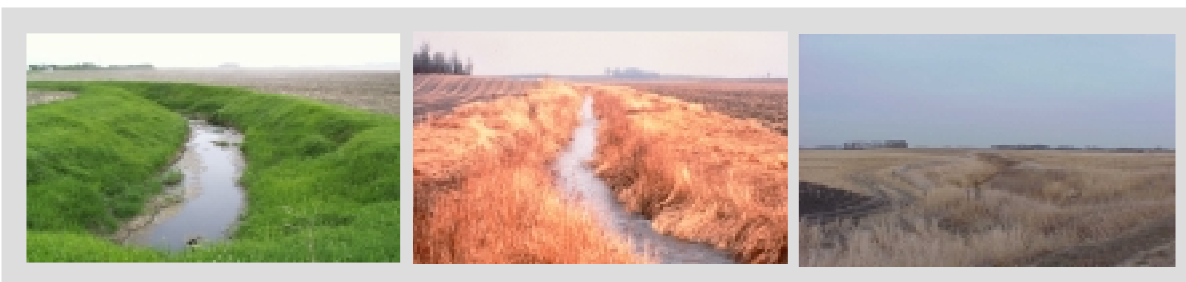
Public Drainage Ditch Buffer Study



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Executive Summary

Study Purpose, Methods, and Background Information

The 2005 Minnesota Legislature directed the Board of Water and Soil Resources (BWSR) to conduct an assessment of the use, maintenance, and benefits of required grass strips along public drainage ditches, in consultation with farm groups, local government units, conservation groups, and federal agencies implementing voluntary buffer programs. A work group of stakeholders was established for this study and met five times between September 9, 2005, and February 8, 2006. The work group decided not only to provide perspective and recommendations for this study, but also to explore other drainage issues, potential areas of consensus, and associated recommendations.

The requirement for grass strips along certain public drainage ditches is contained in Minnesota Statutes, Section 103E.021 – "Ditches must be planted with permanent grass." Drainage authorities were first given an ability to require minimum 1-rod grass strips along public drainage ditches in 1959. The principal purpose apparently was to help reduce ditch maintenance requirements related to tillage to the edge of public ditches. In 1977, the Legislature changed this permissive authority to a requirement triggered by the appointment of viewers by the drainage authority to determine benefits and damages for a ditch system. Drainage proceedings that necessitate the appointment of viewers include establishment, improvement, certain major repairs, and redetermination of benefits.

Soil types, topography, and precipitation cause agricultural crop production in much of the southern and western portions of Minnesota to benefit from artificial drainage, with more isolated application in other parts of the state. Most drainage ditches have a trapezoidal channel shape and include spoil banks along one or both sides of the ditch, which can cause runoff from adjacent lands to flow along the landward side of the spoil bank until it reaches a side inlet to the ditch. Because land uses in the north-central, eastern, and northeastern parts of Minnesota involve substantial forestland, wetland, hay land, and pasture, drainage ditches in these areas are often bordered by perennial vegetation ("natural" buffer).

A questionnaire was developed and mailed to all potential public drainage authorities in Minnesota in October 2005 to gather information about implementation and maintenance of required grass buffer strips. Questions were also included about types of drainage records, total miles of public drainage ditch in each jurisdiction, and impediments to implementation of Section 103E.021. The Minnesota State University, Mankato, Water Resources Center was contracted to assist with compilation and interpretation of responses. County, Watershed District, and Soil and Water Conservation District associations assisted in promoting drainage authority participation in the questionnaire.

The Minnesota State University, Mankato, Water Resources Center was also contracted to develop Geographic Information System (GIS) analyses and associated illustrations of the status of voluntary buffer implementation along public drainage ditches. Shape file information for the federal Conservation Reserve Program (CRP) Conservation Practice CP-21, Filter Strip and CP-22, Riparian Buffer was acquired from the USDA Farm Services Agency. BWSR also provided MSU's Water Resources Center access to its Reinvest in Minnesota (RIM) Reserve database for this analysis, including associated data for the Conservation Reserve Enhancement Program (CREP) in the Minnesota River Basin (i.e. the federal-state partnership of the CRP and RIM Program). Also available for this analysis was previous GIS data generated by Minnesota State's Water Resources Center for a 13-county area of south-central Minnesota, including a public drainage ditch layer.

The University of Minnesota Water Resources Center was contracted to conduct a literature review regarding benefits of grass buffer strips along drainage ditches. This review considered different types of vegetated buffers along different types of watercourses to enable the definition of benefits of narrow grass buffer strips along drainage ditches.

Conservation agency contacts and web sites in other Midwestern states were consulted by BWSR to gather information about requirements, incentives, and state agency roles related to buffers along public drainage ditches in those states.

Comparison of Data from 1987 and 2006 Studies

A related study regarding the implementation and enforcement of Minnesota Statutes, Section 103E.021 was conducted by the Soil and Water Conservation Board (a predecessor of BWSR) in 1986 and reported to the Legislature in January 1987. Following is a summary of comparable findings from the 1986-87 study and this study.

Table 1. Comparison of Key Results from 1987 and 2006 Studies

Fact or Question	1987 Study	2006 Study
Number of SWCDs (1986/7), or potential drainage authorities (2005/6) contacted	91	133 (87 counties, and 46 watershed districts)
Number of SWCDs (1986/7) or potential drainage authorities (2005/6) that responded	77	82 counties (94%) 45 watershed districts (97%)
Miles of public drainage ditches reported	15,173 miles	17,311 miles
Miles of public drainage ditches required to have minimum 1-rod grass strip(s)	1,155 miles (7.6% of total public ditch miles reported)	2,138 miles (12.3% of total public ditch miles reported)
Miles of public drainage ditch with required grass strip(s) known to be in place	499 miles (43% of total required miles)	1,561 miles (72% of total required miles
Number of enforcement actions	10 counties / watershed districts reported enforcement 1 DNR notification to co.	128 reported enforcement actions since 1986 by a county or watershed district
Plan for regular inspection of grass strips	Not asked in 1986	16 of 18 watershed districts with drainage ditches (89%) 30 of 70 counties reporting (43%)
Plan for systematic redetermination of benefits	Not asked in 1986	10 drainage authorities
Miles of public drainage ditch with voluntary or "natural" buffer on one or both sides, based on GIS analyses, which indicate a total of 21,415 miles of public drainage ditch in Minnesota.	Not attempted in 1986	CRP = 1,569 miles CREP = 122 miles RIM= 96 miles Subtotal = 1,787 miles "Natural" = 9,724 miles Total = 11,511 miles

Key Additional Findings from the Questionnaire to Drainage Authorities

1) The responsibility for administration of public drainage systems in Minnesota is vested in local government units by state drainage law. This primarily involves counties and watershed districts. Because there is not an overall state system or protocol for managing public drainage system records, the various drainage authorities have developed different records management systems according to their perceived needs. Drainage authorities that have implemented modern, electronic inventory and record management systems were able to respond much easier to questions asked of them by the study questionnaire. The Local Water Management Challenge Grant Program administered by BWSR and funded in part by the Legislative Commission on Minnesota Resources continues to help cost-share a number of these records modernization initiatives for drainage systems.
2) The total miles of public drainage ditches in Minnesota could not be defined with accuracy. The questionnaire to drainage authorities indicates 17,311 miles, but two counties with known public drainage ditches did not respond to the questionnaire. The Surface Hydrology GIS data layer for Channelized Streams and Ditches created by the Minnesota DNR indicates 21,415 miles, but is missing data for one county (Swift) with significant reported miles of public drainage ditches and appears to include at least some private ditches.
3) Since the 1987 study, 341 public ditch proceedings were reported to have triggered the appointment of viewers and the Minnesota Statutes, Section 103E.021 grass strips requirement. The predominant types of proceedings involved were ditch improvements (114) and redetermination of benefits (111). The most prevalent impediments to implementation of required grass strips defined by drainage authorities are the cost of redetermination of benefits (48) and concerns of assessed landowners about the cost vs. benefits of the minimum 1-rod grass buffers (41). However, a significant number of drainage authorities also indicated grass buffer strips only being required when viewers are appointed is also an impediment (29). Ten drainage authorities indicated that they have a program for systematic redetermination of benefits. This could reflect the need to update both drainage system benefits and contributing lands that should be assessed for current and/or future drainage system maintenance.
4) The questionnaire indicates that approximately 89 percent of watershed districts and 43 percent of counties that responded to Question 8 have a program in place for regular inspection of grass strips in accordance with Minnesota Statutes, Section 103E.021, Subd. 4 and Section 103E.705, Subd. 2.
5) Enforcement actions by drainage authorities for maintenance of grass buffer strip requirements has increased significantly from the 1987 study to this study. However, the “in-place” grass buffer miles on one or both sides of public ditches reported in 2005-2006 is 72 percent of the miles reported to be required by Minnesota Statutes, Section 103E.021.
6) Interpretation of the starting point for measurement of the required minimum 1-rod grass strips appears to be significantly variable (see the results for Question 12 of the questionnaire, and associated discussion, in Section 2 of this report).
7) Comments provided by drainage authorities on the questionnaire seem to indicate some fear and frustration about the potential outcomes of this study and the time and effort required to fill out the questionnaire.

Key Findings Regarding Voluntary Buffers Along Public Drainage Ditches

1) Although the sources and accuracy of data available for GIS analyses are limited, the analyses conducted by this study indicate that major federal and state conservation programs have enabled filter strip and riparian buffer practices to be established along approximately 1,787 miles of public drainage ditches in Minnesota (8.3 percent of the computed total 21,415 miles of public drainage ditches, including 7.3 percent CRP, 0.6 percent CREP, and 0.4 percent RIM).
2) Concentrations of conservation program application were noted in three areas of the state. These concentrations are attributed to the Minnesota River Basin CREP, opportunities associated with topography in these areas, concentrated efforts of local government unit officials and staff, and interested landowners.
3) A GIS assessment of "natural" buffers along public drainage ditches (land uses with perennial vegetation) indicates that approximately 45 percent of the total 21,415 miles of public drainage ditches in Minnesota may be buffered by perennial vegetation other than grass strips required by Minnesota Statutes, Section 103E.021 and conservation program lands.
4) Approximately 60 percent of the estimated total 21,415 miles of the public drainage ditches in Minnesota may currently be buffered by either "natural buffers" (45 percent), voluntary conservation programs (8.3 percent), or Section 103E.021 grass buffer strips (7.3 percent).

Key Findings Regarding Benefits of Narrow Grass Buffers Along Drainage Ditches

1) Although very limited research has been done regarding grass buffers along drainage ditches, a number of potential benefits are supported by, or can be inferred from, the available literature, including:
   - helping to stabilize ditch banks and prevent tillage to the edge of the channel;
   - trapping water-born sediment, where there is sheet flow across the grass buffer strip;
   - trapping wind-blown sediment, depending on grass stand management, timing of potential grass harvest, and width of the grass buffer strip;
   - improving water quality by trapping sediment and microbes and recycling nutrients, primarily where there is sheet flow across the grass buffer strip;
   - providing narrow strips of wildlife habitat, ecotones, and wildlife movement corridors;
   - providing some buffer of the ditch channel related to potential application of pesticides and herbicides on adjacent cropland.
2) Potential water quality benefits typically depend on sheet flow across the grass buffer strip. Where raised spoil banks exist along the ditch, the water-born sediment and nutrient trapping benefits may be negligible, because runoff from the adjacent land flows to and along the spoil bank to a side inlet to the ditch. Side inlet controls, such as conduits through spoil banks, can temporarily detain field runoff in ponding areas along ditches, trapping substantial water-born sediment and helping to reduce peak flows in the drainage system.
3) Control of ditch bank erosion and stability, as well as potential control of wind-blown and water-born sediment, can significantly reduce ditch maintenance. This can also reduce the frequency of disturbance of the ditch channel, banks and grass buffer strips caused by ditch maintenance, and the associated costs to the drainage system.

