.

> *"We have a lot of water storage areas, and I don't think they do much for peak flow or water quality -- too much stagnant water, gets held too long. Some mis-management of the release scheduling. They're causing erosion that there never was before because of the way they're outletted"* (Farmer/contractor, Crookston)

Drainage increases peak flow. When scale or type of drainage was not specified, many participants said that ag drainage increases peak flows. However, when specifying the type of drainage system, many people said that surface systems increase peak flow, while subsurface systems reduce peak flow because they increase soil infiltration rates and therefore reduce surface runoff (compared to ditch-only systems or undrained areas). Surface runoff reaches streams much faster than water flowing through the soil and a tile system before reaching the stream. Speakers were not always clear about whether they were comparing tile drainage to an un-drained landscape, or ditches compared to tile systems; and if they were talking about peak flows at the tile outlet, the ditch outlet, in natural streams, or at the outlet of a major basin. Participants said that peak flows after a storm may be reduced by downsizing culverts, creating storage, and installing controlled subsurface drainage.

> *"Surface drainage would increase the peak flows, but subsurface is actually a longer drainage period. . . compared to surface."* (Engineer/agency, Montevideo)

Drainage may or may not increase total volume of flow. Compared to statements about peak flows, participants made fewer direct statements about the total yield or volume of water. Those who did (mostly from the engineer/agency groups), said drainage increases total flows.

> *"Drainage increases annual water yield. Consistently, you get more water out of whatever outlet you're looking at wherever you have a drained landscape."* (Engineer/agency, Crookston)

There were also many indirect comments that implied how people viewed the impacts of drainage on flow. For example: A few people in both an engineer/agency group and a farmer/contractor group mentioned that landowners have complained about upstream neighbors sending more or faster water downstream. Several people noted that shallower tile delivers less water than deeper tile. People disagreed about whether controlled subsurface drainage would decrease flow volume or flow peaks. Some participants noted that water storage, such as in holding ponds, reduces flow to streams.

> *"If you propose an increase on a drainage system, and go to a hearing, and your neighbor who you are friends with stands up to you and says 'I don't want your water coming any faster'. There is peer pressure in drainage."* (Farmer/contractor, Mankato)

> Regarding controlled subsurface drainage: *"I don't know about total flows so much as the peaks, the concentration. It'll meter it out slower; it will save more so it's available when we need it."* (Engineer/agency, Mankato)

Many participants seemed uncertain about the relationship between drainage and flows. They either thought drainage had little impact on flow volumes, thought the impacts varied with the situation, or were not comfortable with our understanding of complex hydrology.

> *"County drainage systems were designed to handle a watershed – the amount of water coming down from the sky in that area. That's what my impression has always been. With more seepage tile, that doesn't mean there is more water going to come down from the sky and go down the river."* (Farmer/contractor, Montevideo)

> *"If we can take land that we're growing 120-150 bushels/acre and grow corn up to 200-250 [by tile draining it], we're using a lot more water. In the long-run you're going to have less water coming off land."* (Farmer/contractor, Montevideo)

> *"I think we see trends that more flow exists, more bluff erosion, but I don't know if we have the relationship down very well."* (Engineer/agency, Mankato)

> *"If the field level of water is this high and its flooding in Fargo, our tiling lines ain't doing nothing for that. Water in tile lines aren't even flowing."* (Farmer/contractor, Crookston)

> *"We have more volume coming out of the whole system than we used to. . . . At some scales, rate control might help, but on a bigger scale, volume may the biggest driver of problems".* (Engineer/agency, Mankato)

Tile drainage creates a "sponge" effect. Many participants stated that tile drainage increases the potential to store water in the soil profile. But again, speakers did not usually specify whether they were comparing pattern tile systems to a completely un-drained landscape, a landscape with ditches only, or to random tiling of potholes. They often did not clarify the time scale of the storage – whether short term after a large event, or to mitigate a long wet period (e.g. spring flood season in the Red River Basin.)

> *"A tiled field will yield you as much storage as anything. More, because you have more acres [to store water in, compared to a pond]."* (Farmer/contractors, Crookston)

> *"Out-of-bank floods are happening much more frequently; they're losing a lot more rows near the stream than we used to. We need to talk about what were the conditions before the rainfall occurred. Later in summer, I agree that a drained field will act like a sponge and generate less runoff. But it's early in the year, before the crops are up, when soils are wetter that we're seeing the problem."* (Engineer/agency, Mankato)

Soil filters water. In addition to increasing peak flows and increasing water storage capacity, a third common view of ag drainage was that it took advantage of the natural filtering capacity of soil.

> *"We have thousands and thousands of acres of bioreactors already by having four foot drainage. I really believe it – because of my experience with septic programs. They're telling us we can treat raw sewage with three feet of well-aerated soil. And we basically have four feet with most of our fields."* (Farmer/contractor, Montevideo)

> *"I've tested my water. Sometimes it's drinking water quality and sometimes it's 13-15 ppm [nitrate]. And almost always negative on the bacteria (except the one time I mentioned). I'll drink from an outlet that doesn't have an intake. It's better than well water."* (Farmer/contractor, Montevideo)

> *"We have enough people closing up their inlets putting in pattern tiling, I feel that is filtering as good as it's going to get."* (Drainage authority, Montevideo)

> *"Everyone's so afraid of tile and everything that's coming out of it -- it's as clean as bottled water."* (Farmer/contractor, Crookston)

> *"Is there a difference in water quality if tile is not as deep, because water doesn't filter through as much soil?"* Another participant: *"I think Gyles did some work at Waseca on that. And I think there was a nitrate correlation, the deeper you put the tile the more total N loss there is through the tile lines."* (Farmer/contractors, Mankato)

Tile drainage enables conservation. Many participants noted that overland flow and soil erosion are lower because tile systems allow water to infiltrate into the soil. Pattern-tiling has given people the option to use conservation tillage practices. One farmer didn't feel he could include soybeans in his rotation unless the ground was well drained with tile.

> *"We're sending the river much cleaner water than is sent there with the overland flooding that occurs without drainage. It allows us to farm properly, without as much moldboard plowing."* (Farmer/contractor, Montevideo)

A few people asked where the nitrogen goes if it doesn't go into tile drain water.

> *"But if the nitrate doesn't go through the tile lines, where does it go? If it stays in the soil, well, great, it's there for the next crop. But usually it goes someplace."* (Farmer/contractor, Mankato)

Dispersed water management is better. Many participants believed that the greatest impact on mitigating floods and improving water quality comes from applying practices broadly across the landscape. Practices such as controlled subsurface drainage, agronomic practices, and appropriate sizing of culverts and field systems were appealing because their effects are in the upper reaches of a watershed.

For example, several participants (especially in the farmer/contractor groups) suggested that it was important to start with ***good agronomic practices across the landscape*** rather than trying to solve issues with large impoundments or buffers low in the watershed. A few people said nitrate levels in tile drain water are of little concern if farmers don't apply excess nitrogen fertilizer. One participant in a farmer/contractor group described a study showing that a heavily manured field lost less nitrogen than

a commercially fertilized field. The group was very interested in the hard evidence that manure – which is often maligned – could have positive impacts.

> *"I look at how much we do on the downstream and the open ditch portion of our systems versus what we do up on the farming landscape. If we have a one percent gain of water quality on 100 acres, is that more of a net gain than when we have a 20% gain in water quality once it hits the open ditch? Which is a better bang for the buck? Sometimes things that we do on the landscape – whether its conservation tillage or whatever – a small gain over a big acreage might have a net effect that's much bigger than a bigger percentage gain once we hit the main channels."* (Farmer/contractor, Mankato)

Several people in all three regions and especially in Crookston felt that ***dispersed, upstream flood mitigation*** efforts would be cheaper and more effective than flood control at the bottom of the watershed, such as on the Red River main stem. Dispersed flood mitigation included downsizing culverts throughout the system and using tile systems (with or without control structures) to provide short term water storage.

> *"If this waffle thing were implemented in the Red River Valley, we wouldn't be talking about building a billion dollar ditch around Fargo-Morehead."* (Drainage authority, Crookston)

During the discussions of woodchip bioreactors, several people suggested taking advantage of existing ***dispersed denitrification*** sites. Water standing in lift stations denitrifies. Water flowing through rich soil and heavy vegetation in ditches can denitrify. Participants wondered if they could enhance or take credit for the effectiveness of these.

Buffers and good side inlets reduce sediment in ditches. The engineer/agency and drainage authority groups strongly agreed that buffers and side inlets were basic first steps for keeping excess sediment out of the ditches and for controlling maintenance costs. The farmer/contractor groups agreed, but were more likely to emphasize the importance of targeting buffers to critical sites and designing (and not over-designing) to suit the needs of the site. Many participants noted that buffers have limited filtration value and were more useful for keeping equipment out of ditches.

Impressions of the impact of surface intakes varied. Participants had varied opinions about how to drain a pothole. Their observations may be summarized as: dense pattern tile under a low spot is a relatively newer approach and perhaps the most effective for both draining and protecting water quality. Gravel or blind inlets are less effective and create some management challenges. Open inlets are a bother to farm around and not great for water quality. However, an open inlet is better than having an open channel from the field to the ditch.

Participants wanted more information about the magnitude of impact of various practices. The effect has to be big enough to justify the cost and the goal has to be achievable.

> *"Are we really conserving enough nutrients that it's going to make a big difference in the end, if this is something to appease people who say agriculture is the cause of the hypoxic zone, for example? Is it going to make enough of a difference to put that cost into it?"* (Farmer/contractor, Montevideo)

> *"I'd like to see the research continue, but I would not like to see public institutions like the universities push this type of thing very hard, because it is a very costly thing."* (Farmer/contractor, Montevideo)

> *"The idea that we can continue to clean things up: that's great, but there needs to be an economic threshold where we say it may not be economical for a river to be fishable and*

> *swimmable where for decades in our history it hasn't been that way. It seems there should be a limit to where we throw more dollars at something that's as good as it's going to get. Maybe if we continue to do what we're doing, it will do it without adding extra costs."* (Farmer/contractor, Montevideo)

Get the word out. Some farmer/contractors expressed frustration that research results were not getting to the public and to legislators. Specifically, one complained that research about the importance of bank sloughing as a sediment source wasn't getting published, and another that researchers weren't sharing with legislators their data about the positive impacts of manure.

C.4. Drainage systems relate to watersheds

The drainage authority groups were asked about larger-scale drainage issues. In particular, they were asked to describe the drainage-related activities mentioned in the water plan for their county or watershed and to discuss what role drainage can play in addressing water quality and water flow issues

Drainage is not often an explicit part of water plans. Participants in Crookston, compared to the other two regions, identified more examples of conservation drainage practices in their water plans, especially related to water flow management such as impoundments and culvert sizing.

> *"The broader issue of drainage is certainly being addressed in those plans but often at a high level. We know we have to store water, we know it's a problem, but it's hard to get at the specifics that lay out a [multi-stakeholder water storage] project. Those seem so complex to put together – beyond what a typical government entity planning process can do."* (Drainage authority, Mankato)

Participants in all three regions frequently mentioned ditch buffers and side inlets as part of their plans. Participants from all regions acknowledged the relevance to water issues of all the conservation drainage practices. In the southern and western regions, specific references to drainage were uncommon in water plans – either because the plans were not meant to be that detailed or because conservation drainage concepts are too new and unfamiliar. In Mankato, one participant noted that their water plan emphasized bank erosion. Since the link between bank erosion and drainage is unclear, drainage practices were not in the plan. In Montevideo, the conversation turned to the challenges of implementing redeterminations and drainage system changes, the importance of strong leadership from board members and commissioners, and the good collaboration needed among agencies, local leaders and landowners.

Few had an explicit vision of the future drainage system. Most members of the drainage authority groups took a large-scale, watershed view of water issues. Still, when asked to describe their vision of what the drainage systems in their area will look like in the future, few were able to articulate in those terms. When pressed, their first priority was most commonly to increase buffers and side inlets. A few (especially in the Crookston group) envisioned more impoundments or other means for temporarily storing water. Others mentioned the value of large tile mains in place of open ditches, rock inlets, and two-stage ditches.

Conversations often turned to the ***barriers to these visions***. For example, the Mankato group turned to the challenges of getting buffers on private ditches. In Crookston, the conversation quickly turned to the

challenges of collaboration among stakeholders who hold conflicting perspectives for water storage. The stakeholders included the DNR, road authorities, counties, watershed districts, and landowners in various parts of the watershed.

Upstream activities have downstream impacts.

> *"Those were beautiful ditches on the lower reaches. Thirty some years ago they channelized the upper end of it; and I've got hundreds of pictures of the lower end of it is paying for it."* (Drainage authority, Montevideo)
>
> *"I like controlled drainage because it starts at the upper ends of the watershed first which affects everything downstream."* (Engineer/agency, Mankato)
>
> *"I know so many channels that are incised--because of the changes in the channel, straightening and that kind of thing--and in those incised channels, the benefit of those buffers that are constantly caving is limited*." (Engineer/agency, Crookston)

Of all the groups, the engineer/agency groups talked the most about system-level impacts. For example, several people noted the importance of matching culvert sizes upstream and downstream. At the end of the session, when asked what was missed during the discussion, several people in the engineer/agency groups mentioned the importance of taking a systems level view of interactions and the cumulative impacts, instead of addressing individual designs and practices separately.

> *Regarding culvert sizing: "You have to design on a system basis, not on every one individually." "Yes, start at the top of a watershed and work your way down."* (Engineers/agencies, Montevideo)
>
> *A system-wide approach would help – across a watershed and multidisciplinary. If you do that analysis, goals will become apparent, and it will be easier for people to accept decisions that have to be made because now they see what they'll be getting for having to make a trade off.* (Engineers/agencies, Mankato)

But drainage specialists don't do much systems thinking or watershed-level drainage projects. A few engineer/agency participants observed the lack of long-term research at a watershed scale, and the lack of information about which practices are actually on the landscape now. This lack of data limits understanding of the cumulative impact of practices and designs and to scale up the information from the field level.

> *"We talked about each of these practices separately, but a big barrier is systematic holistic planning on a watershed basis."* (Engineer/agency, Mankato)

A few participants were especially intrigued by the potential of doing more large-scale thinking.

> *I'm interested in something Gary talked about: the multi-disciplinary integrated approach rather than the plot-scale studies that we grew up with. Bringing together different disciplines to solve the problem and ask what might the landscape need to look like; what might a drainage infrastructure need to have?*
> (Engineer/agency, Mankato)

Water planning will have to change with precipitation trends. A few participants wondered how this discussion would change if we were in a trend described as a dry spell.

> *"Regarding controlled drainage; we need to keep in mind that we've been in a long wet period, but it could change to long dry period, we can't predict weather so we have to deal with it"* (Farmer/contractor, Crookston)

"10 yr plans should be changing every year. Right now we're writing plans in a wet climatic cycle - so we're assuming we'll have too much water all the time." (Drainage authority, Crookston)

"Don't let the dry cycle lull you to sleep. That's what's happened to Fargo-Moorhead. They have a flood; the next year it's dry and o.k. we don't have any problems. Ten years later they have another flood and they ask why didn't we fix this last time." (Drainage authority, Crookston)

"Do you think our discussion and plans would change if this was a dry cycle, or if the population keeps growing so rapidly? It's hard to imagine thinking there isn't enough water, but would our plan be able to deal with a water shortage?" (Drainage authority, Crookston)

C.5. The term "conservation drainage" is confusing

Several agencies in Minnesota and in other states use "conservation drainage" as an umbrella term to refer to a suite of drainage practices and designs that provide the benefits of drainage while addressing the unwanted impacts. However, at the focus groups, it was not a commonly understood term and several participants expressed problems and confusion with the meaning of the phrase.

"I see the intent of the word. If it somehow conveyed the understanding that you're taking bad drainage systems and making them more conservation-oriented, rather than adding drainage to where it doesn't exist. I don't know how to say that."
"Once you sit in on this [conversation] you start to understand that. But when you see it plastered, your first reaction is 'Oh my gosh, what's this?'" (Engineers/agencies, Crookston)

"We have had a little bit of a definitional issue in that sometimes 'conservation drainage' is used synonymously with 'controlled drainage', and now there's an attempt to expand that definition -- which is appropriate. People like me might still be confused for a while with terminology." (Drainage authority, Mankato)

"It's the impacts of drainage and you're trying to mitigate some of the known impacts. I don't know what's the better term than best management practice drainage. "Conservation drainage" does imply [that you are doing conservation]. It's not the same. It is an oxymoron." (Engineer/agency, Crookston)

"I <u>really struggle</u> with the title of 'conservation drainage'". (Engineer/agency, Crookston)

"It started out being 'controlled' drainage and now it's 'conservation' drainage, because 'control' just threw up a red flag; everyone was against it before they knew what it was." (Drainage authority, Montevideo)

Participants suggested several alternative terms that illustrate how people think about the concept of conservation drainage: soil and nutrient conservation drainage, hydrology management, managed or controlled drainage, drainage management systems, drainage BMPs, or BMP drainage.

"I was looking at conservation from the standpoint of water quality, ag sustainability, whatever. But we're really talking about 'Drainage management systems'".
(Engineer/agency, Crookston)

"'BMP drainage.' That's the term we used without getting everyone all wound up. We were thinking of maintenance activities needed, the two-stage ditch, side water inlets, the whole nine yards. Nothing about drainage is bad; it's just if and when you're going to do it, do it right." (Engineer/agency, Crookston)

C.6. Institutions could be improved

Working with government can be either frustrating or successful. Policies and institutional structures were frequently noted as barriers to efficient implementation of conservation drainage approaches. On the other hand, participants described positive efforts of watershed districts, counties, and other entities, and successful applications of existing policies.

Sources of frustration included extensive time and bureaucracy (in particular, for wetland mitigation), lack of flexibility to implement site-specific solutions, perception of government landowners as not playing by the same rules as private landowners, policies that do not reflect current technology and farming techniques, and the conflict of interest with having one person or one office providing both regulation and technical assistance to implement conservation practices.

Successful institutions were perceived as fair and responsive to the needs of the parties affected.

> *"If you have a willing landowner who wants to do the right thing, and they are prescriptively denied from doing it, they won't come back twice."* (Drainage authority, Montevideo)
>
> *"One problem is that government by nature tends to be incremental, and every now and then you need something transformational. It's incredibly difficult for people who work in government, including all the agencies, to really look at something transformational."* (Drainage authority, Montevideo)
>
> *"They're trying to protect their livelihood by not contacting NRCS. They could utilize NRCS for all kinds of good conservation things, but they just don't want to run the risk. If there was some way to go out there and blind themselves to just the issue at hand, farmers would be a lot more receptive."* (Engineers/agencies, Montevideo)
>
> *"It is frustrating to work with permitting agencies – I don't want to belittle that – but in general, good projects get permitted. It might take longer, or you have to jump through more hoops than you think are necessary. Where we get into trouble is where you want to store water where environmentalists have good reasons to be opposed. And then you run into regulatory roadblocks, and rightly so in some cases. In my experience, that's not the biggest impediment; it's acceptability of the site by landowners in and around that footprint."* (Engineer/agency, Crookston)
>
> *"We're talking farmers into putting in basically small terrace systems themselves, because getting the NRCS involved delays the process with engineering and everything else. And we've done this long enough that we know how to do it to prevent erosion."* (Engineer/agency, Montevideo)
>
> [Regarding replacing farmed wetlands with a single wetland,] *"To me that was the perfect plan; it was exactly what everybody wanted; but it took 5 years to do it. . . . Too many agencies got involved: Army Corps, USFWS, NRCS." "We did one similar to that in conjunction with a CREP project. It worked within the CREP program, that was simple, but to do it outside some of these other programs – to go through the mitigation process – I would never do that. Too cumbersome, and expensive." "If the farmers could just get wetland credits, because wetland credits are very expensive. Walmarts and highway departments are buying them up. I know farmers, if it was a simple process, they'd be creating wetlands to drain into."* (Farmers and contractors, Montevideo)
>
> *"That's a good thing about the watershed projects because we don't have to follow those prescriptive rules that you are talking about with SWCD and NRCS. If they can't fit a project in their scope they come to us because they know we have the flexibility to do it."* (Drainage authority, Montevideo)

Inconsistencies between counties or other authorities were repeatedly noted. (Some may have been the result of misunderstandings.) For example, counties and watershed districts vary in how aggressively they enforce ditch buffer strip requirements, and there is variation as to what event triggers a farm visit by a wetland regulatory authority to delineate wetlands.