Key Findings from Other Midwestern States

1) Minnesota, Wisconsin, and Ohio have state requirements for permanent grass strips, ditch corridors, or seeded berms, respectively, along certain public drainage ditches. Iowa, Illinois, Indiana, and Michigan do not have state or local government requirements for vegetated buffers along public drainage ditches at this time.
2) The Conservation Reserve Program (CRP) is a major incentive program for installation of filter strips and riparian buffers, including along public drainage ditches, in all Midwestern states. Some states, including Minnesota, also have state programs that can provide incentives for installation of vegetated buffers along drainage ditches. Conservation Reserve Enhancement Programs (CREPs) that include filter strip and riparian buffer practices are available in several Midwestern states, including Minnesota.
3) Some Midwestern state and local government units (not including Minnesota) provide technical assistance for public drainage system design and maintenance.
4) State agencies in Michigan and Ohio are involved in inter-county public drainage systems.
5) All of these Midwestern states have some level of state agency involvement in drainage policy administration, as well as drainage information and education.
6) The Wisconsin Buffer Initiative recently published a report regarding watershed prioritization and the use of conservation practices, including buffers, to improve river, stream, and lake water quality in Wisconsin. This 3.5-year study was initiated in response to an impasse regarding scientific justification for a proposed rule mandating riparian buffers and conservation tillage along watercourses in Wisconsin. A link to the report is provided in Section 5.

Work Group Topics of Discussion and Recommendations

1) The study work group discussed a number of drainage issues to find areas of agreement and potential recommendations. Several of these topics involved potential solutions to impediments identified by drainage authorities to implementation of required grass buffer strips, including:
   - Clarifying the definition of the point of beginning for measuring the required grass buffer strips.
   - Enhancing the ability of drainage authorities to establish and maintain buffer strips.
2) The work group also recommended:
   - Developing recommended method(s) for drainage record modernization.
   - Developing a Best Management Practice (BMP) Manual for public drainage systems.
   - Further consider the pros, cons and advisability of requiring regular reporting by drainage authorities.
   - The work group should continue to discuss these drainage topics during 2006 and seek consensus recommendations to the Legislature, with continued facilitation by BWSR.

Section 1: Study Purpose and Background

Purpose

The 2005 regular session of the Minnesota Legislature included discussion about a potential need for clarification of Minnesota Statutes, Section 103E.021 – "Ditches must be planted with permanent grass." This discussion resulted in the following appropriation and directive to the Board of Water and Soil Resources to conduct an assessment of public drainage system buffers.

"$109,000 the first year is for an implementation assessment of public drainage system buffers and their use, maintenance, and benefits. The assessment must be done in consultation with farm groups, watershed districts, soil and water conservation districts, counties, and conservation organizations, as well as federal agencies implementing voluntary buffer programs. The board shall report the results to the Senate and House of Representatives committees with jurisdiction over drainage systems by January 15, 2006. This is a onetime appropriation."

Consultation

A work group was established for this study, including representation from the following organizations, associations, agencies, and the Legislature:

- Association of Minnesota Counties (AMC)
- Minnesota Association of Soil and Water Conservation Districts (MASWCD)
- Minnesota Association of Watershed Districts (MAWD)
- Minnesota Board of Water and Soil Resources (BWSR)
- Minnesota Center for Environmental Advocacy (MCEA)
- Minnesota Department of Agriculture (MDA)
- Minnesota Department of Natural Resources (DNR)
- Minnesota Environmental Partnership (MEP)
- Minnesota Fish and Wildlife Legislative Alliance (FWLA)
- Minnesota Farm Bureau
- Minnesota Farmers Union
- Minnesota Lakes Association / Minnesota Conservation Federation (MLA / MCF)
- Minnesota Pollution Control Agency (MPCA)
- Minnesota Viewers Association (MVA)
- Red River Watershed Management Board (RRWMB)
- Representative Rick Hansen, District 39A

The work group met on September 9 and November 16, 2005, as well as January 4, January 18, and February 8, 2006. The Minnesota Farm Bureau provided a meeting facility, which is gratefully acknowledged. The functions of the work group included:

1) Coordination, discussion, and advice from multiple perspectives for the topic of public drainage ditch buffers, as well as other drainage topics.
2) Assistance developing the scope of the study, which included the following components:
   a) background information to help readers of the study report have a more common understanding about drainage ditches and grass strip requirements in Minnesota;
   b) a study questionnaire to all drainage authorities in Minnesota to obtain status information about the required grass strip implementation, maintenance, and enforcement, as well as other related drainage system management information;

   c) information about the status of implementation of voluntary buffers along public ditches in Minnesota through key federal and state conservation programs;
   d) a literature review regarding benefits of grass strips along drainage ditches; and
   e) information about requirements, incentives, and state agency roles related to buffers along public drainage ditches in Midwestern states.
3) Assistance communicating with drainage authorities and encouraging participation in the study questionnaire.
4) Review and discussion of interim progress on the study.
5) Review and comment on drafts of the study report.
6) Identification, prioritization, and discussion of drainage topics, including issues associated with grass buffer strips, and providing consensus recommendations.

Key Definitions

Drainage System – Minnesota Statutes, Chapter 103E states that a drainage system is "a system of ditch or tile, or both, to drain property, including laterals, improvements and improvement of outlets, established and constructed by a drainage authority."

Drainage System Buffer – Includes the minimum 1-rod grass strip required along certain public drainage ditches by Section 103E.021, as well as vegetated strips, restored wetlands, and other lands voluntarily set-aside through federal, state, and local programs, that serve as buffers along drainage ditches and within drainage systems.

Drainage Authority – In Minnesota, as in a number of other states, a local unit of government is directed, or created, by state statute to administer public drainage systems in accordance with state drainage law, on behalf of the assessed landowners of public drainage systems. Counties, Watershed Districts (WDs), and metro Water Management Organizations (WMOs) can serve as public drainage authorities in Minnesota.

Grass Strip – Also referred to as a grass buffer strip or grass buffer.

Private Drainage Ditch – A drainage ditch constructed and maintained completely by a landowner on his or her land or by multiple landowners under private agreement(s).

Public Drainage Ditch – A drainage ditch governed by Minnesota Statutes, Chapter 103E, Drainage.

Spoil Banks – Soil excavated to create or maintain ditches and typically placed adjacent to, and along, the ditch on one or both sides.

Viewing – Determination of the benefits and damages to all property affected by a public drainage system project and providing an associated viewers' report to the drainage authority. "Damages," in relation to viewing and grass buffer strip establishment, refers to the payment of fair market value for the permanent right-of-way for the grass strips.

Viewers – Residents of Minnesota qualified to assess drainage benefits and damages, who must be disinterested in the drainage project for which they are appointed by a drainage authority.

Primer on Agricultural Drainage Ditches in Minnesota

Agricultural drainage involves both open ditches and subsurface drain tile. Figure 1 illustrates how much of the agricultural land in the Midwest can benefit from improved drainage. This map was prepared by the National Soil Tilth Laboratory at Iowa State University in Ames, Iowa, and is based on soil drainage class, soil hydrologic group, and slope of the land. Note that much of the southern, west-central, and northwestern areas of Minnesota have agricultural land that can or does benefit from improved drainage for crop planting, growing, and harvest. Studies by the University of Minnesota and other land grant universities in the U.S. have indicated typical pay-back periods for artificial drainage to be on the order of 10–15 years during moderate to wet climatic periods. It should also be noted that drainage systems can have adverse downstream impacts on water quantity and quality in relation to increased peak flows and transport of sediment and nutrients.

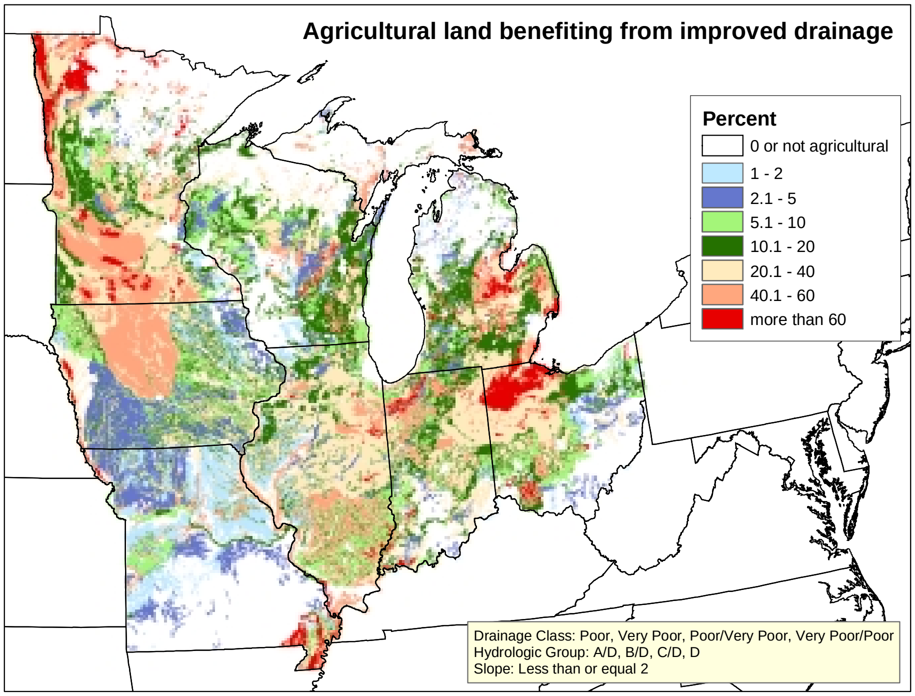


Figure 1 – Midwest Agricultural Land Benefiting from Improved Drainage

Drainage ditches have been used extensively to improve the productivity of agricultural lands in Minnesota. This is indicated by the red lines in Figure 2 (source Minnesota Department of Natural Resources). Varying estimates of the total length of drainage ditches, or channelized streams and ditches, in Minnesota range from about 20,000 miles to 27,000 miles, respectively.

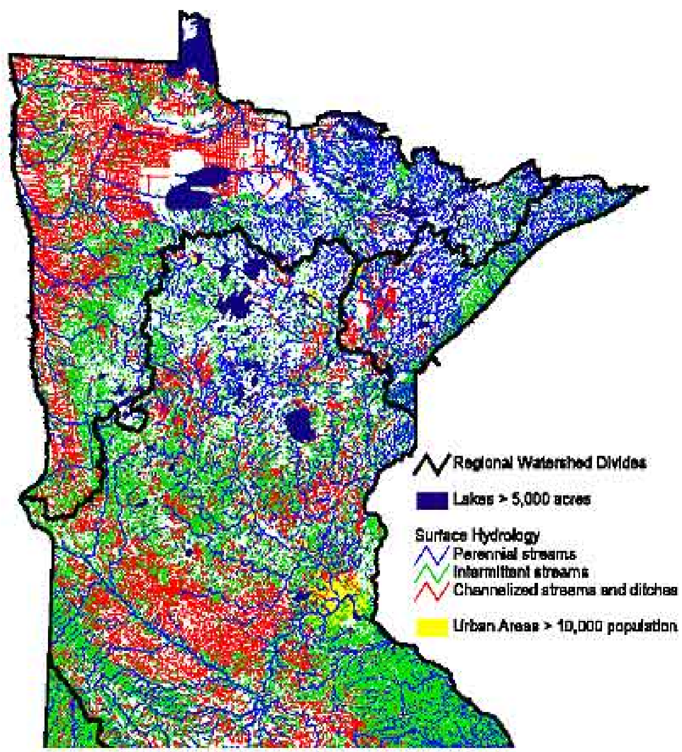


Figure 2 – Streams and Ditches in Minnesota

Drainage ditches are typically constructed with trapezoidal cross sections and the excavated soil placed as spoil banks adjacent to, and along, one or both sides of the ditch. Spoil banks are typically spread onto adjacent fields and leveled sufficiently to enable farming on much of the spoil bank area. Spoil banks are sometimes set back from the ditch channel to avoid placing additional weight on the channel bank (for reasons of bank stability) and/or to provide for better access for ditch maintenance. Continuous spoil banks can also serve as levees, in which case side inlet conduits are often installed through the spoil bank. This design with side inlet conduits can also serve to meter flow into the ditch, helping to control downstream peak runoff, and to create temporary ponding behind the spoil bank that settles out sediment before field runoff water enters the ditch.

The alignments of drainage ditches typically follow the lowest land to an outlet. It is also common for ditches to be located along property boundaries, field boundaries, and/or roads to minimize dividing of fields. Figures 3 and 4 illustrate composite cross sections of typical current drainage ditch designs. From the beginning of agricultural drainage in Minnesota up until the mid 20th century, the design and construction of the side slopes of ditch channels typically ranged from 1 horizontal to 1 vertical (1H:1V) to 2 horizontal to 1 vertical (2H:1V), due to construction equipment and methods. In more recent decades, drainage ditch maintenance, improvement, and establishment has generally utilized flatter channel side slopes (typically ranging from 2H:1V to 4H:1V) for reasons of improved channel bank stability, ease of maintenance, and/or safety (where drainage ditches are located along roads).

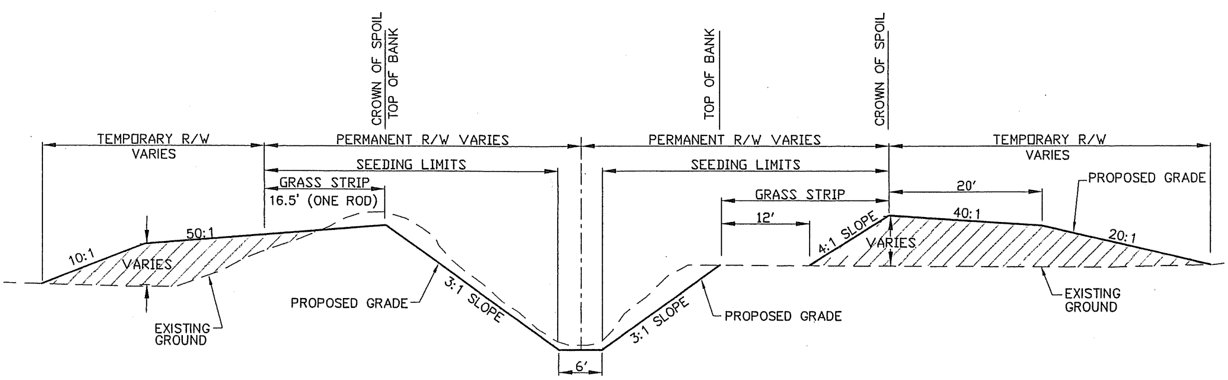


Figure 3 – Typical Current Drainage Ditch Designs with Adjacent and Set-Back Spoil Banks (not to scale)

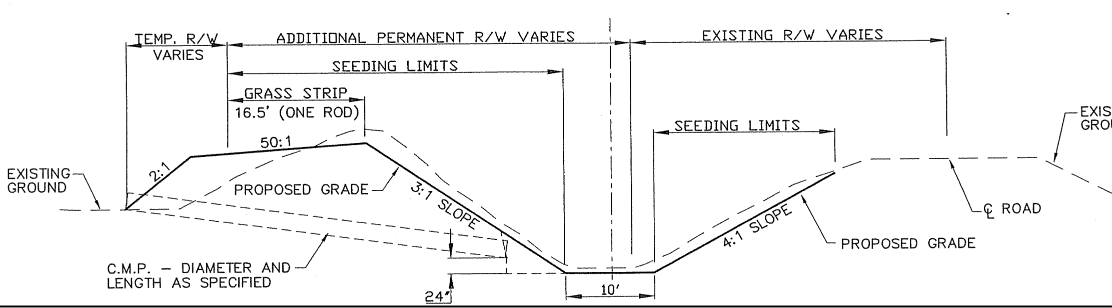


Figure 4 – Typical Current Drainage Ditch Designs for Side Inlet Conduit and Along Roads (not to scale)

Figures 5 and 6 below show public drainage ditches with adjacent grass strips. Figure 7 shows a voluntary grass buffer installed via the Continuous Conservation Reserve Program (CCRP) administered by the federal Farm Services Agency (FSA). Figure 8 shows a voluntary buffer along a drainage ditch implemented via the Reinvest in Minnesota Reserve (RIM) Program administered by BWSR. These examples are for prime agricultural lands in Minnesota, which involves the southern, western, and northwestern portions of the state.

Figure 5 – Typical Drainage Ditch for Southern and Western Minnesota with Narrow Grass Buffer Strips - Spring

Figure 6 – Typical Drainage Ditch for Southern and Western Minnesota with Narrow Grass Buffer Strips - Fall

Figure 7 – Voluntary Riparian Grass Buffer Along Drainage Ditch (CP-21 Filter Strip, 66 ft. each side, via CCRP)

Figure 8 – Voluntary Riparian Buffer Along Drainage Ditch (via RIM Reserve Program)

Figures 9 and 10 show examples of ditches in northern parts of Minnesota, where forestland, wetlands, pasture, and hay land are predominant land types and uses. It's important to note that for these land types and uses, perennial vegetation typically exists along public and private drainage ditches. Some of the public drainage ditches constructed in the early 20th century in northern Minnesota were unsuccessful at draining the land for agricultural production. An example of this situation are drainage ditches indicated by red lines in Figure 2 north of Lower and Upper Red Lake in north central Minnesota.

Figure 9 – Example of Drainage Ditch in Northern Minnesota

Figure 10 – Example of Drainage Ditch in Northern Minnesota

Pertinent Statutes

Minnesota Statutes, Chapter 103E – "Drainage" includes the primary drainage laws of our state. This chapter applies to all public drainage authorities, including counties, watershed districts, and metro water management organizations. Chapter 103D – "Watershed Districts" refers to Chapter 103E for drainage systems and associated projects administered by watershed districts. A county may transfer drainage authority to a watershed district or metro water management organization on a system-by-system basis. Section 103E.021 of Chapter 103E requires planting, maintenance, and enforcement of a minimum 1-rod grass strip along certain public drainage ditches. Following are the five subdivisions of Section 103E.021.

Section 103E.021 Ditches must be planted with permanent grass.

Subd. 1. Spoil banks must be spread and grass planted. In any proceeding to establish, construct, improve, or do any work affecting a public drainage system under any law that appoints viewers to assess benefits and damages, the authority having jurisdiction over the proceeding shall order spoil banks to be spread consistent with the plan and function of the drainage system. The authority shall order that permanent grass, other than a noxious weed, be planted on the banks and on a strip 16-1/2 feet in width or to the crown of the leveled spoil bank, whichever is the greater, on each side of the top edge of the channel of the ditch. The acreage and additional property required for the planting must be acquired by the authority having jurisdiction.

Subd. 2. Reseeding and harvesting grass. The authority having jurisdiction over the repair and maintenance of the drainage system shall supervise all necessary reseeding. The permanent grass must be maintained in the same manner as other drainage system repairs. Harvest of the grass from the grass strip in a manner not harmful to the grass or the drainage system is the privilege of the fee owner or assigns. The county drainage inspector shall establish rules for the fee owner and assigns to harvest the grass.

Subd. 3. Agricultural practices prohibited. Agricultural practices, other than those required for the maintenance of a permanent growth of grass, are not permitted on any portion of the property acquired for planting.

Subd. 4. Compliance work by drainage authority. If a property owner does not bring an area into compliance with this section as provided in the compliance notice, the inspection committee or drainage inspector must notify the drainage authority. If a property owner does not bring an area into compliance after being notified under section 103E.705, subdivision 2, the drainage authority must issue an order to have the work performed to bring the property into compliance. After the work is completed, the drainage authority must send a statement of the expenses incurred to bring the property into compliance to the auditor of the county where the property is located and to the property owner.

Subd. 5. Collection of compliance expenses. (a) The amount of the expenses to bring an area into compliance with this section is a lien in favor of the drainage authority against the property where the expenses were incurred. The auditor must certify the expenses and enter the amount in the same manner as other drainage liens on the tax list for the following year. The amount must be collected in the same manner as real estate taxes for the property. The provisions of law relating to the collection of real estate taxes shall be used to enforce payment of amounts due under this section. The auditor must include a notice of collection of compliance expenses with the tax statement.

(b) The amounts collected under this subdivision must be deposited in the drainage system account.

HIST: 1990 c 391 art 5 s 4

Section 103E.021 is referred to in the following other sections of Chapter 103E.

- **Section 103E.315 Assessment of drainage benefits and damages**
  - **Subd. 8. Extent of damages**
- **Section 103E.321 Viewers' report**
  - **Subd. 1. Requirements**
- **Section 103E.705 Repair procedure**
  - **Subd. 1. Inspection**
  - **Subd. 2. Grass strip inspection and compliance notice**
  - **Subd. 3. Drainage inspection report**
- **Section 103E.728 Apportionment of repair costs.**
  - **Subd. 2. Additional assessment for agricultural practices on grass strip**

Brief History of Minnesota Statutes, Section 103E.021

1959 – Minnesota Statutes, Section 106.673 Ditches, Planting with Permanent Grass.

- Drainage authorities *may* require that a grass strip be installed along drainage ditches from the top edge of the ditch channel, 1-rod wide, or to the crown of the leveled spoil bank, whichever is greater.
- This authority was provided *when* viewers are appointed for a drainage system proceeding. (Appointment of viewers is required when a drainage system acquires land rights.)
- The associated Legislative records from 1959 are not definitive about the intended purpose for the grass strip. However, it appears that the primary original purposes were to prevent farming up to the edge of public drainage ditches, improve channel bank stability, reduce associated sediment in ditches and, thereby, to reduce ditch maintenance. It is expected the minimum 1-rod (16½ ft.) dimension was based on a "rod" being a common unit of measure in many legal descriptions for rural land.

Figure 11 – Ditch with Farming to the Top of Channel Bank

1977 – Minnesota Statutes, Section 106.673 Ditches must be planted with permanent grass.

- The "*may*" in Section 106.673 was changed to "*shall*."
- The resulting grass strip *requirement* retained the trigger of *when* viewers are appointed to assess benefits and damages for a ditch proceeding.

1985 – Recodification: Section 106.673 became Section 106A.021

1989 – Recodification: Section 106A.021 became Section 103E.021

1991 – The Minnesota Public Drainage Manual was prepared by the DNR, in consultation with drainage authorities, viewers, attorneys, engineers, involved associations, and other state agencies.

The primary purpose of the "Minnesota Public Drainage Manual" was to provide an in-depth procedural reference source, with statewide acceptance and application, to help improve the quality and consistency of application of Minnesota drainage law. Figures 12 and 13 show illustrations from the drainage manual about the

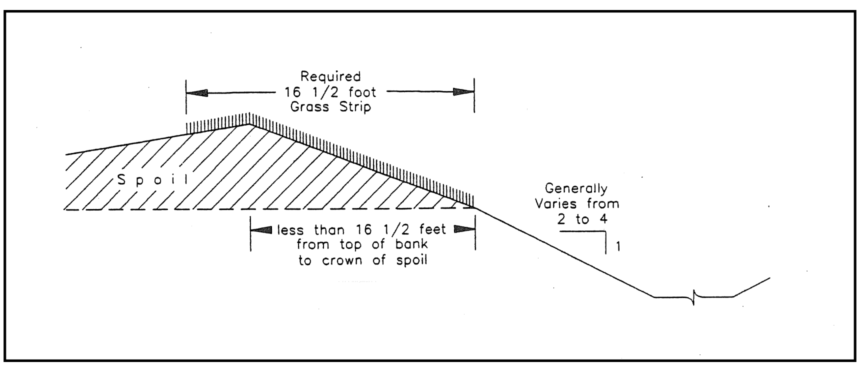


Figure 12 – Typical Ditch Section with Less than 16½ ft. from Top of Channel Bank to Crown of Spoil Bank

minimum 1-rod grass strips required by Minnesota Statutes, Section 103E.021 (from Figure 3-3 of the drainage manual). The manual indicates that only a normal grassed channel side slope meeting the applicable minimum slope for safety is required where a public drainage ditch is located immediately adjacent to a road.

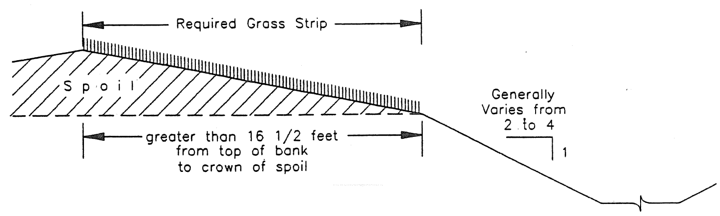


Figure 13 – Typical Ditch Section with More than 16½ ft. from Top of Channel Bank to Crown of Spoil Bank

Drainage Proceedings That Require the Appointment of Viewers

Note that the grass strip requirements of Minnesota Statutes, Section 103E.021 are triggered by the appointment of viewers by drainage authorities. Following are the types of drainage proceedings that require the appointment of viewers, in accordance with Chapter 103E.