> *"In X County, they do a farm visit every time you put tile in the ground, regardless. That's one of the contentions: it varies a lot county by county."* (Engineer/agency, Montevideo)
>
> "*Most of the townships do have control over [buffers], or the counties, and the county officers don't even do anything. They see a whole field dump ten tons of sediment in the ditch, and the county actually goes out there and cleans it up, and they don't send a bill to anybody."* (Engineer/agency, Crookston)
>
> *"We've [required buffers on private ditches]. It's in our permitting rules and regulations, in our watershed plan. If a ditch is over a certain width and depth, we have the ability to request [a buffer strip]. We've had about 5, 6 people who have had no problem. They've come in for a permit to clean it out again, we go through the process with them, and we just tell them that we prefer a 16 ½ ft buffer, and they've done it. Our rules say that they have to, but it's not enforced that way. . . if you show people what it can do for them, and that maintenance requirements are reduced, it makes sense to them."* (Drainage authority, Montevideo)

The importance of educating bankers about the value of investing in drainage was noted by the farmer/contractor group in Crookston. Young participants, in particular, have had difficulty getting financing to invest in subsurface drainage on poorly drained soils.

Watershed districts versus counties as drainage authorities. Some areas are dealing with the question of whether counties or watershed districts are preferable as drainage authorities. Where the watershed crosses county lines, counties are not eager to hand over authority to a body that may be dominated by people from another county. Several watershed district representatives emphasized the advantages of watersheds addressing drainage issues: They can address all water issues together, including drainage, in the context of the whole watershed system, and they only have to address water issues, not other county concerns.

> *"Some watershed districts develop plans that have very specific subwatershed practices and goals. I haven't seen those in more rural watershed districts. That's a good model for a watershed basis, but in rural areas where there are no watershed districts, it's left to county water plans, and those historically have lacked the same degree of technical input and comprehensiveness as some of the watershed district plans."* (Engineers/agencies, Mankato)
>
> *"As a county commissioner, even if you don't turn ditches over to the watershed district, you should try to work closer with them. So there is just one set of rules."* (Drainage authority, Crookston)
>
> When asked for examples of successful efforts: *"All watershed districts are a success. That's what we do. It's a success in progress; we are slowly tackling one thing after another. For example, we have done 48 wetland restorations over the past 20 years, and that's just wetland restorations. But every watershed district is doing that. And you can only tackle small pieces at a time. You can't say everybody's going to have a buffer, or a wetland. You pick and choose and do the best you can."* (Drainage authority, Montevideo)

There was ***disagreement about whether or not watershed boards should be elected***. Some participants thought they ought to be elected because they have taxing authority and tremendous responsibility. Others thought they needed to have the room to make difficult and unpopular decisions.

In a related topic, one group briefly raised political and timing concerns about the proposed ***legislation to create 7 or 8 basins statewide*** that would have taxing authority.

C.7. Views of stewardship

Impressions of stewardship values varied with participants' experiences.

> *"We are building soil and cleaning the river environment dramatically with tile. Environmentalists take the opposite viewpoint, which is disturbing." "A lot of environmentalists think farmers aren't good stewards, but it's not profitable to be a poor manager." "In my lifetime, we've cleaned up the environment and not gotten worse; we've gotten better. There are all kinds of practices that help. And people are more aware of it." "What should we do to improve lakes and watersheds? More of the same. They keep raising the bar and we keep meeting them."* (Farmers/contractors, Montevideo)
>
> *"In ag, 99% of farmers are good stewards, but a few aren't, and we could make big strides if they were not next to a body of water."* (Drainage authority, Mankato)
>
> *"Maybe 15% or 20% of farmer population gives some thought to stream quality, runoff, etc., but most people don't think about it and want to grow as much corn as they can. And it gets back to economics."* (Farmer/contractor, Mankato)
>
> *"There are a lot of people [for whom] the economics is the strongest pull for them, but there's also that feeling of making a difference [environmentally]. Combined together gives you double." "That's what I'm seeing. We've got a lot of young farmers in our area, I see a big change."* (Drainage authority, Montevideo)
>
> *"If you're a good steward of the land, [buffers] would be a no brainer. But because of societal pressures, it is not something that's part of the ethic that's out there anymore."* (Engineer/agency, Crookston)
>
> *"It still does come back to economics. I have a dozen customers to tile per year, and I never had anyone say, 'what's the best way to design this to protect water quality.' Never ever mentioned."* (Farmer/contractor, Mankato)
>
> *"In 1985, that's when conservation went out the window. Prior to that we had the ACP. . . ." "Prior to the farm bill, you didn't have big crop insurance, crop deficiency payments. Now people farm as many acres as they can, and they risk nothing. If they get a failed crop, they get paid for that. Prior to that: to keep your farm for the next generation you had to take care of it. It has really changed. We're not the big stewards that we claim to be."* (Engineer/agency, Crookston)

C.8. All practices and designs have a place

Prioritize results, not practices. When pushed to prioritize the various approaches to conservation drainage, every group made the point that all options are important in different places. Each water management effort is a site-specific endeavor. Promoting single practices across the state at the expense of other practices will limit the number of areas that can be improved.

From field scale to watershed scale, the following practices were discussed.

Appropriate sizing of field systems

There were differing approaches to designing field systems. Most contractors felt that effective depth and spacing are learned through trial and error, while others find the Minnesota Drainage Guide to be useful.

> *"Tile is not a science, everything is trial and error [from site to site]."* (Contractor, Crookston)

Contractors from all regions said depth and spacing are determined first by the pre-existing systems, steep slopes and undulating fields. If a landowner has a choice in sizing and spacing, it will be selected based on cost-benefit constraints. In fact, one participant said the practice should be called "profitable sizing" instead of "appropriate sizing".

> *"Appropriate sizing of drainage systems is based on economics. You put in as big of a main as you can justify, but I don't know anyone who went way overboard on a main – just because it's so expensive. You don't see people overdoing it on the mains, do you?"* [Another participant:] "*No, usually they're two sizes too small."* (Contractors, Mankato)

There was confusion about what is meant by appropriate sizing, and how to determine "appropriate". One of the engineers said, "drainage and farming is not by guess and by gosh;" drainage spacing and fertilizer applications are based on many years of research that we shouldn't waste time repeating. Another participant countered by pointing out Gary Sands' comments about the gap in understanding of the optimal point on the curves showing yield benefit, cost, and N loss for various tile spacing.

Some of the farmer/contractors were not familiar with – but were interested in – research showing the impacts of depth and spacing. Specifically, participants questioned whether very deep tile (e.g., six feet) will reduce yields compared to shallower tile. They also wanted to understand the impact of tile depth on N loss. One participant wondered if deeper tiles would allow the soil to filter out more N, while another pointed out research at Waseca showing deeper tile does in fact increase N loss. This raised another question: what happens to the N if it doesn't go through tile lines? Is it available to crops or does it have implications elsewhere?

> *"With a two year payback on 60 ft spacing, you can bet I'm going to start doing 30 foot spacing. Appropriate sizing is as much as you can show will economically work; I truly believe we are improving the environment with these systems."* (Contractor, Montevideo)

Field systems are an opportunity for water storage. People in several groups agreed that appropriate sizing is not costly or difficult, though it does require extra upfront planning and a reliance on the skills of the installer. From that perspective, several people in both engineer and contractor groups saw sizing as a more practical way to achieve dispersed water storage compared to controlled subsurface drainage or setting aside land dedicated to holding water.

One of the farmer/contractor groups pointed out that this is about sizing of the whole system, including culverts and outlets, not just the field systems.

Contractors and farmers determine system designs. Participants in an engineer group noted that tile salesmen, not engineers or NRCS, have the key role in determining system design. On the other hand, contractors noted that the landowner makes the tiling decisions. A farmer noted how important it was for him to choose the right contractor and back hoe operator to get the design he wanted.

There were different views about the importance of system features on flow volume versus timing. The focus of discussion varied among tile depth, spacing, size, or drainage coefficient. One of the engineers emphasized that pipe size is more important than spacing. On some soils closer spacing is needed, but you can still control N loss by reducing the drainage coefficient with a small tile. One farmer/contractor felt that closer spacing reduced the time it takes to drain a field, but didn't increase flow volume.

Controlled subsurface drainage

Controlled subsurface drainage was the most discussed of all the practices, perhaps because it is most closely associated with the idea of "conservation drainage". Despite the interest, most people, especially the farmers/contractors, wanted a lot more information before they would be comfortable adopting the practice.

> *"You start looking at the cost factor, the topography, and the amount of micromanaging you're going to have to do, in addition to the initial costs – then you weigh out the benefits of increased yield, potentially. Are we really conserving enough nutrients? Is it going to make enough of a difference to put that cost into it? I wouldn't think so."* (Contractor, Montevideo)

Controlled drainage could be a water storage tool. Some participants (mainly engineers/agencies) were very attracted to the potential benefits of leaving more water in the field to support crop growth. All three engineer groups expressed interest in using controlled drainage as a way to get dispersed storage capacity, without losing farm land. One person wondered what would be the cumulative impact of many controlled systems in a watershed.

> *"It's a waffle plan underground, that's what it is."* (Engineer, Crookston)

However, some participants, especially in Crookston, were quite concerned about leaving the water table high over the winter and eliminating soil storage to reduce spring floods. The other concern with winter storage (in all regions) was the potential for frost to break tile lines.

Many questioned the practicality. Most of the discussions were directed toward concerns with the practicality of installation and management. People in all regions felt that the greatest potential was in the Red River Basin. In other regions, much of the land is either too steep, pocked with potholes, or already tiled. Many were skeptical about the potential to retrofit controlled drainage into existing subsurface drainage systems.

The other practical concern was how to manage the control structures—will they have to be managed by hand? How many will be required on a large farm? How can they be farmed around? Some people questioned how the water table could be managed effectively when we cannot predict the weather to know when storage is needed.

> Referring to control structures: *"An operational nightmare."* (Farmer/contractor, Crookston)
>
> *"If they were automatic, that would be a game changer."* (Farmer/contractor, Mankato)

Many questioned the yield and nitrate benefit. Many participants asked for more research and demonstrations to quantify a yield benefit. Without that, the cost is hard to justify. A couple people

noted that the current data set only covers three years, which is not enough to demonstrate performance under a range of weather conditions.