- Ditch establishment.
- Ditch improvement, including channels and outlets.
- Redetermination of benefits for a public drainage system.
- Repairs that require the taking of any property not contemplated and included in the original proceeding for the establishment of the public drainage system.

Funding of Public Drainage Ditches and Required Grass Buffer Strips

Public drainage systems are funded by the benefited landowners and administered by public drainage authorities, in accordance with state drainage law. The costs of establishing, improving, or repairing public drainage ditches, including the grass buffer strips required by 103E.021, are assessed in proportion to the value of drainage system benefits determined for each parcel within the benefited area of the drainage ditch. Viewers appointed by the drainage authority determine the value of drainage system benefits for each benefited parcel.

The requirement to install permanent grass buffer strips is most often triggered by improvements of drainage ditches and/or redetermination of benefits. Typical costs associated with the installation of grass buffer strips include:

- viewing, including redetermination of benefits and damages;
- engineering design services, if a ditch improvement or major repair is involved;
- legal and administrative services for ditch proceedings;
- permanent right-of-way for the grass buffer strips;
- temporary right-of-way for spreading of spoil (e.g. temporary loss of crop production), if ditch excavation is involved;
- establishment and maintenance of grass on the buffer strips and channel banks, as necessary;
- installation of side inlet controls, if utilized.

Previous Study of Grass Strips Along Public Drainage Ditches

Laws of Minnesota, 1986, Chapter 389, Art. 27 Drainage Report – "The Soil and Water Conservation Board shall determine the length and area of drainage ditches that are required to be planted with permanent grass under Section 106A.021 and prior law, and the enforcement actions taken by the Commissioner of Natural Resources or Enforcement personnel to maintain the grass strips."

The Soil and Water Conservation Board used a survey questionnaire and ditch project inventory form directed to the state's 91 Soil and Water Conservation Districts (SWCDs), which coordinated with county and watershed district drainage authorities to gather the required information. No information was received from 14 SWCDs. Six of the non-reporting SWCDs have few, if any, public drainage ditches. The results of the study were presented in a report to the Minnesota Legislature titled "Minnesota Public Drainage Ditch Systems," dated January 1987. Following are key findings and recommendations of the 1986-87 report:

- 77 of 91 SWCDs responded to the survey questionnaire;
- 15,311 miles of public drainage ditches were reported, of which 14,019 miles were established prior to the requirement for grass strips in 1977;
- 7.6 percent (1,155 miles) of the total reported public drainage ditches were required to have grass buffer strips at that time, representing 4,619 acres of permanent grass;
- 57percent (656 miles) of the reported total miles of ditches required to have grass buffer strips were not known to be maintained, or the condition of the grass strips was unknown;
- drainage authorities had enforced Section 103E.021 in 10 counties;
- the DNR had enforced Section 103E.021 in one county and did not maintain an inventory of public drainage systems or projects administered by drainage authorities;
- it was recommended that a detailed inventory of public drainage ditch systems is needed to assist enforcement of the required grass strips; and
- it was also recommended that guidance should be developed by the state, in consultation with drainage authorities, for conducting an inventory, periodic inventory updates and inspections of drainage systems.

Existing Guidance Documents for Public Drainage System Administration

- As previously mentioned, the "Minnesota Public Drainage Manual" was published in 1991 (ftp://ftp.dnr.state.mn.us/pub/dow/MNDrainageManual/). This guidance document is an in-depth procedural reference source, with statewide application, to help improve the quality and consistency of administration of Minnesota drainage law. This guidance document was developed by the DNR, in consultation with drainage authorities, viewers, attorneys, engineers, involved associations, and other state agencies. This type of document was recommended by the 1986-87 Minnesota Public Drainage Ditch Systems study. The drainage manual remains a primary reference document for public drainage system administration in Minnesota.

- In 1997, the Association of Minnesota Counties (AMC), first published a guidance document titled: "Understanding Minnesota Public Drainage Law: An Overview for Decision-makers." This document was prepared to assist a broad spectrum of individuals at the local, state, and federal levels who are involved in public drainage proceedings. It was used as a reference for a statewide public drainage forum in November 1998, sponsored by the Board of Water and Soil Resources.

- In 2002, the AMC updated “Understanding Minnesota Public Drainage Law: An Overview for Decision-makers” to reflect a new authority (Minnesota Statutes, Section 103E.812) that allows the transfer of all, or part, of a public drainage system to a water management authority defined as a county, city, watershed district, water management organization, stormwater management district, lake improvement district or other special purpose district.

- “Water Project and Drainage Law in Minnesota,” Gerald Von Korff, 2005.

Public Drainage System Inventories

During the past 10 years, a number of counties and several watershed districts have either conducted or are planning to conduct a public drainage system inventory within their jurisdiction. These are significant efforts to modernize drainage records, typically involving electronic databases and Geographic Information Systems (GIS). The primary records modernization objectives have included:

- to bring together all pertinent data that exists in various government offices relating to public drainage systems within the jurisdiction;
- to create a modern system to more efficiently and effectively store, access, and manage public drainage system information; and
- to improve the ability to correlate location, assessment, and status information with other pertinent databases within the jurisdiction, such as assessed parcel boundaries, watershed boundaries and land uses.

Other benefits of modern drainage system inventories that utilize databases and GIS include:

- enhanced drainage system management, including tracking of drainage proceedings, inspections, and maintenance;
- easier notification of landowners affected by drainage system proceedings;
- easier to identify opportunities to better integrate conservation programs (and associated drainage management options) with drainage system management.

These inventories have been identified as a high priority need in Comprehensive Local Water Management Plans. State Local Water Management Challenge Grants, administered by BWSR, have been a substantial provider of funding to help pay for these public drainage system inventories. The Legislative Commission on Minnesota Resources has been a key source of state funding for the Local Water Management Program in recent years. The average state cost-share for these drainage inventories to date has been approximately $24,000 per county or watershed district, with a range of $5,000 to $55,000. These challenge grants require a minimum 1 to 1 match of cash and/or in-kind services by the participating local government unit.

Counties and Watershed Districts Receiving Local Water Management Challenge Grant Funding for Public Drainage Inventories			
County	**FY Funded**	**Watershed District**	**FY Funded**
Brown	2006	Buffalo Creek	1997
Chippewa	2004	Buffalo-Red River	2006
Cottonwood	2006	North Fork Crow River	2000 & 2002
Douglas	1997	Red Lake	2006
Faribault	2004	Wild Rice	2006
Goodhue	2006		
Kandiyohi	2004		
Lake of the Woods	1997		
Le Sueur	2004		
Lincoln	2004		
Martin	1997		
Meeker	2004		
Mower	1997		
Nicollet	2006		
Pope	1997		
Renville	2006		
Swift	2004		
Todd	2006		
Yellow Medicine	2004		

The results of the questionnaire to drainage authorities presented in Section 2 of this report indicate that the following additional counties and watershed districts have a GIS-based public drainage system inventory.

Additional Counties and Watershed Districts with Public Drainage Inventories	
County	**Watershed District**
Blue Earth	Bois de Souix
Dodge	Minnehaha Creek
Jackson	Rice Creek
Ramsey	Two River
Scott	

It is expected that the above inventories vary in format and level of detail, because the types and qualities of public drainage records vary and drainage inventory development has been accomplished over a number of years with changing technology.

Section 2: Questionnaire to Drainage Authorities

Purpose and Scope

A fundamental purpose of this study was to assess the implementation of required grass buffer strips along public drainage ditches, including their use and maintenance. This necessarily included the establishment and enforcement of grass strips, in accordance with Minnesota Statutes, Section 103E.021 and associated provisions of Chapter 103E. Local drainage authorities in Minnesota are responsible for these public drainage ditch buffer implementation, maintenance, and enforcement requirements.

Through consultation with the study work group and others, BWSR developed a two-part questionnaire to drainage authorities. Part 1 (see Appendix 1A) included 14 questions to gather and assess the following information:

- type(s) of drainage records;
- total miles of public drainage ditch in each drainage authority jurisdiction;
- types of ditch proceedings that have triggered implementation of grass strips since 1986;
- miles of ditch required to have the required grass buffer strips;
- miles of required grass buffer strips installed;
- miles of required grass buffer strips currently in place;
- status of rules or policies for the harvest of grass buffer strips;
- status of programs for regular inspection of ditches;
- grass buffer strip enforcement actions taken since 1986;
- impediments to implementation of Section 103E.021;
- existence of plans or procedures for systematic redetermination of drainage system benefits;
- drainage authority interpretation of the location of the top of channel bank for implementing the minimum 1-rod grass buffer strip requirement;
- approximate miles of public drainage ditches buffered through voluntary conservation programs (tracking not required by drainage authorities, but expected some to know);
- additional comments about grass buffer strips or Section 103E.021.

Part 2 of the questionnaire was developed to help drainage authorities tally drainage ditch projects requiring grass buffer strips since 1986. In retrospect, Part 2 should have been labeled Part 1, as the totals calculated by completing Part 2 provided some of the appropriate responses to Part 1. About one-third of the respondents completed part 2 of the questionnaire. About one-half of these were incomplete and of limited value; therefore, Part 2 information was not included in this report. Several counties highlighted their difficulty in completing part 2 as a direct result of lacking an automated ditch records system. The contacts for these drainage authorities requested a statewide, web-based system for tracking and managing ditches/ditch projects.

Methods

BWSR contracted with the Minnesota State University, Mankato, Water Resources Center to help develop and implement the questionnaire to drainage authorities and to assemble and interpret questionnaire results. Dr. Shannon Fisher, director, MSU, Mankato, Water Resources Center was the principal investigator, and Steven Moe, GIS specialist, the principal GIS assistant.

In late October 2005, BWSR mailed a letter to all drainage authorities in Minnesota requesting participation in the questionnaire. A copy of this letter is included in Appendix 1A. The letter included the following attachments:

- a copy of the January 1987 report titled “Minnesota Public Drainage Ditch Systems”;
- copies of the questionnaire – Part 1 and Part 2;
- a stamped, addressed point-of-contact postcard to identify the assigned point of contact in each drainage authority;
- a stamped, addressed envelope for return of the completed questionnaire.

Concurrent copies of the letter and attachments were sent to all county auditors, and the letter (without attachments) was sent to county ditch inspectors.

In early November 2005, the president of the AMC sent a letter to all counties requesting participation in the questionnaire and an AMC policy analyst sent an associated memo to all county administrators and coordinators. In late November, the Minnesota River Board sent a letter to all member counties to encourage participation in the ditch buffer questionnaire. At the MAWD Annual Meeting in early December 2005, BWSR presented an overview of the Public Drainage Ditch Buffer Study and encouraged watershed district participation. At the AMC Annual Conference, BWSR and AMC encouraged participation of counties in the questionnaire. Shannon Fisher, of the Minnesota State University, Mankato, Water Resources Center, and BWSR staff communicated with many drainage authorities to encourage and assist completion of the questionnaire. BWSR and MASWCD also communicated with all SWCDs in the state during this study to inform them about the study and questionnaire and to encourage assistance to drainage authorities, as applicable.

Results of the questionnaire are summarized below and the raw data responses can be reviewed in the 3-page foldout in Appendix 1B.

Compilation of Results from Questionnaire to Drainage Authorities

Questionnaires were sent to 133 local governing units that had the potential to have public drainage ditches under their jurisdiction (87 counties and 46 watershed districts). Of these governing bodies, 126 returned the questionnaire, sent written communications, or cooperated through other means to provide responses. The counties had a return rate of 94 percent (82/87) and the watershed districts had a return rate of 97 percent (45/46) (See Figure 14 and Figure 15, respectively). The quality of responses varied. Some questionnaires, although returned, provided limited information. Based on the 126 questionnaires returned, the following results were tallied. Data sources for some questions are less than 126, as each question may not have been answered by each respondent, and 32 potential ditch authorities had no ditches under their jurisdiction.