Most people didn't question the benefit of controlled drainage for reducing nitrate losses, but some questioned whether the nutrient reductions were enough to justify the costs.

Lift stations are a more practical alternative. Several groups suggested that existing lift stations could be used to control the water table. Some of the farmer/contractors were open to learning more about how they could manage lift stations more effectively to get the benefits of controlled drainage without the cost investment.

Some farmer/contractors were open to ***planning installations to accommodate control structures later***, even if they weren't installed initially.

A few people questioned the role of government. A couple people expressed apprehension about ceding control of the control structures if they accepted cost-share dollars. One asked why Minnesota (unlike other states) does not provide payments to manage lift stations and control structures.

Woodchip bioreactors

Woodchip bioreactors were appealing to some people because they seem to be a simple way to treat nitrate and they can be attached to any existing tile system without taking land out of production. On the other hand, several people questioned whether they were practical and effective enough to justify the cost.

Show me more. Bioreactors were new to many participants, especially in the Crookston groups. Of those who had heard of them, most wanted more information and demonstrations to show their effectiveness, and especially to document the maintenance requirements – how long will they last before the woodchip medium needs to be removed and replaced?

In addition to maintenance, the other major concern was the amount of space required. Current demonstrations treat a few tens of acres. Some people wondered whether it would be practical to build one big enough to treat a few hundred acres.

Where else is nitrate treated? Three people from three different groups questioned whether water treatment could be achieved with existing alternatives: 1) The four feet of well-aerated soil above tile lines treat water, just as three feet of soil is considered enough separation under septic systems. 2) A lot of denitrification happens in ditches, which might be managed to improve performance. 3) Based on nitrate tests of tile water, water in lift stations tends to denitrify while standing.

Side Inlets

Side inlets are also related to the issues raised in the "Water Storage and Culvert Sizing" section.

Confusion over definitions. "Side inlets" meant different things to different people. The leaders of this project were thinking of inlets from field tile systems or overland flow into ditches. Some of the participants were thinking of culverts or of the connection from field ditches to road or other ditches.

Side inlets are widely relevant. As with buffers, participants in most of the groups (especially all of the Montevideo groups) saw broad benefits of good side inlets throughout a ditch system. The benefits of inlets for reducing erosion and maintenance costs are visible and intuitively make sense. The farmer/contractor groups discussed them very little, but did note that they are easy and not particularly expensive. In contrast, participants in one of the engineer/agency groups thought that cost was a significant barrier and it was sometimes a challenge to convince landowners of the value of inlets.

> *"I chose side inlets as the number one practice, because there's at least some opportunity in all drainage systems for these."* (Engineer, Montevideo)

More design guidance is needed. A few people raised design issues. Specifically, one of the drainage authorities felt they didn't have a good way to design the size of pipes, and others were concerned about designing the tile and the inlet pipes to ensure there is no surface runoff and water doesn't stand so long it drowns crops.

> *"It's cheaper to farm around the cut they've put in the ditch than to pay $1500 to put in tile with a riser."* (Engineer, Montevideo)

Inconsistency about whether inlets are repairs or improvements. One of the groups observed that some counties perceive inlets as improvements, while the law treats them as repairs.

Some counties' staff and decision-makers are more willing than others to allow upsizing of culverts.

Education is needed.

> *"That's one of the things I'm hoping you can help convince people: that it won't harm you in terms of productivity [to have water backed up for 24 hours] and it will help with water quality."* (Engineer/agency, Montevideo)

> *"Public drainage system allows the system to pay for erosion control structures, but it's a question of whether or not the landowners believe they're really needed."* (Engineer/agency, Montevideo)

Buffers

"Buffers are a no-brainer" was an opinion expressed in nearly all of the drainage authority and engineer/agency groups. All three groups rated it high on their recommended practices. Buffers were considered one of the cheapest and most effective actions that can be taken to improve water quality. Several of the drainage authority participants were adamant about the value of buffers for reducing maintenance costs.

> *"If redetermining benefits, two points are no brainers: buffers and side inlets."* (Drainage authority, Montevideo)

Another benefit mentioned a couple times was the public relations value of buffers – the public can see the grasses and the wildlife.

Is the benefit of grass buffers over-stated? Many participants had experienced the value of a minimal buffer for keeping sediment out of a ditch by keeping farm equipment away from the edge. At the same time, many people questioned the benefit of extra wide buffers and the filtration value of buffers. Commonly, spoil banks slope away from the ditch so water does not filter through the buffer, and a few cuts through the bank may circumvent all the benefits of the buffers. This led several people, especially

farmer/contractors, to suggest that buffers need to be targeted to limited locations where they can actually treat water.

> *"To some of the public and legislators, buffers are seen as a panacea. That's such a simplistic view of things."* (Engineer, Crookston)

A minimal buffer should be mandated. Several drainage authority groups and engineer/agency groups got into discussions about how to use existing policy tools to promote more buffers. Even where landowners have been paid for buffer land, some authorities are less diligent than they could be about monitoring them and requiring maintenance of the buffers. One authority has required buffers as a condition for cleaning out ditches. Another has successfully required buffers on private ditches as a requirement for a permit.

> *"If you show people what it can do for them, and that maintenance requirements are reduced, it makes sense to them."*(Drainage authority, Montevideo)

Some people considered it a matter of fairness to mandate buffers – a farmer without a buffer creates a burden on downstream ditch beneficiaries.

The Red River basin participants were more likely than those from other regions to feel they had a very low proportion of ditches with buffers.

It takes flexibility and money to increase the amount of buffers. Because buffers take land out of production, some financial incentives are needed. At the same time, they would be far more attractive to landowners if incentive programs allowed more flexibility. Specifically, participants suggested that landowners be allowed to use buffers as turning headlands or to harvest forage from them. They wanted the width of the buffer to reflect the unique local soil and landscape erosivity instead of being a set width.

Participants in the Mankato group discussed how private landowners could be encouraged to add buffers, but this requires adequate staffing of local offices to work with landowners.

Other barriers. Landowners can be uncomfortable with the permanency of easements.

One of the contractors in Crookston pointed out that tile has allowed growers to reduce salinity and thus farm an area that otherwise would have been left as a buffer.

Water storage and culvert sizing

The topic of water storage generated some of the liveliest and most extended discussions of any of the topics. It quickly became clear that this was a broad topic that meant different things to different people. Some of the features of water storage that needed clarification were:

- ***Goal:*** Wildlife habitat, flood mitigation, or water quality.
- ***Time scale:*** Permanent water storage in a wetland versus medium-term storage during a wet period versus short-term (e.g. 24 hour) storage after a storm.
- ***Spatial scale:*** Dispersed storage in the soil profile versus field-edge storage in small depressions versus moderate-sized impoundments versus massive impoundments over hundreds of acres.

- ***Mechanism:*** E.g., tile systems to create storage in the soil profile, down-sizing of culverts to temporarily hold water behind roads, down-sizing of inlets to temporarily hold water behind a ditch berm, breaking tiles to restore wetlands. A few people included agronomic and other practices that increase infiltration or evapotransporation.
- ***Land use while storing water:*** E.g., land could be: permanent water storage, wetland habitat, in-ditch storage, farmable after temporary early-spring flooding, farmable except after a large storm, or farmable with crops that can tolerate brief inundation.

Given all those faces of "water storage" ***most people weren't familiar with the full complement of options***. However, participants were generally interested in this discussion and open to learning more.

> Some examples of a broad vision of ways to store water:
>
> *"The bigger issue is: where in the existing system is there some storage potential. While road ditches, the image of them as canals and long term storage is too steep of a hill to climb, there might be potential throughout public and private infrastructure for taking a little off the peak. We need to look at potential within the current system to do some storage, not wait for some whole new cloth."* (Engineer/agency, Mankato)
>
> *"A lot of investment does go into wetland restoration and creation to provide storage and habitat. In SE, maybe not quite as much money has been put into the riparian corridor and bringing back headwater stream function and in-stream storage."* (Engineer/agency, Mankato)
>
> *"I've got a spot that I want to pump water into a storage facility, keep it there until July, and then reintroduce it back into the system in July and August."* (Farmer/contractor, Mankato)

Goals need to be clarified. In the Crookston groups, by far the most important goal was flood control and thus water storage was of much greater interest than the other conservation drainage practices.

One of the Mankato groups pointed out that wetland-related policy has largely been driven by wildlife and secondarily for water storage and quality. They supported a way to modify policy to add a water storage and quality component on top of the wildlife driven benefits.

With regard to wildlife habitat, the quality of a wetland makes a difference. There was some awareness that storage for flood mitigation may or may not be compatible with habitat needs, however there was little discussion or awareness of wetland features that make it more or less valuable to wildlife.

Concern about where storage could go on the landscape. A lot of participants had a hard time seeing where storage would fit on the landscape. In Montevideo, we heard that the landscape was too rolling to locate a large impoundment (i.e., something larger than a roadside detention impoundment). In Mankato, we heard the best storage areas were also the most productive ground – low spots in the middle of fields. In Crookston, we heard a discussion laying out the storage site options: 1) on-channel in good valleys, 2) existing public lands, and 3) wetlands on private lands – all three of which had serious constraints.

One person in Montevideo felt that the most cost-effective water treatment would be large impoundments low in a watershed. In contrast, the more common sentiment in Crookston was to favor dispersed small storage in the upper parts of watersheds, such as through the use of culvert sizing.

"The potential for something like controlled drainage, or appropriate sizing of drainage systems, that are practical and easy sells – these practices may have great potential for water storage, and might be more economic ways to store water on the land or change the way it flows . . . "

"Storage is the gamut from small wetland restorations to culvert sizing. I keep thinking of the technical papers: if we systematically store an inch of runoff across the entire landscape, we almost eliminate 10 year flood events to agricultural land. Systematically storing one inch of runoff - I don't know how much that would cost - but it seems like the benefits would be great, because those are the storm events that really hurt producers during the growing season. . . ."