The following copy of the questionnaire provided to the counties has been filled in for quick reference of the cumulative responses provided by the ditch authorities. For each of the 14 questions identified above, the section after the questionnaire summary provides compiled descriptive statistics and brief discussion points about the questionnaire results. Individual ditch authority questionnaire results can be found in Appendix 1B.

Public Drainage Ditch Buffer Study

Questionnaire Responses
Counties

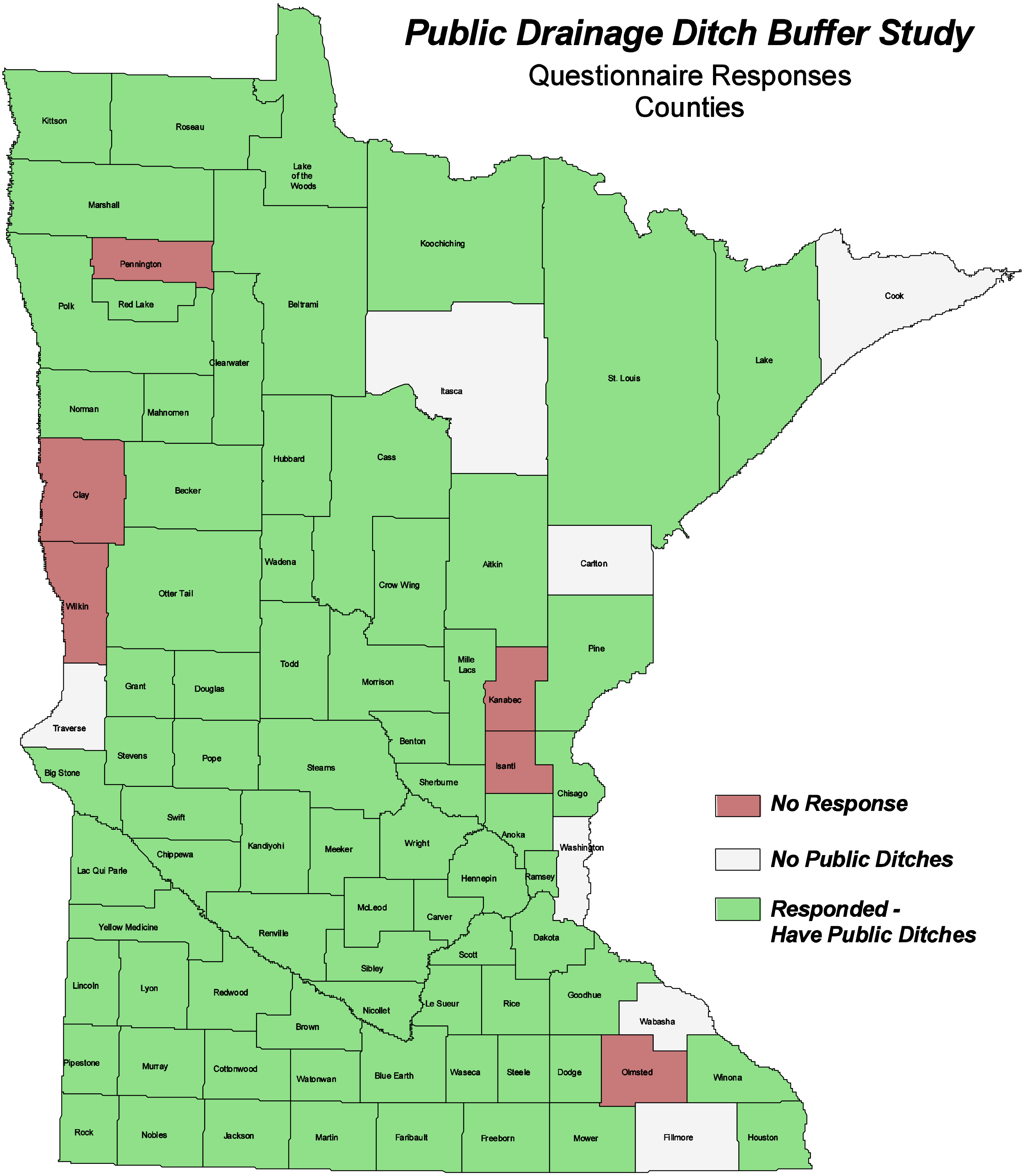


Figure 14

Public Drainage Ditch Buffer Study

Questionnaire Responses
Watershed Districts

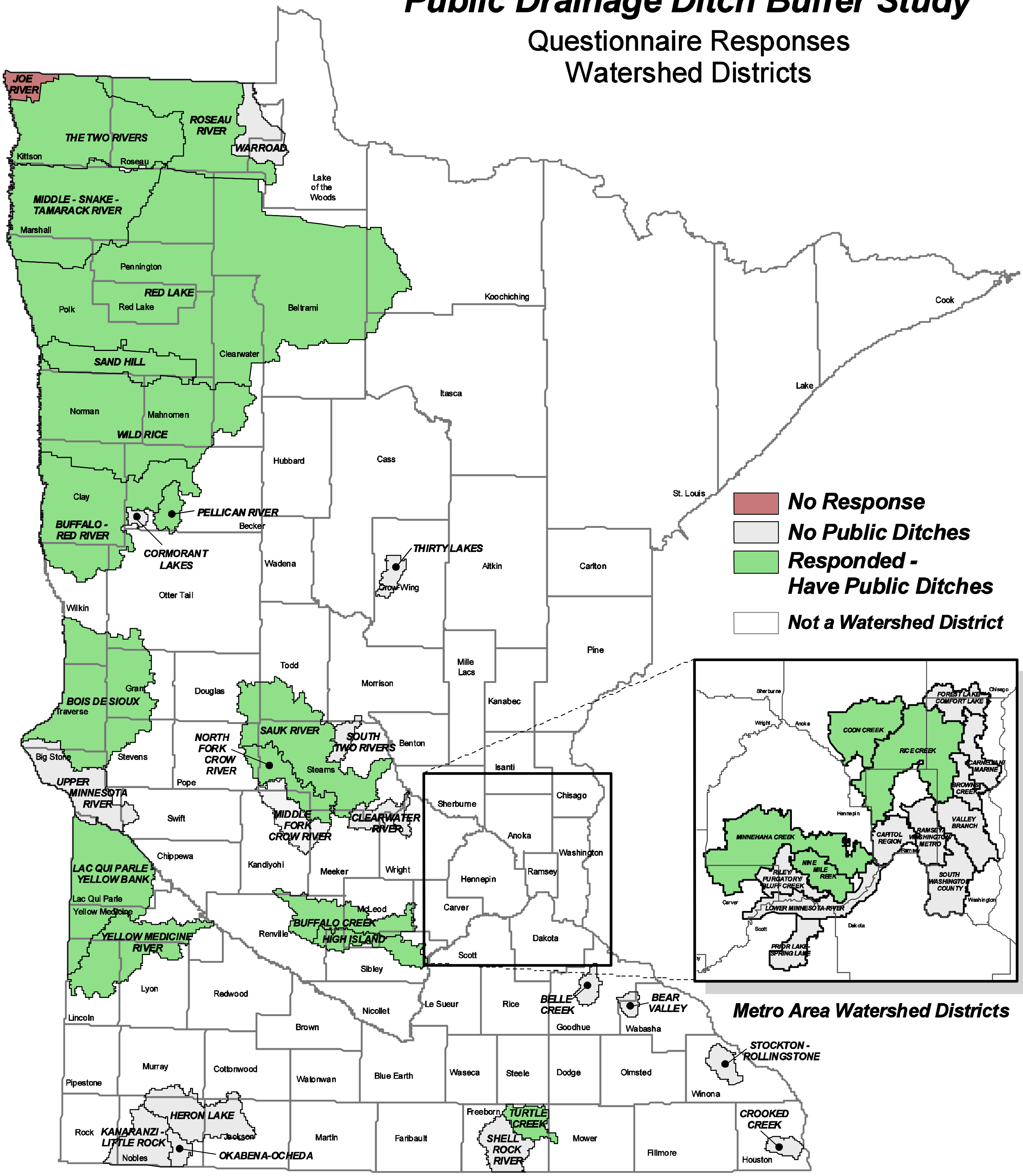


Figure 15

Public Drainage Ditch Buffer Strip Study - Questionnaire Results Summary

1. What type of public drainage system inventory and/or records does your drainage authority have? *(Please check all that apply.)* a. __**28**_ Inventory b. _**43**__ Records Only
   - c. GIS based _**25**__
   - d. Electronic database _**17**__
   - e. Spreadsheet(s) _**20**__
   - f. Paper files and master map _**64**__
   - g. Paper files only _**33**__
   - h. Other (please describe) _**10**__ __________**responses varied**___________________

2. How many miles of open public drainage ditches are under your jurisdiction? __**17,311.1**_ miles

3. How many ditch projects or proceedings under your jurisdiction, since the SWCB survey in 1986, have triggered the appointment of viewers and the requirement for installation of permanent grass buffer strips in accordance with Minnesota Statutes 103E.021? *(Please indicate the number for each type.)*
   - a. Establishment of a new public drainage ditch. _**44**__ projects or proceedings
   - b. Improvement of an existing public drainage ditch. _**114**_ projects or proceedings
   - c. Ditch repair in accordance with 103E.715, Subd. 6. _**57**__ projects or proceedings
   - d. Redetermination in accordance with 103E.351. _**111**_ projects or proceedings
   - e. Other (Please define.) _**15**__ projects or proceedings

4. How many miles of public drainage ditches under your jurisdiction are required to have a one-rod, or wider, permanent grass buffer strip, in accordance with 103E.021?
   - a. On one side of the ditch. _**328.4**____ miles
   - b. On both sides of the ditch. _**1,809.1**__ miles

5. How many miles of public drainage ditches identified in question 4 have had the required grass buffer strip(s) installed?
   - a. On one side of the ditch. _**284.0**____ miles
   - b. On both sides of the ditch. _**1,256.3**__ miles

6. Of the grass buffer strips installed in accordance with 103E.021 under your jurisdiction, how many miles are currently in place?
   - a. On one side of the ditch. _**303.8**____ miles
   - b. On both sides of the ditch. _**1,256.9**__ miles

7. Does your drainage authority have rules or policies for the harvest of grass buffer strips by the landowner and/or assigns, in accordance with 103E.021, Subd. 2? *(Please mark the most applicable category.)*
   - a. Yes – rules or policies are in place. _**13**__
   - b. Rules or policies are under development. _**5**__
   - c. No – rules or policies are not in place or under development at this time. _**69**__

8. Does your drainage authority have a program for regular inspection of ditches and required grass buffer strips, in accordance with 103E.021, Subd. 4 and 103E.705, Subd. 2?
   - a. Yes _**46**__
   - b. No _**43**__

9. How many times, since the SWCB study in 1986, has your drainage authority taken the following grass buffer strip compliance actions in accordance with 103E.021, Subd. 4. and 103E.705, Subd. 2.? *(Please provide a number for each category.)*
   a. Sent a compliance notice to a noncompliant property owner. _**109**_ times since 1986
   b. Issued an order to have the work performed necessary to bring a noncompliant property into compliance with 103E.021. _**15**__ times since 1986
   c. Sent a statement of the expenses incurred to bring a property into compliance to the county auditor and the property owner. _**4**__ times since 1986

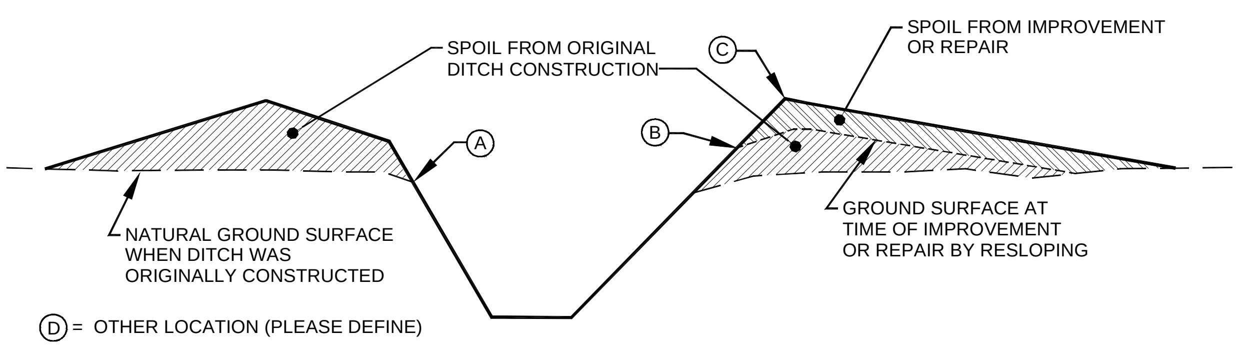
10. What, if any, impediments to implementation of 103E.021 grass buffer strips are experienced by your drainage authority? *(Please mark all that apply.)*
   a. Drainage system landowner concerns about costs of permanent easement acquisition and loss of cropland vs. benefits of grass buffers. _**41**__
   b. Cost of redetermination of benefits. _**48**__
   c. Grass buffer strips only being required when viewers are appointed. _**29**__
   d. Interpretation by drainage authority attorney that the drainage system can't pay to restore vegetation affected by spoil placement on CRP contract land. _**4**___
   e. Other impediment. *(Please define.)* _**9**___
   ________________**responses varied – see section below**____________

11. Does your drainage authority have a plan and/or procedures in place to update drainage ditch benefit determinations on a routine basis? __**10**_ Yes _**80**__ No
   If yes, please briefly describe the plan or procedures. **responses varied – see section below**

12. Where does your drainage authority define the top edge of the channel of the ditch when applying the grass buffer strip width requirement of 103E.021? **D was not reported by any drainage authority.**

   a. For new ditches. **A) 19**
   B) 5
   C) 27

   b. For ditch Improvements or repairs. **A) 10**
   B) 8
   C) 40



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13. Approximately how many miles of public drainage ditches under your jurisdiction are currently buffered through voluntary conservation programs such as CRP, RIM, CREP, or another program?
   a. On one side of the ditch. __**935.1**___ miles
   b. On both sides of the ditch. __**1,513.3**_ miles

14. Any additional comments about grass buffer strips or 103E.021? **28 respondents provided additional comments – they are summarized under #14 below**_____________________

Discussion of Questionnaire Results

1) *Type(s) of drainage records*

- The questionnaire indicated a wide range of drainage record types.
- Some ditch authorities have significant electronic capacity and utilize GIS technology; however, many rely on paper records and/or paper files with a master map.
- Several drainage authority contacts requested a statewide, web-based program for tracking ditches/ditch projects. Such a program would be a user-friendly entry point in each county or watershed district and could be used to automatically generate annual reports and provide a venue for data collection without tapping into limited staff time.
- Given the information provided earlier in this report under "Public Drainage System Inventories," there may be some confusion about what the counties actually have in place, as some counties that have received cost-share for an inventory did not report such capacity. This might be a question of cost-share and inventory timing for some drainage authorities.

2) *Total miles of public drainage ditch in each drainage authority jurisdiction*

- A total of 17,311.1 miles of open public drainage ditch were reported from 94 different ditch authority jurisdictions.
- 32 jurisdictions reported that they do not have a public ditch system and/or ditch authority.
- 15 of the 94 authorities with ditches provided estimated numbers based on a cursory review of available information (noted in Appendix 1B).
- 5 counties included in the total of 94 ditch authorities that returned a questionnaire were unable to provide ditch mile totals, due to paper record volume and limited time.
- Differences in total ditch miles between the current questionnaire results, the 1986 questionnaire, and our GIS estimates (see Section 3) were present. Figure 16 highlights the statewide total from each of these estimations and the figure caption provides a brief explanation about why these differences likely exist.

3) *Types of ditch proceedings that have triggered implementation of grass strips since 1986*

- Since the 1986 study, 341 ditch projects or proceedings were reported that triggered the appointment of viewers and Minnesota Statutes, Section 103E.021 buffer requirements.
- The projects noted above were limited to 40 ditch jurisdictions.
- The most active drainage authorities, in regard to requiring buffers through 103E ditch proceedings, were Buffalo-Red River Watershed District (38), Martin County (32), Freeborn County (24), Murray County (23), and Big Stone County (16).
- 6 of the counties reported that "Other" actions or proceedings invoked the appointment of viewers and buffer requirements; these included the addition of lateral ditches, association with highway projects, association with a voluntary grant program, Section 103E.705 repair, and commissioner's orders.

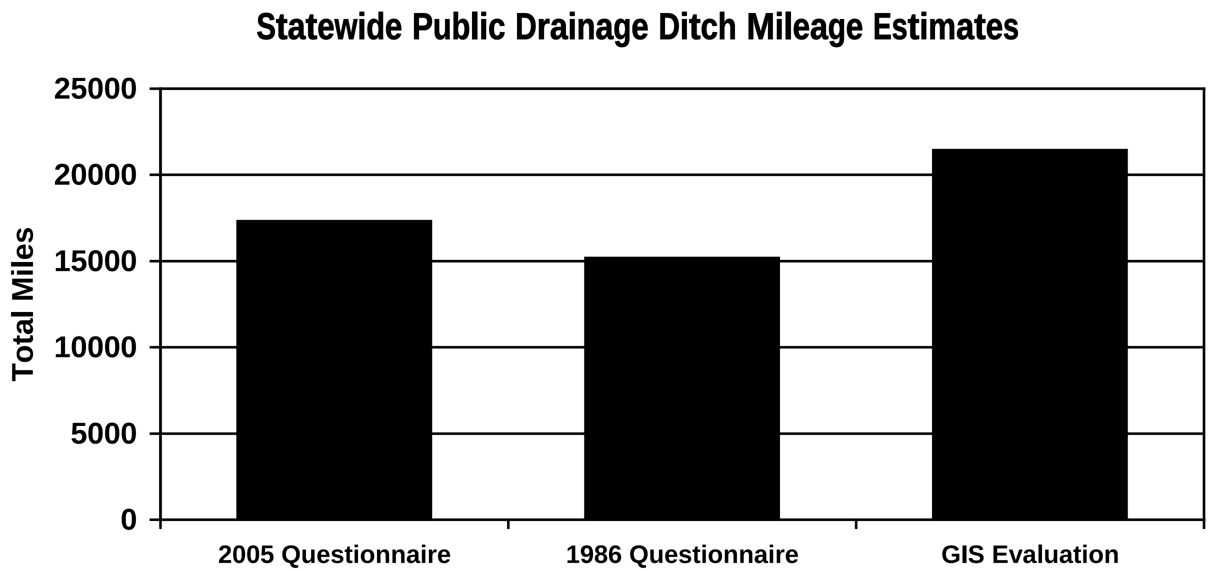


Figure 16. Estimations of public drainage ditch miles in Minnesota vary by reporting technique and data quality. In 2005, questionnaire respondents from 81 counties and 45 Watershed Districts reported 17,311.1 miles. In 1986, questionnaire respondents from 77 soil and water conservation districts reported 15,173.4 miles. A GIS-based estimation utilizing the Minnesota Department of Natural Resources (DNR) surface hydrology data indicated approximately 21,414.7 miles (see Section 3 for more information). It is difficult to verify the exact miles of public open ditch in Minnesota, as many jurisdictions have no ditch inventory and/or did not submit questionnaire responses. Likewise, the DNR data used in the GIS-based estimation had verifiable missing data from three counties and appeared to include a small percentage of private ditches.

4) *Miles of ditch required to have the required grass buffer strips*

- 2,137.5 miles of open public ditch were reported to be required to have a Minnesota Statutes, Section 103E.021 minimum one-rod buffer on at least one side (Table 2).
- In the 1986 report, 1,154.8 miles of public ditch were reported to have a required minimum 1-rod buffer strip in place; however, it was not clear if these miles were now included under the Section 103E.021 miles reported in the questionnaires.
- Therefore, 12.3 percent of the public drainage ditch system (as reported in Question 2 above) is required to have permanent grass strips, as compared with 7.6 percent in 1986.
- When a ditch is required to have 103E.021 buffers in place, both sides of the ditch are required to be in buffer, unless the ditch is located along a road, railroad, or other infrastructure where a buffer is not possible.

5) *Miles of required grass buffer strips installed*

- Although 12.3 percent of the total public drainage ditch miles reported are required to have a buffer strip under Section 103E.021, installation of these buffer strips is not complete (Table 2).

- Of the 328.4 ditch miles reported as "required to have buffer strip on one side," 284.0 miles have been installed (86.5 percent), and for the 1,809.1 ditch miles with a requirement for both sides, 1,256.3 miles have been installed (69.4 percent).

6) *Miles of required grass buffer strips currently in place*

- The total miles of ditch with "in place" buffer strips included all of the ditch miles identified in number 5 above and a few additional miles that were in place prior to 1986.
- 1,569.7 ditch miles were reported to have the required buffer "in place" (Table 2).
- Based on the total ditch miles reported in number 2, 9.1 percent of the public ditch system is buffered with a Section 103E.021 grass strip (recall that 12.3 percent should have a buffer in place).
- This should not be interpreted, however, to indicate that 90.9 percent of the open public ditch system is not buffered – other types of voluntary and natural buffers are in place on the public ditch system (see Section 3 below).

Table 2. Summary of Minnesota Statutes, Section 103E.021 ditch buffer reporting from the 2005 ditch authority questionnaire, including miles of ditch required to have buffer, miles installed, and miles of buffer actually in place.

Ditch Miles	Required Buffer Miles	Buffer Miles Installed (% of Required Miles)	Buffer Miles in Place (% of total ditch miles reported)
1-side Miles	328.4	284.0 (86.5)	303.8 (1.8)
2-Side Miles	1,809.1	1,256.3 (69.4)	1,265.9 (7.3)
Total Miles	2,137.5	1,540.3 (72.1)	1,569.7 (9.1)

7) *Status of rules or policies for the harvest of grass buffer strips*

- 13 (6 counties and 7 Watershed Districts) indicated that they have rules or policies in place to address buffer strip grass harvest in accordance with Section 103E.021, Subd. 2.
- 5 entities indicated rules under development and 5 did not respond to the question.
- A majority (69 respondents) noted that they do not have rules or policies in place.
- Note that Section 103E.021, Subd. 2 requires county drainage inspectors to establish rules for harvest of required grass strips. However, a majority of drainage authorities reportedly do not have such rules.

8) *Status of programs for regular inspection of ditches*

- 46 jurisdictions indicated that they have a program for regular inspection of Section 103E.021 grass buffer strips.
- 43 jurisdictions reported that they do not have a program in place.
- The presence of inspection programs was higher in the watershed districts.
- 16 of the 18 watershed districts with public drainage ditches reported a program in place (89 percent).
- Of the 70 counties that reported on this question, 30 had a program in place (43 percent).

9) Grass buffer strip enforcement actions taken since 1986

- Questionnaires indicated that since 1986, 128 enforcement actions have been taken.
- 109 compliance notices to noncompliant property owners were sent by ditch authorities.
- 15 orders were issued to bring noncompliant property into compliance.
- 4 times since 1986 statements of expenses incurred to attain compliance were sent to the county auditor and property owner by the ditch authority.
- The most active jurisdictions for enforcement were High Island Creek Watershed District (20); Chippewa County (19); Buffalo-Red River Watershed District (17); Yellow Medicine River Watershed District (15); and Dodge County (11).

10) Impediments to implementation of Minnesota Statutes, Section 103E.021

- Various issues were cited as impediments to Section 103E.021 grass buffer strip implementation.
- A set of potential "impediments" were listed for the respondents to select from and "other" impediments could be listed for inclusion in this report.
- Landowner concerns about permanent easement acquisition costs and loss of cropland value compared with buffer value gained were noted by 41 ditch authorities.
- The costs of conducting the redeterminations were designated by 48 authorities and buffer strips being required only when viewers were appointed were noted 29 times.
- The other impediments listed by several jurisdictions included:
    - natural buffers already in place (i.e., no need to invoke Minnesota Statutes, Section 103E.021);
    - no perceived benefits of viewer appointments and redeterminations of benefits;
    - many repairs kept minor to avoid invoking appointment of viewers, grass strip requirements, and associated costs;
    - perceived jurisdiction losses (from the county to the watershed districts) after redetermination;
    - weed control (easier to control when tilled);
    - and lack of enforcement.