"Broadly distributed storage, which culvert sizing does, is the key. An inch of storage runoff is about what you can store behind road grades in the Red River Valley. You wouldn't store that much during a ten-year event – you're more focused on maximizing that storage use in the less frequent bigger events. But that's about the storage you could provide if you implemented culvert sizing over the whole basin - about 1 inch of runoff - which is huge."
(Engineers/agencies, Crookston)

Cost is huge. Nearly every group observed that the cost of impoundments can be huge because a large area of land is taken out of crop production permanently. (Participants valued land not just by its market price, but as earning potential and a retirement fund.) Similarly, unless they have to be replaced anyway, culverts are costly. They have an extremely long lifespan and don't need to be replaced often. Some people viewed field-scale practices, such as controlled subsurface drainage and appropriate sizing, as more economical ways to store water on the landscape. One person in Mankato thought the cost of storage is too high for the public to bear and it would have to be partially internalized into the cost of drainage systems. Another participant pointed out the influence of tax law related to land sales and easements, and how these impact the cost of drainage opportunities.

Permanency can be a deterrent to landowners. While permanency is necessary or preferred for some water storage projects, several people in the engineer/agency groups noted that permanent easements are hard for landowners to swallow. Landowners want flexibility to respond to future changes in the economic environment and water management goals.

"The decision [to store water] seems permanent; permanent decisions are harder to make."
(Engineer/agency, Mankato)

Many noted the real and perceived engineering constraints on road detentions. Outside of Montevideo, few people had heard of using road embankments as detention berms for short-term storage of water behind culverts. Most people's initial reaction was apprehension about the risk to the road structure. Many participants had seen washed out roads and overwhelmed culverts, and were skeptical that road authorities would tolerate this practice, or that they could allow and encourage road detention and still meet design standards.

Similarly, in cases where road detentions would result in temporary ponding in fields, participants from several groups were skeptical that the designers could reasonably assure that temporary ponding would not damage crops and pastureland.

Some participants connected the issue of washed out roads to the importance of addressing appropriate culvert sizing on a system wide basis. The upstream and downstream culverts need to be matched, which can be a difficult task.

Managing education and public relations is important. Like any conservation practice, down-sizing culverts and creating short-term storage must be implemented in a way so all the affected people understand the project risks, and benefits. For example, one participant described a flood mitigation impoundment which was designed to permanently hold a small amount of water. However, the public perception was that the impoundment had little capacity to absorb temporary flood waters. Public education and demonstration would be needed to gain their support.

The first reaction of participants who were relatively new to water storage options was distrust of allowing water to pond on cropland and a feeling that downsizing can only be a negative for crop production. Participants who were more familiar with water storage felt that these fears were significant barriers to implementation. Given the perceived consequences of downsizing of culverts for water storage, people need to see locally relevant demonstrations of the benefits and they need a high level of assurance that production will not be affected. If a heavy storm comes soon after the implementation of a new practice, the resulting damage may sour people against similar projects for a long time.

> *"Many farmers would view it as, 'well if you reduce the size I'm worse off. Can't be anything but worse off.'"* (Engineer/agency, Montevideo)
>
> *"It sounds like a no-lose situation, to get compensated when you lose a crop. But people are not willing to admit defeat."* (Farmer/contractor, Mankato)
>
> *"After farmers have seen it work in a few places, some farmers would volunteer to have it done. The demonstration of it is important."* (Drainage authority, Montevideo)

Wetland mitigation takes far too long and is too bureaucratic. Many participants from all three regions felt the three-to-five years required for the wetland mitigation process was a substantial barrier. Several participants offered examples of landowners who could and would create high quality wetlands if they were allowed to drain individual small potholes (type 1 wetlands) within cropland fields and combine the affected farmed wetland into a targeted area to restore a large wetland (type 2 or greater). However, the multiple contacts required, the strained communication, the complicated and cumbersome process was too expensive, too frustrating and too slow.

> *"If the process was easy, people would do it. It's not a money issue. Farmers are wasting money on FWs [farmed wetlands] every year, so that would pay back fast."* (Farmer/contractor, Montevideo)

Need consistent guidance and management from local and state agencies. A few participants from the farmer/contractor groups expressed frustration with management of projects for conflicting goals. One example was of a dam installed for sediment storage and flood reduction, but now maintenance that was originally planned is being blocked. Another example was of drainage water management on state land that conflicted with management on neighboring lands: the private landowners felt the agencies were not bound by the same rules. A third example came from a landowner who wanted to manage for a temporary spring wetland but couldn't get a clear answer on when or how high to manage the water level in the farm field for migrating waterfowl.

Cost of storage is manageable. Participants from most groups, especially in Montevideo, noted that the cost of storage is not insurmountable. Some suggested that more careful targeting of land set-aside programs could improve cost-effectiveness. Several people noted that smaller tile systems and culverts are cheaper to install than larger impoundment or water retention systems. Good areas for converting

to wetlands may be cheaper than other farmland because they are often less productive due to chronically poor drainage. Costs is not always the primary barrier: As noted in a previous section, many participants thought landowners would be happy to trade farmed wetlands for a targeted, restored wetland, or to flood fields temporarily in the spring if they had straight forward guidance and minimal "red tape." Other participants noted it would be far less costly to compensate farmers for being flooded once every ten years than to buy the land outright for flood storage. One engineer described how a watershed is requiring a properly-sized outlet as a condition for getting a permit for tiling and new culverts, and thus is essentially implementing appropriate culvert sizing.

> *"We're looking at a billion dollars to run water around Fargo. Who knows what's possible for landscape-scale changes. They will be driven by public opinion, and societal interests, so don't write [changes] off based on cost."* (Engineer/agency, Montevideo)

Storage is more than ponds. Some participants tried to broaden the concept of storage: Many suggested that a tiled field provides storage in the drained soil profile. Others wanted to know the potential for in-stream or in-ditch storage. One pointed out that ditch buffers provide short term storage by increasing infiltration.

Two-stage ditches

Many participants had little awareness of the design and goals of a two-stage ditch and were not familiar with research or demonstration results. However, most groups were interested in discussing them, especially those in Crookston.

Two-stage ditches have multiple benefits. Interest stemmed from the potential to fix ditches in bad repair, reduce maintenance cost, create in-ditch water storage, imitate the function of a natural stream, provide habitat, and achieve water quality improvements alone or by combining two-stage ditches with impoundments and culvert sizing.

Cost to establish a two-stage ditch is intimidating. The main concern was the huge cost of moving so much soil along so many miles of ditches. Few new ditches are being dug, so implementing two-stage ditches means re-shaping existing ones during the repair process.

Other participants noted that two-stage ditches are feasible if projects are handled in stages and if critical stretches were targeted rather than improving the whole system. Also the lower maintenance costs could help justify the initial expense. (Some speakers pointed out that re-sloping ditches significantly reduces maintenance.)

Questions about where the sediment goes. A few participants raised the question of what happens to the sediment if it is not being deposited in the ditch channel. There was some discussion about whether a two-stage system generates less sediment or if sediment is simply passed downstream.

> *"I'm not sure it's better to pass [sediment] downstream so we don't have to clean it out close to the source. I want to see a debate on whether that's appropriate."* (Engineer/agency, Crookston)

Communication needed with landowners and board members. The Mankato farmer/contractor group discussed landowner perceptions of two-stage ditches. They wanted people to understand that a wider ditch does not mean a farmer is sending more water downstream and that maintenance costs may be

reduced. Another concern was that some board members need a better understanding of ditches and the overall maintenance costs provided by the LGU, and the benefitted party.

> *"We need demonstrations. Since we, as an industry, community, haven't seen these two-stage ditches, it's difficult to trust and understand them."* (Farmer/contractor, Mankato)

Agronomic practices are part of the package

Field practices need more attention. All of the farmer/contractor groups (and one of the engineer/agency groups) observed that agronomic practices were not on our list of conservation practices, yet should be a high priority – especially nutrient management. Two participants (farmer and agency staff) argued that it would be far more effective to focus on field practices instead of waiting until water gets to the ditch to start addressing water quality.

Participants noted three interactions between agronomic practices and drainage. 1) ***Drainage allows for good stewardship*** in that it makes reduced tillage possible and one farmer felt it allowed him to include soybeans in his rotation by helping pull salts out of the soil. 2) Two groups said ***nitrates will not be an issue in tile drainage water*** if farmers are reasonable with their nitrogen applications. 3) A drainage authority in Crookston noted that as crop diversity has decreased, there are fewer fields of ***grass and other crops that can tolerate standing water without damage and thus could serve as locations for brief water storage.***

One drainage authority at Crookston thought there was increased erosion in the last 20 years due to lack of soil cover. In contrast, a few people in other regions thought tillage was less aggressive and erosion was lower now compared to decades ago.

C.9. Summary of barriers

What keeps people from implementing conservation drainage designs and practices? The answers (detailed above) fell into the following categories.

Practicality and cost constraints dominated the discussions. Participants described issues related to retrofitting existing systems, landscape constraints, compatibility with farming operations, drainage effectiveness, and environmental effectiveness.

Awareness was the next most common barrier discussed. Many people have not seen the practices, and are not familiar with –or have misperceptions about – what their impacts are, where they work best, how they work, costs, and long-term operations and maintenance.

Policy and institutions were a common target of complaints. In particular, people were frustrated with the lack of flexibility to apply site-specific solutions, and the amount of time and bureaucratic steps required to participate in programs, such as wetland mitigation or even technical assistance. The result is that people do these practices on their own or not at all.

It is worth repeating here what was said in the "People are Key" section above: participants often pointed out the importance – both positive and negative – of the particular personalities who hold public positions and implement the policies and programs.

Lack of data: Research and full-scale demonstrations are needed to show the effectiveness of practices in a range of landscapes and weather conditions. Landowners and public officials need a lot of assurance that the systems won't fail before they will invest money and risk yields, roads, and other resources.

Communication to understand goals and build trust: Participants often expressed a need to clarify goals. Which objective is dominant in a particular situation: water quality, ag production, flood mitigation, or habitat? Communication is needed to help everyone understand the local goals and to understand each others' stake in the process. The engineer/agency group in Mankato had the most explicit discussion about goals, but they did not reach a conclusion about the extent to which goals are understood and articulated, and who should be developing those goals.

> *"It's hard for me to wrap my brain around it without having some goals. . . . Until then, I just see a circular discussion continuing, whether it's research, or a debate of the validity of that research, ..."* (Engineer/agency, Mankato)

D. Findings and Conclusions

D.1. The time is ripe for increased communication

Participants were concerned about drainage issues and generally were ready for more discussion. Ongoing discussions are needed to bridge differences of experience and perspective. Stakeholders need to work together to develop a shared understanding of goals and identify broadly acceptable approaches to water management issues.