11) Existence of plans or procedures for systematic redetermination of drainage system benefits

- Of the 90 respondents to this question, 10 indicated that they have a plan in place to systematically redetermine ditch benefits (11.1 percent).
- A majority, however, did not have a plan in place (80) and many indicated that they had no intention of initiating or promoting such a program in their jurisdiction.
- For those with a plan in place, the programs were structured in several ways, to include:
    - Systematic assignment of viewers and redetermination (1-5 per year);
    - Annual review to identify systems with the oldest benefits determination, greatest new inflows, and/or obvious flaws;
    - When major repairs are conducted;
    - When assessment discrepancies arise (landowner complaints and repair costs that exceed benefit estimates); and
    - By petition and/or request of landowners.

12) Drainage authority interpretation of the location of the top of channel bank for implementing the minimum 1-rod grass buffer strip requirement

- The responses to this question highlight the presence of some confusion about the appropriate positioning of the required 1-rod grass buffer strip.
- Many jurisdictions noted that they would measure the 1-rod strip differently, depending on the type of ditch project (new or repair/improvement).
- Refer to Question 12 in the results section above for numbers of responses.

13) Approximate miles of public drainage ditches buffered through voluntary conservation programs

- Respondents indicated that they were aware of 2,448.4 miles of open public drainage ditch buffered under voluntary programs (14.1 percent of the total miles reported in number 2).
- Of these voluntarily buffered ditch miles, 935.1 miles are buffered on one side and 1,513.3 miles have both sides in some type of voluntary buffer program.
- The total miles of voluntary buffers indicated by some counties differed substantially from the GIS-based voluntary buffer assessment conducted by the Minnesota State University, Mankato, Water Resources Center (refer to Section 3 below for more information).
- Drainage authorities are not required to report voluntary buffer implementation, so it is not surprising that many did not have good data on this topic.

14) Additional comments (from respondents) about grass buffer strips or Minnesota Statutes, Section 103E.021

Apparent confusion about statutory interpretations, actual buffer requirements, and inconsistent applications across jurisdictions triggered a wide range of comments about Section 103E.021 and this questionnaire. Twenty-eight respondents provided comments. The comments are summarized below in five general categories: Land Use Conflicts and Concerns; Cost Issues; Implementation Challenges; Alternatives; and Buffer Satisfaction.

Land Use Conflicts and Concerns

- Developing areas change the dynamics of not only the drainage systems, but also the landowner priorities, thereby making redeterminations, voluntary program buffers, and ditch maintenance more difficult.
- In portions of the state, the public ditches are in remote undisturbed areas and are already in permanent vegetation, as the lands adjacent to the ditches are unsuitable for other uses (e.g., tilled agriculture land).
- Natural, or at least unmaintained, buffers are abundant in some areas and staff fear that application of Section 103E.021 in their areas will cause a degradation of buffers already in place (as these buffers reportedly would not meet the stated requirements under the law for "grass" strips).
- In many parts of the state, ditch systems have not been managed for 80+ years and many are considered effectively abandoned by vegetative overgrowth.
- Open ditches are often in association with road right-of-ways and, therefore, one side does not fall under Section 103E.021 requirements.

Cost Issues

- Although most jurisdictions understand that buffers help reduce erosion and sedimentation, the expense of purchasing and maintaining buffers is considered prohibitive.
- Agencies and the public (other than the assessed landowners) are not paying their fair share for the public benefits of buffers along public ditches.

Implementation Challenges

- A majority of ditch repair that is done is planned in small increments to avoid the need to assign and pay for viewers and deal with Section 103E.021.
- Records are often obscure and difficult to interpret, or sometimes lost all together.
- More buffers would be in place if redeterminations were cheaper, less complex, and never resulted in the loss of jurisdiction over the ditch.
- Overlapping jurisdictions (e.g., county and watershed district) causes confusion about who is responsible for which ditches.
- Absentee landowners do not want the potential hay from buffer strips and renters want as much cropland as possible.

Alternatives

- CRP is becoming more attractive in some areas as soil rental rates increase and voluntary programs should be the means of getting buffers in place.
- Buffer installation in conjunction with side inlet controls should be the focus of efforts like this.
- Greater effort on tax relief incentives would provide bigger gains than many other program efforts.
- Some locales have adopted setback requirements (e.g., 50-ft) that make the 1-rod buffer inconsequential.
- The 1-rod measurement should be defined as the area starting from the peak of the spoil bank outward from the ditch.

Buffer Satisfaction

- The importance of buffer strips is underrated and can save everyone money and frustration in the long run.
- The buffer requirement should be implemented on all open ditches and public waterways.
- There is nothing wrong with the language in Section 103E.021.

Questionnaire Findings

The questionnaire revealed several important points about open public ditch systems in Minnesota. It also brought frustration about the time and effort required to fill out the questionnaire and fear over drainage-related issues back to the surface among drainage authorities. The findings below relate to the questionnaire responses above, including comments on the questionnaire process.

1) The capacity for ditch authority contacts (see contacts list in Appendix 3) to accurately and efficiently respond to questions about public ditch systems is variable. Easiest response appeared to be dependent on the jurisdiction's access to electronic ditch records and GIS-based inventories – which many of the jurisdictions do not have in place.

2) Some ditch authorities, particularly among counties, perceive insufficient funding and staffing are available to accomplish the many requirements associated with the state's drainage law, including the implementation and monitoring of buffer strips.

3) Confusion and disagreement about how to measure the required buffer widths was evident; however, a majority of the reporting ditch authorities (53 percent for new ditches and 69 percent for ditch improvements/repairs) utilize a measurement that extends away from the ditch starting at the top of the ditch bank and spoil bank (see point "C" on the figure for Question 12 of the questionnaire in the results section above).

4) 94 jurisdictions reported that they have ditch authority and 89 of these jurisdictions reported 17,311.1 miles of open public drainage ditches.

5) Since 1986, 341 ditch projects were identified that triggered the appointment of viewers and requirements for Section 103E.021 grass buffer strips.

6) Improvement of an existing drainage ditch, and redetermination of benefits were the most cited proceedings that invoked Section 103E.021 requirements (114 and 111 ditch proceedings, respectively, since 1986).

7) Routine redetermination of benefits was noted in 10 of the reporting ditch authority jurisdictions; however, the plans in place varied significantly and the definition of "routine" appeared to have wide interpretation. A majority of the ditch authorities indicated that they have no intentions of starting regular, or routine, redeterminations.

8) 12 percent of the open public ditch miles reported are required to have buffer strips on one or both sides, up from 7.6 percent in 1986; however, only 72 percent of these required buffer areas have been installed (compared to 43 percent in 1986).

9) Approximately 9.1 percent of the public ditch system reported is buffered with minimum 1-rod buffers associated with 103E.021 requirements; however, this does not imply that the other 90.9 percent is not buffered – other voluntary programs and natural buffers are also in place.

10) Almost 79 percent of the ditch authorities that responded to the questionnaire indicated that they do not have policies in place that regulate the harvest of grasses from required buffer strip areas. Some indicated no landowner interest in harvesting, so policies were not needed.

11) Approximately half of the ditch authorities have a program in place for the regular inspection of ditches and buffer strips; however, these programs were more prevalent in the watershed districts.

12) 128 enforcement actions were reported for non-compliant grass buffer strips since 1986; which is a substantial increase from what was reported in the 1986 report; however, many comments focused on the lack of buffer enforcement.

13) Impediments to implementing grass buffer strips were numerous; cost and complexity of redeterminations, landowner concerns about easement costs and reimbursement, and the cost-benefit of lost cropland replaced with buffers were all cited as major impediments.

14) Many jurisdictions indicated that more grass buffer strips could be in place if the appointment of viewers was not a requirement for buffer strip mandates.

15) Ditch authorities appeared to have limited knowledge about voluntary buffers in their jurisdiction, but they typically are not major players in these conservation practices, and are not required to maintain associated records.

Numerous concerns were noted during the questionnaire process; however, the most frequently voiced issues involved the abundance of "natural" buffers in many areas (northern Minnesota), the need for side inlet controls, and lack of funding to support required ditch buffers.

Section 3: Status of Voluntary Buffers Along Public Drainage Ditches

Purpose and Scope

The legislative directive to BWSR included consultation with federal agencies implementing voluntary buffer programs. In consultation with the study work group, BWSR interpreted this to include definition of the implementation status of voluntary buffers along public drainage ditches in Minnesota. It was decided that, if possible, this definition should be accomplished using GIS. Development and reporting of this study component was included in the contract between the BWSR and the Minnesota State University, Mankato, Water Resources Center.

Because the federal Conservation Reserve Program (CRP) and associated Continuous Conservation Reserve Program (CCRP) are two major conservation programs that implement vegetated buffers, BWSR requested the Farm Services Agency (FSA) to provide GIS shape files for Conservation Practices CP-21, Filter Strip and CP-22, Riparian Buffer currently in place in Minnesota. FSA agreed to provide this CRP information for a small administrative processing fee. This information was provided by the FSA to the BWSR in mid December 2005 and, thereafter, by BWSR to the Minnesota State University, Mankato, Water Resources Center. This information includes data for regular CRP, CCRP, and the Conservation Reserve Enhancement Programs in Minnesota, which are a partnering of CRP and the Reinvest in Minnesota (RIM) Reserve Program. The Minnesota State University, Mankato, Water Resources Center was also provided access to BWSR's GIS data for RIM and CREP to correlate the locations of associated conservation easements and contracts with the locations of public drainage ditches. A summary of major conservation programs that include riparian buffer practices is shown in Appendix 4.

Methods

Statewide Evaluation

Utilizing a surface hydrology data layer prepared by the Minnesota Department of Natural Resources, we were able to separate out open ditches identified in their assessment (Figure 17); however, we were not able to verify that all of these ditches were part of the "public" ditch system. Based on a review of some ditch locations and GIS information provided by some counties, it appears that some private ditches, although minimal, are also included in the DNR layer. It was determined that the DNR surface hydrology data layer does not include information from Winona, Lake, Cook, and Swift counties. However, of these, only Swift County is known to have significant public drainage ditches.

The first step was to reduce the ditch lines down to realistic field-level scales. Each ditch line was initially split at each vertex to prevent individual ditch lines from turning corners. Then ditch lines longer than 100.5 meters were selected and divided so that no individual ditch segment would be larger than 100 meters in the GIS evaluation. By breaking the ditch lines into segments, it became easier to test each ditch segment for an association with a voluntary buffer (obtained from other GIS layers). The length of 100 meters was arbitrary; however, it was a reasonable compromise between file size manageability and accuracy.

The next step involved creating a layer of target lands along public drainage ditches where buffers can be identified as being adjacent to the ditches from the layer above. A 25-meter zone in both directions from each ditch line segment (referred to as the "ditch zone") was chosen based on visual observation to compensate for feature errors. Therefore, a 50-meter ditch zone corridor with the ditch in the center was evaluated. Although it would be best to limit the ditch zone to a one-rod buffer area of interest on each side, accuracy of the GIS layers would not allow such a precise evaluation. The 25-meter area of interest on each side of the ditch would be more likely to capture buffer locations in the assessment. Each side of the ditch was initially queried separately and later merged together to create one polygon feature with attributes that identified which side of the ditch a potential buffer was located (necessary to facilitate discussion about ditches with one or two sides buffered).

For the statewide assessment, we utilized a GIS layer from the FSA that contained data for CRP lands with CP-21 or CP-22 (data current as of November 2005). We also used existing CREP/RIM data obtained from BWSR (data current as of May 2004). The ditch zone layer and CRP, RIM, and CREP lands were added to an ArcGIS map. The subsequent assessment tested each ditch segment to determine if any of these programs were present in the ditch zone. Ditch zones for each ditch segment that intersected CRP, RIM, or CREP were selected and exported to new files where they could be more readily analyzed. It was known that CREP lands were included in the CRP layer; however, it was not possible to extract the CREP lands from the CRP totals. To avoid over-estimation of voluntary buffer lands, the CREP totals, as determined from the CREP/RIM assessment (where CREP could be separated), were deducted from the CRP total, leaving what we believe to be a relatively accurate estimation of the total CRP-only coverage.