Community-builders are critical. Implementing solutions depends on local staff in stable positions and who are knowledgeable and skilled at building long-term relationships with landowners and other stakeholders. Without this, program dollars are of limited effectiveness. Good community builders must be supported by state and local leadership and funding.

A commitment to communication is critical. Several participants noted the need for all parties to be committed to listening to other perspectives and working towards win-win solutions. From that foundation, it is possible to address the seemingly conflicting interests of upstream and downstream neighbors, and of economic and environmental goals.

When discussing impacts of practices and designs, there is often confusion about the scale and frame of reference. Some disagreements about drainage impacts may be eliminated by clarifying where people's assumptions differ. For example, is the impact at the farm, stream, or basin scale? Is intense pattern-tiling being compared to low density tiling, ditches only, or to pre-settlement conditions? To what degree do the drainage impacts vary with precipitation trends?

Goals and priorities are not always explicit. Decisions about drainage systems are made with one or more goals in mind: production, water quality, flood mitigation, and/or habitat. People won't necessarily share the same interests and goals. However, at the local level, stakeholders need to understand each other's interests and to understand what goals can reasonably be accomplished with a particular project.

Responsibilities are often confusing. The roles and responsibilities of various state and local agencies were not always clear to participants. For example, the laws related to wetlands include Swampbuster (federal), Clean Water Act Section 404 (federal), and the Wetland Conservation Act (state). The responsible agencies that may become involved include watershed districts, Soil and Water Conservation Districts, NRCS, the DNR, USFWS and USACE. Agencies could do more to clarify (and simplify) their roles.

Opinions differ about public versus private responsibilities. One perspective is that landowners are gaining all the economic benefits from drainage and therefore should pay any costs for mitigating downstream impacts. Another perspective is that society (taxpayers) should help pay for societal benefits such as clean water that are provided by private landowners. During local conflicts it may help to make this disagreement explicit so parties can reach better mutual understanding, if not complete agreement.

People use different dictionaries. "Conservation drainage" is a relatively new term and is not broadly understood. More work is needed to communicate that "conservation drainage" is an umbrella term for a suite of designs and practices aimed at providing the benefits of drainage while minimizing negative impacts on the environment.

Other terms also cause confusion and need to be defined when they are used. People differ in their impression of which practices are included when they hear terms such as "side inlets," "water storage," or "appropriate sizing," so it is not surprising that they have different impressions of their impacts, results, or level of agency control. For example, various participants used "side inlet" to refer to ditch-to-ditch connections, tile-to-ditch connections, culverts, or overland flow to ditches.

Many stakeholders; many avenues for education and communication. Drainage is a large issue that is best addressed in multiple mediums and forums. In the questionnaires, participants indicated a strong preference for workshops as a source of information (Appendix B), but other avenues are also important, depending on the stakeholder group and type of information. Popular agricultural news outlets, professional publications, public meetings, stakeholder networks, and on-line resources serve different functions and different audiences.

Water storage, in particular, has not been discussed broadly. In general, participants have had limited experience with, and exposure to, the wide range of options for creating temporary water storage, including sizing of field systems, culvert sizing, ditch designs, and large impoundments. Communities need broad discussion and relevant demonstrations to be able to identify local opportunities for water storage and to develop landscape-scale plans for implementation.

Drainage issues are often discussed in terms of individual fields or sub-systems, neglecting their impacts on the larger system and the watershed. Watershed-scale or ditch-scale planning may improve the perceived fairness and effectiveness of system repairs and maintenance. System-wide factors often determine the stability and effectiveness of drainage systems, the risk of localized flooding, and damage to infrastructure.

D.2. Education needs

Demonstrations and case studies. Landowners need to see practices and designs established in a realistic setting before they can invest in their drainage system and risk losses or failure. In particular, demonstrations of controlled subsurface drainage, woodchip bioreactors, culvert sizing, two-stage ditches, and road impoundments are needed.

Demonstrations may also be used as an opportunity to communicate options and constraints on conservation drainage with the non-farm audience.

Hydrology fundamentals. The hydrology of agricultural regions is complex and often misunderstood. Some relevant topics include:

- Compare sediment and flow dynamics in various types of streams and ditch designs.
- Explain how field-scale activities add up to system- or watershed-scale impacts.
- Describe the state of knowledge about streambank erosion.

- Describe the state of knowledge about impacts of artificial drainage.
- Explain how the functions of wetlands vary with the type of wetland, as indicated by the depth and timing of inundation and vegetation. One wetland may not necessarily be exchangeable for another.
- Describe how fish and wildlife ecology is related to hydrology and water quality.
- Describe nitrogen cycling, especially how N loss is affected by flow volume and denitrification in various landscape positions within the surface and subsurface drainage system.

Help connect farmers and non-farmers. Farmers feel that urban citizens and legislators have a lot of influence over their livelihoods, but understand little about current livestock and row-crop agriculture. Specifically, they would like non-farmers to perceive how farmers have made great strides in recent decades in reducing erosion and improving manure application, and that existing undisturbed wetlands are very rarely drained anymore. They would like acknowledgement that their livelihoods and resources are at stake when drainage policies are implemented and they have the most site-specific breadth and depth of knowledge of their working lands.

Learning from colleagues. Building opportunities for communication within stakeholder groups is as important as communication across groups. People want to learn from their own colleagues and from leaders they trust.

Institutions and policies. Many people are confused by or unaware of the roles, responsibilities and services of various agencies involved in wetland delineations and easements and other water related policies and programs.

D.3. Important principles

Fairness was an important principle to participants. Fairness is not the same as equity; landowners do not expect equal treatment where sites are different. Landowners do expect rules to be applied predictably and consistently among private and public landowners and among the various counties and local government units. They also expect wetlands to be defined consistently.

The effectiveness of drainage authorities depends on them maintaining an image of objectivity and fairness.

Program flexibility is important because "best" is site specific. No single practice is a panacea. Participants prefer the concept of programs that support results rather than specific practices and that allow enough local control to make site-appropriate decisions. One form of inflexibility is ***excess "bureaucracy"***, i.e., the amount of time and steps required to participate in a program. The length of time required is especially a barrier to wetland mitigation projects – even those that would be directly beneficial to the landowner.

D.4. Opportunities for immediate action

Choosing when to make decisions and when to gather more information is always a balancing act. On the one hand, more research, demonstrations, and discussions are needed to understand the impacts of drainage options and identify the most appropriate applications. On the other hand, people are making decisions now about the installation and maintenance of drainage systems and those decisions need to be based on the best information available. ***All the practices and designs*** discussed in this report have been tested and demonstrated to some extent and have potential for immediate applications. In particular, there is broad support for the following.

Leave the door open. For minimal extra cost, drainage systems can be designed in a way to allow users to add water table control mechanisms later.

Use existing research on sub-surface drainage design. A lot has been done to measure the impact of tile sizing, spacing, and depth on yield, cost, and environmental impacts. Use this information to optimize system designs.

Buffers and side inlets are broadly accepted for reducing sediment in ditches. Their use could be increased, with the caveat that appropriate designs and targeting are important. Some participants thought some drainage authorities were not fully utilizing their authority to implement buffers and side inlets.

D.5. The Red River Basin

Agricultural drainage in the Red River Basin differs from other parts of the state in several ways:

- Artificial drainage is dominated by ditches rather than tile. Intensive tiling is beginning in some areas and interest is likely to grow.
- Ditches tend to be shallower and have fewer or narrower buffers than in other regions.
- Both watershed districts and counties administer Chapter 103E drainage systems.
- Flooding is a primary concern.
- The climate is drier on average.

For these reasons, drainage work in the Basin will differ from the rest of the state:

- Focus on flood mitigation. Dispersed, upstream water storage in the form of culvert sizing and tiling may be as important as large downstream impoundments and dikes.
- There may be more need to assess and promote buffers, compared to other parts of the state.
- Many areas are a “blank slate” for tiling, providing the opportunity to plan for controlled subsurface drainage and other conservation drainage approaches.
- Drainage tile systems may function differently for flood control in the flat landscape of the Basin than in other parts of the state. Research and guidelines may need to reflect these differences.
- Much lower drainage coefficients (e.g. 1/8 inch to 3/8 inch drainage in a 24-hour period) are reasonable, compared to wetter parts of the state.

D.6. Statewide research needs

The following list is based on participant questions and concerns.

Understand impacts

- Examine cumulative and integrated impacts of practices and designs across a watershed. This will require documenting what practices are actually in use.
- Clarify impacts of impoundments and their management on nitrogen, sediment, and flooding.
- Continue to document how hydrograph characteristics (yield, peaks, etc.) are impacted by the type of drainage systems (e.g., surface, subsurface, varied spacing and depth). Differentiate impacts at the scale of a field, small watershed, and large watershed.
- For the Minnesota River basin, continue research on ravine/streambed/streambank erosion, its relationship to drainage, and variation between watersheds. Continually explain the current state of knowledge and confidence level of research conclusions.
- Develop tools to support watershed-scale drainage design and management, and for estimating downstream effects.

Refine practices and provide guidance

- Show practices at a practical (field) scale. Include economic analysis. Compare costs and benefits. Show infield application of practices, structures and designs to both landowners and to non-farmers.

Controlled subsurface drainage

- Provide long-term demonstrations of controlled drainage to quantify yield benefit, cost, flow rate, and N benefit versus cost over varied weather conditions. Long-term demonstrations of woodchip bioreactors are needed to quantify N benefit versus cost, and life-span/maintenance requirements.
- Develop guidelines for winter storage of water in drainage tile to mitigate flooding and prevent frost damage.
- Develop designs and technologies that require fewer and more convenient drainage control structures.
- Develop guidelines for retrofitting controlled drainage and other practices to existing systems.
- Develop guidelines for alternative means for managing the water table, e.g. with lift stations.

Water storage

- Study the potential for using tiled land as a form of water storage for flood mitigation. Explain regional differences between the Red River basin and the rest of Minnesota. Provide comparisons of the volume and timing of potential water storage in the soil profile versus surface impoundments.
- Identify economically viable crops that can grow in short-to-medium-term water impoundment areas.

Two-stage ditches

- Study and compare the fate of sediment in a self-cleaning, two-stage ditch to a conventional ditch with improved side slopes.
- Provide guidance on how and where to target two-stage ditches and how to transition between conventional and two-stage ditch designs.

Other practices

- Regarding field drainage systems, explain the interaction of depth, spacing, size, and drainage coefficient and how to choose the most appropriate combination.
- Regarding side inlets, provide guidance on size of pipes.
- Regarding wetlands, provide guidance on what is needed for habitat. For example, what should be the depth and timing of ephemeral spring flooding of a field for waterfowl migration? Under what conditions are habitat goals compatible with water storage/flood mitigation goals?

E. Guidelines for Action

The "Findings and Conclusions" can be summarized into the following guidelines for those involved in agricultural drainage.

- ***Support long-term relationships*** and the individuals who are skilled at building and maintaining productive relationships. "Win-win" options are available, but they can only be implemented with the help of people who can build the necessary trust and collaborations.
- ***Be part of the conversation.*** Hydrology and drainage are complicated. Building widespread understanding is an ongoing process involving both outreach to stakeholders and engagement of diverse groups in dialogue. Leaders and organizers at all levels should promote conversations about drainage in a wide variety of forums. Specifically, workshops and other in-person contact are especially important, but popular news outlets and on-line resources also play a role. Communication is needed both within and between stakeholder groups, including the non-farming public. At the local level, build a better understanding of hydrology and a shared understanding of goals. Carefully structure meetings of diverse stakeholders to support open communication. Be precise in defining terms and be explicit about assumptions when discussing impacts of drainage.
- ***Clarify, delineate, and communicate the roles and responsibilities*** of the various state and local agencies. Landowners and other clients sometimes perceive inequities, inconsistencies, or inefficiencies.
- ***Discuss and clarify who is responsible for costs of managing or mitigating upstream contributions*** to drainage systems. People have different perspectives of when the landowner is responsible and when society (the taxpayer) is responsible.
- ***Examine options for water storage*** on the landscape. This is one key for achieving effective agricultural drainage while minimizing impacts on streams and lakes. Water storage ranges from large-scale impoundments to temporary ponding behind small inlets and even storage in the soil. Cropping practices that increase evapotranspiration are a related water management tool. Each situation offers different opportunities.
- ***Promote watershed-scale views of drainage.*** Approach planning and management from the watershed scale. This may mean reviewing culvert sizing or water storage options across the whole watershed. Or it may mean establishing a county or district-wide schedule for redetermination of benefits so landowners feel that ditches are being managed fairly and with appropriate priorities.
- ***Continue research and demonstrations,*** especially full-scale demonstrations and analyses of costs and benefits. Landowners need to see how a design works before they can adopt it. Use demonstrations to communicate with both farm and non-farm audiences.
- ***Address regional differences.*** The Red River Basin is particularly distinctive, but other regions also have unique physical and institutional features that impact water management.

Appendix A: Resources

Blann, Kristen L., Anderson, James L., Sands, Gary R. and Vondracek, Bruce. 2009. "Effects of Agricultural Drainage on Aquatic Ecosystems: A Review". *Critical Reviews in Environmental Science and Technology,* 39(11) :909-1001.

Christopher Moore. 2003. *The Mediation Process, 3rd Ed.* Jossey-Bass Publishers, San Francisco.

Minnesota Statutes. 2009. "Chapter 103E. Drainage." Online
https://www.revisor.mn.gov/statutes/?id=103E

Additional drainage law is in Chapter 103D: Watershed Districts.

Minnesota Public Drainage Manual. 1991. Coordinated by the DNR.
http://files.dnr.state.mn.us/publications/waters/Minnesota_Public_Drainage_Manual.pdf
The Manual is a procedural reference guide to interpreting Minnesota drainage code. It is written for county commissioners, viewers, engineers, county attorneys and auditors, watershed district managers, and others involved in public drainage. Includes a history of drainage activity and law.

MN BWSR. 2006. *Public Drainage Ditch Buffer Study*.
http://www.bwsr.state.mn.us/publications/bufferstudyweb.pdf

UM Extension. Online. "The Drainage Outlet." www.drainageoutlet.umn.edu.
Especially browse through the "Educational offerings".

UM Extension. Online. *Agricultural Drainage Publication Series*
"Soil Water Concepts" (www.extension.umn.edu/distribution/cropsystems/DC7644.html)
"Issues and Answers" (www.extension.umn.edu/distribution/cropsystems/DC7740.html)
"Planning an Agricultural Subsurface Drainage System"
(www.extension.umn.edu/distribution/cropsystems/DC7685.html)
"Drainage Water Management" (http://www.extension.umn.edu/DrainageOutlet/QandA.html)

USDA-Natural Resource Conservation Service (NRCS). *Minnesota Drainage Guide.* The guide is out of print. It may be available in SWCD/NRCS offices. According to "Planning an Agricultural Subsurface Drainage System" (Jerry Wright and Gary Sands, 2001, UM Extension Publication BU-07685) it can be obtained by sending a check for $53.50 to: Red-E-Print (651-224-2307) 101 E. 5th St., Suite 211 Skyway, St. Paul, MN 55101.

Waffle® Concept

From the UND website, "The Waffle concept involves augmenting current flood control measures through the temporary storage of springtime runoff in existing depressions within the Red River Basin until major flood crests pass." For information, browse the UND website (www.undeerc.org/waffle/).

Section 3.3 of the following publication reports the results of a landowner survey that complements the information learned from the drainage focus groups.

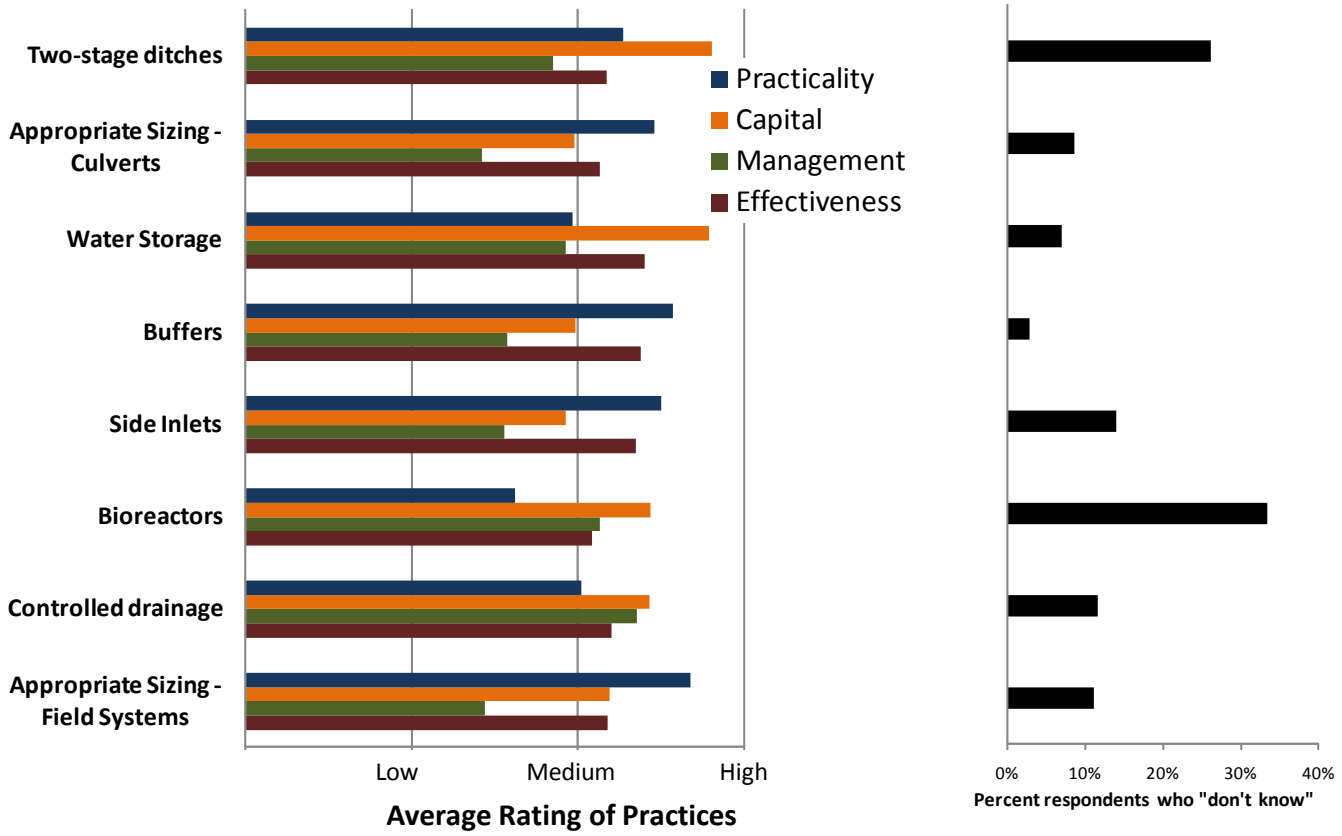
Kurz B.A., Steadman E.N., Harju J.A., Wang X., de Silva L.L., Hanson S.K., Kurz M.D., Peck W.D., Simonsen T.K. 2007. *An Evaluation of Basinwide, Distributed Storage in the Red River Basin—the Waffle Concept*. Final Report for US Department of Agriculture, Natural Resources Conservation Service, Grant Agreement No. 69-6633-2-4. Grand Forks, ND: Energy and Environmental Research Center, University of North Dakota.

Appendix B: Questionnaire Results

Participants completed a questionnaire immediately before the focus group discussion. These were focus groups, not random samples, so the questionnaire results only describe the impressions of the participants.

(1) "Rate conservation drainage practices for use in your region. For each practice, circle "low", "medium", "high" or "don't know" to rate each element."

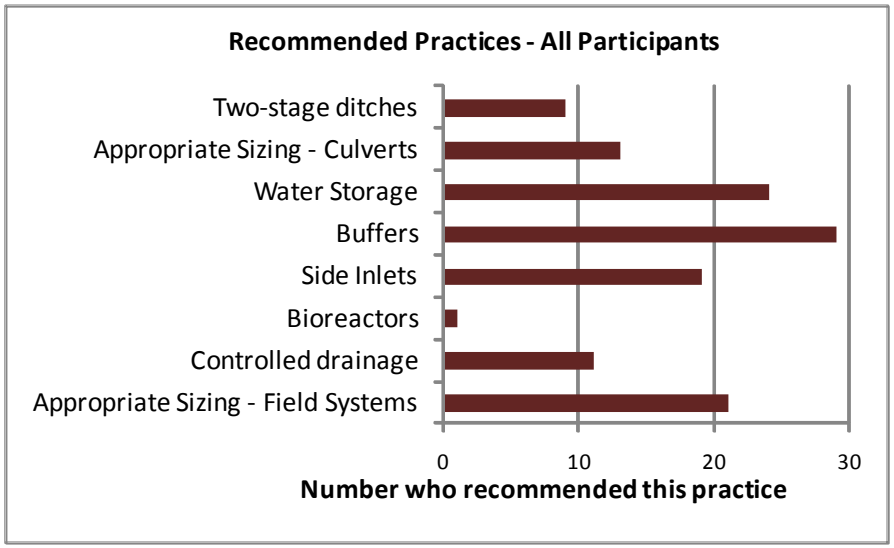
The elements rated were:
Practicality (How practical is it to fit this practice onto the land in your region?)
Initial Cost (How much capital investment is needed to implement this practice?)
Management (How much management is required to maintain this practice over 10 years?)
Effectiveness (How effective will this practice be for improving lakes and streams?)

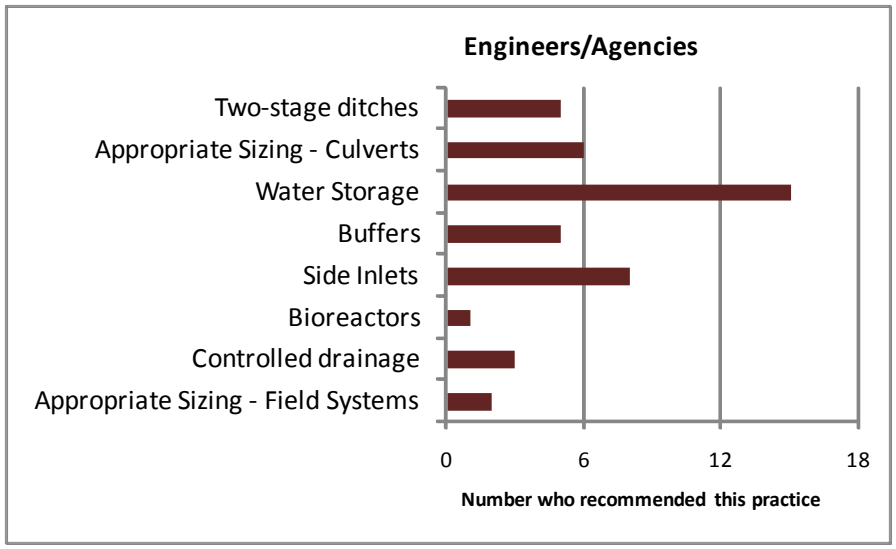


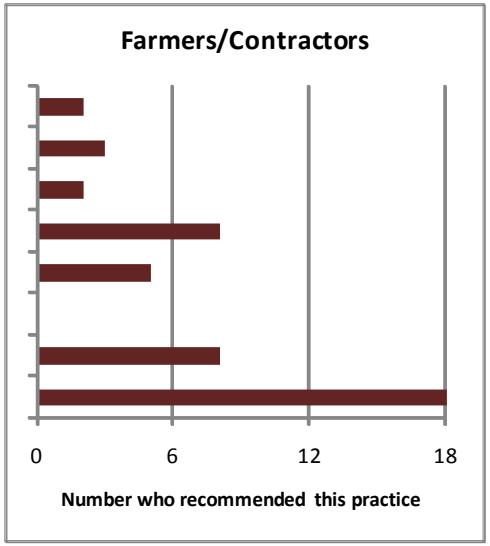
Responses did not vary much between regions, except that participants from the Red River Basin, compared to other regions, gave controlled subsurface drainage a higher rating for practicality and lower rating for initial costs and management requirements.

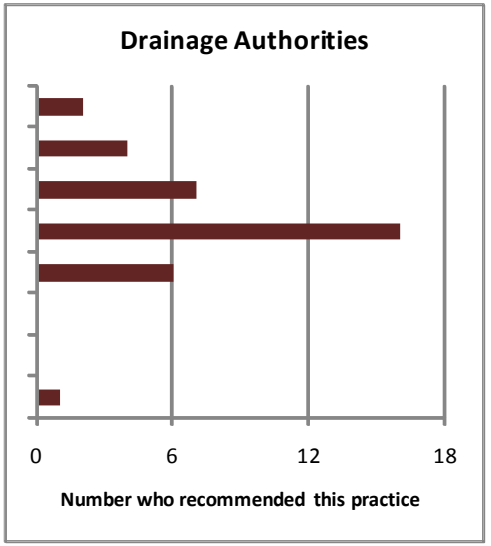
(2) "Which two practices would you most recommend?"

These results should be taken "with a grain of salt" because participants varied in how they interpreted what each of the practices meant and what they were recommending the practice for. This question was used as a springboard for discussion during the focus group.

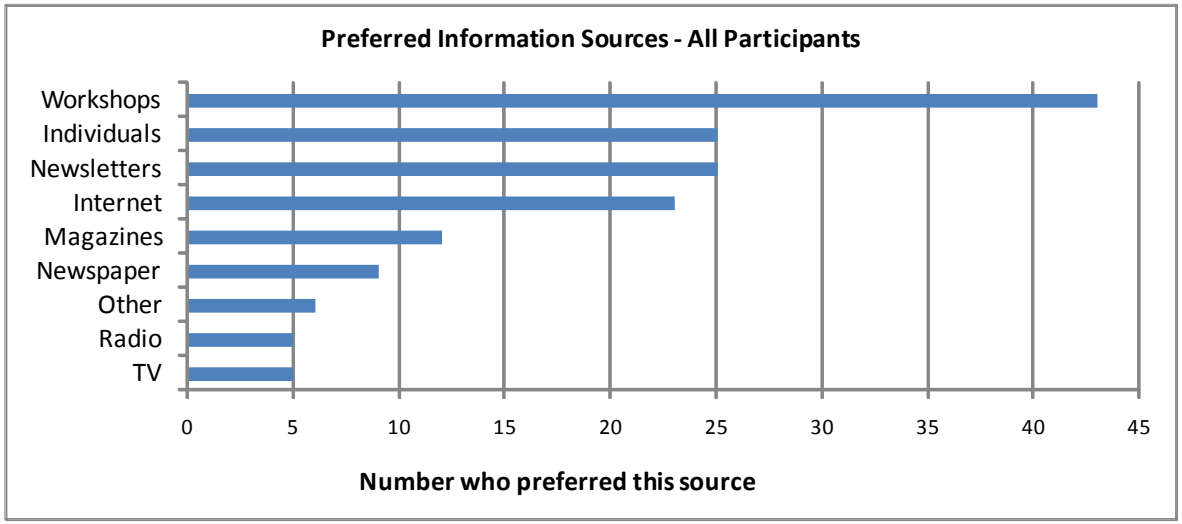


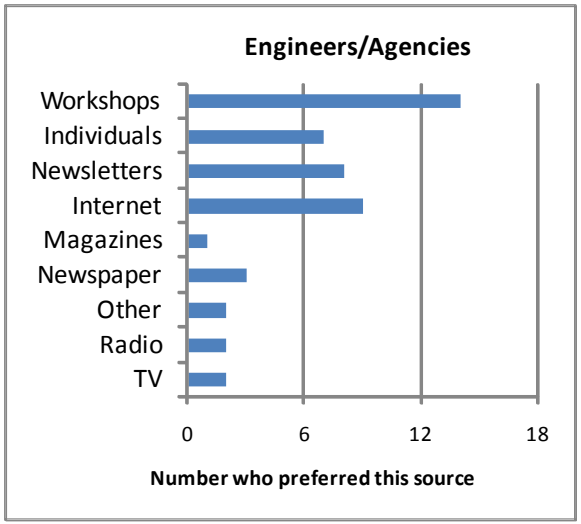


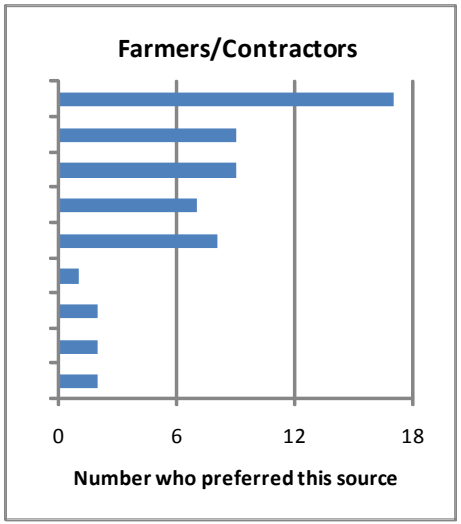


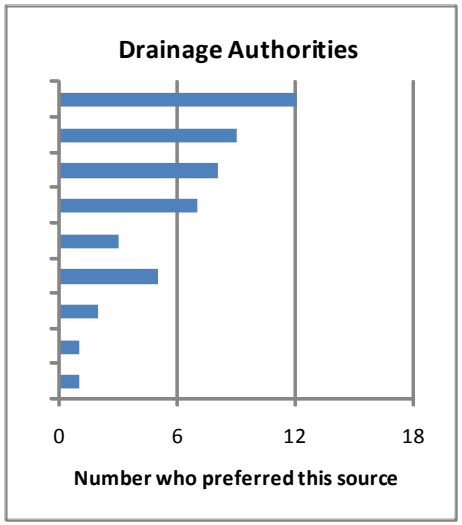


(3) "From which source(s) would you most like to get information regarding conservation drainage? (check up to three)"









Participants specified the following examples for each category.

Individuals: Many people were listed ranging from local consultants and contractors, to local agency staff, to University and MDA specialists.
Newsletters: Commodity groups, LICA, MDA and other agencies, University, SWCD/WD
Internet: The most common response was the University and Extension sites. Also mentioned were MDA and other agencies.
Magazines: Popular farm magazines such as *Corn and Soy Digest*, *Successful Farming*, and *Farm Journal*. One person mentioned *Land & Water.*
Newspapers: *AgriNews*, *The Land*, and local/regional papers were the most mentioned.