In addition to the assessment above for voluntary program presences, we also estimated the total ditch miles that intersected with various land uses. The land use evaluation for lands adjacent to the public open ditch system provided considerable insight about "natural" buffers in place. This is important data to consider, particularly for northern Minnesota counties where forestland, wetlands, pasture, and hay land are prevalent land uses that have perennial vegetation along drainage ditches. We utilized the USGS National Land Cover Dataset from 1992 to estimate the land uses across the state of Minnesota.

13-County (South-Central Minnesota) Evaluation

Utilizing an existing GIS layer prepared by the WRC in 1993, we were able to take a detailed look at the public ditch system in a 13-county area of south-central Minnesota. The 13-county ditch data layer we utilized for this evaluation could be utilized with greater accuracy and precision, due to tighter resolution and more complete inventories of the ditches present. Similar assessments to the one completed for the 13-county area could be completed for other portions of the state; however, time did not permit the labor intensive need to digitize ditch features. The ditch layer was originated from the Minnesota State University, Mankato, Water Resources Center and represents an inventory (as of 1993) of all public ditches in a 13-county area (Figure 18).

The methods used for the 13-county evaluation were the same as those described above for the statewide assessment; however, with a more accurate ditch layer. For this assessment, we used the CRP, RIM, and CREP data as described above. The assessment we completed allowed for the determination of total ditch miles in each of the 13 counties and what proportions of these ditch miles were buffered through voluntary programs. A further evaluation of land uses adjacent to the ditches in the 13-county area was also completed, but only to determine the amount of potential "natural" buffer that is not already enrolled in CRP. Natural buffer is defined in the results discussion below. For parcels where voluntary program buffers overlapped with "natural" buffers, these parcels were removed from the "natural" totals. Data from the 1989 International Coalition Land Use/Land Cover land use layer is considered to be higher quality than the USGS 1992 layer; however, the dataset is not complete for all of Minnesota. The data were available for the 13-county area and was used in place of the USGS 1992 land use layer described above for this area.

Results and Discussion

The evaluation results discussed here need to be utilized with some caution, as some inaccuracy and imprecision are inherent in the data we used and likely altered some results. However, based on discussions with several ditch authority contacts, it appeared that few new ditches had been added in the 13-county area since the creation of these GIS ditch layers. Therefore, the public ditch layers in this assessment should be perceived as a relatively good representation of ditch presence, with the disclaimer that any new ditches added since 1993 would not be included in the assessments. It should be noted, however, that some private ditches appear to be included in the statewide layer. For example, the 13-county evaluation revealed 2,690 miles of public drainage ditches, whereas the statewide evaluation suggested 2,901 miles of channelized streams and ditches for the same 13-county area. The statewide evaluation (based on the DNR layer) estimated 7 percent more ditches in the 13-county area than did the localized evaluation (WRC data layer). It should be noted that the 13-county data layer includes county and judicial ditches only – no private ditches were intentionally included in that section of the evaluation. The statewide layer did not include ditch data for Swift, Winona, Lake, and Cook counties. The GIS assessment indicated 0 miles of public ditch for Swift County; however, the Swift County Questionnaire indicated that 280 miles of public drainage ditches are present in Swift County.

Rather than provide an in-depth explanation of the statewide results, please refer to Table 3 for statewide results, including total ditch miles, ditch miles associated with voluntary program buffers, and ditch miles adjacent to "natural" buffer land uses. "Natural" buffer land uses included wetlands, forests, grasslands (including hay, pasture, and prairie), and shrublands that intersected with open ditches. Lands in voluntary programs (CRP, RIM, and CREP) were not included in these totals, as they were tallied separately. Voluntary program buffers appear to be concentrated in various parts of the state (Figure 17) – often highlighting the water quality priorities that landowners, county/watershed staff, and elected officials place on marketing these programs. The total miles of open drainage ditch, based on the statewide data layer, were 21,414.7. Due to overlap of watershed district and county jurisdictions, we did not attempt to complete a comparison of the total miles reported by the ditch authorities in the questionnaires and the total miles estimated from GIS data. Of the ditch miles in the statewide assessment, 8.3 percent were adjacent to voluntary program locations, including CRP, CREP, and/or RIM.

Of interest to many are the *total* miles of ditch in each of these counties that are buffered – through voluntary buffer programs, Section 103E.021 requirements, and natural buffer areas. Table 3 highlights the miles of required buffer strips that are "in place" from Question 6 on the questionnaire, the total miles of ditch in voluntary buffers, and the total miles of ditch associated with "natural" buffers in each county.

Table 3. Summary of voluntary and natural buffers based on a GIS evaluation. Resolution of the assessment permits a certain level of inherent error. Total ditch miles were calculated using a surface hydrology data layer developed by the DNR. CRP, CREP, and RIM totals were obtained as described in the text above, and natural buffer is based on a land use assessment (see Appendix 3 for details). These data may contain some private ditch miles, and four counties are not included, due to lack of surface hydrology data (Winona, Lake, Cook, and Swift) in the DNR layer.

County	GIS Miles	1-side CRP (mi.)	2-side CRP (mi.)	**1-side CREP (mi.)	**2-side CREP (mi.)	1-side RIM (mi.)	2-side RIM (mi.)	Natural buffer (mi.)	*% with Buffer
Aitkin	574.4	0.2	0.4	0	0	0	0.2	538.1	93.8
Anoka	3.3	0	0	0	0	0	0	1.8	54.5
Becker	125.3	1.0	1.8	0	0	0	0	85.7	70.6
Beltrami	985.1	0	0.2	0	0	0	0	884.9	89.8
Benton	147.1	0.6	0.2	0	0	0.9	0.2	122.4	84.5
Big Stone	25.6	0	0.2	0	0	0	0	8.8	35.2
Blue Earth	155.0	7.9	16.0	1.0	1.5	0	0	37.0	40.9
Brown	237.5	15.2	22.1	2.4	1.2	0	0.1	49.4	38.1
Carlton	127.6	0.2	2.0	0	0	0	0	120.8	96.4
Carver	113.5	1.0	5.5	0	0	0.3	1.2	75.5	73.6
Cass	162.1	0.4	1.3	0	0	0	0	152.0	94.8
Chippewa	261.0	15.9	24.6	1.2	4.4	0.4	1.6	33.9	31.4
Chisago	136.9	0.1	0.1	0	0	0	0	93.6	68.5
Clay	398.3	0.1	1.1	0	0	0.4	1.6	98.7	25.6
Clearwater	150.0	0.6	0.1	0	0	0.7	0.5	98.6	67.0
Cook	Not Included in Assessment – No Data Available in Surface Hydrology Layer								
Cottonwood	73.1	4.2	7.6	1.0	1.0	0.7	0.5	22.7	51.6
Crow Wing	54.2	0	0	0	0	0	0	47.0	86.7
Dakota	2.7	0.1	0.4	0	0	0	0	1.6	77.8
Dodge	104.9	5.7	7.2	0	0	0	0	7.4	19.4
Douglas	48.7	1.1	0.9	0.1	0	1.0	2.4	36.5	86.2
Faribault	242.0	14.1	20.1	2.1	3.1	1.4	0	31.6	29.9
Fillmore	7.3	0.1	0.6	0	0	0	0	2.7	46.6
Freeborn	371.4	53.2	89.9	0	0	2.1	4.4	26.5	47.4
Goodhue	7.6	0.2	0.6	0	0	0	0	0.4	15.8
Grant	142.2	10.6	17.9	0	0	0.7	0.4	14.5	31.0
Hennepin	68.3	0.6	0.2	0	0	0	0.5	41.7	63.0
Houston	0.9	0	0	0	0	0	0	0.7	77.8
Hubbard	24.0	0	0	0	0	0	0	22.9	95.4
Isanti	136.7	0.4	0.3	0	0	0	0	118.9	87.5
Itasca	129.4	0	0	0	0	0	0	121.7	94.0
Jackson	177.3	10.1	14.6	0	0.8	0.5	2.0	42.4	39.7
Kanabec	115.7	0.2	0.4	0	0	0	0.2	103.0	89.7
Kandiyohi	563.7	24.4	42.2	2.0	5.7	2.1	5.9	165.1	43.9
Kittson	499.5	10.7	15.6	0	0	0	0	171.0	39.5
Koochiching	576.8	0.1	0.4	0	0	0	0	552.0	95.8
Lac qui Parle	333.8	18.1	48.4	5.7	5.6	0.4	3.3	61.3	42.8
Lake	Not Included in Assessment – No Data Available in Surface Hydrology Layer								
Lake of the Woods	686.0	1.5	2.0	0	0	0	0	586.6	86.0
Le Sueur	242.5	19.3	37.1	0.7	1.3	1.8	2.8	102.6	68.3
Lincoln	104.3	2.9	7.7	2.2	3.0	0.2	1.1	48.6	63.0
Lyon	140.4	6.4	10.9	0.5	2.3	0.3	0.5	27.7	34.6
Mahnomen	180.0	1.7	5.4	0	0	0	0	52.8	33.3
Marshall	1,371.0	9.4	19.2	0	0	0.6	0.3	465.5	36.1
Martin	202.6	4.9	14.3	2.0	5.2	0.2	0.7	49.4	37.9
McLeod	258.4	12.1	27.9	0	0	0.9	1.5	108.7	58.5
Meeker	199.2	5.2	9.9	0	0	0.3	1.7	113.1	65.4
Mille Lacs	122.4	0	0	0	0	0	0.4	105.4	86.4
Morrison	212.9	0.9	2.5	0	0	0.6	2.1	191.0	92.6
Mower	247.6	11.1	17.5	0	0	1.5	0.8	42.6	29.7
Murray	95.5	5.7	7.9	0	0	0	0	35.1	51.0
Nicollet	296.7	19.1	18.5	0.8	0.7	0.1	0.3	58.5	33.0
Nobles	131.9	5.5	17.6	0	0	0	0	32.3	42.0
Norman	842.5	24.8	46.2	0	0	0.4	3.2	184.4	30.7
Olmsted	11.8	0	0.6	0	0	0.1	0.3	4.8	49.2
Otter Tail	286.8	5.9	16.1	0	0	0	3.6	217.2	84.7
Pennington	470.9	4.5	10.6	0	0	0	0	81.6	20.5

Table 3 Continued									
County	**GIS Miles**	**CRP 1-side**	**CRP 2-side**	****CREP 1-side**	****CREP 2-side**	**RIM 1-side**	**RIM 2-side**	**Natural buffer**	***% in Buffer**
Pine	153.2	0	0.2	0	0	0	0	133.4	87.2
Pipestone	25.0	0.4	1.4	0	0	0	0	9.0	43.2
Polk	1,210.3	33.4	22.0	0	0	0	0	221.5	22.9
Pope	18.8	0.4	0.3	0	0	0	1.4	13.2	81.4
Ramsey	38.0	0	0	0	0	0	0	18.9	49.7
Red Lake	243.6	2.4	6.4	0	0	0.4	0	36.1	18.6
Redwood	274.9	24.2	40.4	5.6	7.8	1.0	2.8	40.9	44.6
Renville	719.9	32.1	41.3	11.0	22.8	2.5	5.0	117.9	32.3
Rice	55.9	2.7	6.2	0	0	0.2	0.4	30.4	71.4
Rock	9.1	0.4	0.7	0	0	0	0	1.6	29.7
Roseau	1,269.5	3.4	5.6	0	0	0	0	619.7	49.5
Scott	3.6	0.3	0	0	0	0	0	2.3	72.2
Sherburne	160.3	0.6	2.0	0	0	0	0	139.8	88.8
Sibley	521.3	19.8	29.6	4.0	1.9	1.2	3.4	144.9	39.3
St. Louis	798.3	0.4	0	0	0	0	0	735.3	92.2
Stearns	317.7	6.6	11.7	0	0	0.2	0.7	219.5	75.1
Steele	223.8	20.6	29.3	0	0	1.8	4.3	34.5	40.4
Stevens	74.2	1.8	11.3	0	0	0	0	13.1	35.3
Swift	Not Included in Assessment – No Data Available in Surface Hydrology Layer								
Todd	261.8	0.8	1.3	0	0	0	0	234.6	90.4
Traverse	321.8	27.4	42.7	0	0	0.3	1.0	21.2	28.8
Wabasha	2.3	0	0	0	0	0	0	1.8	78.3
Wadena	237.2	1.4	3.4	0	0	0.1	0.4	209.4	90.5
Waseca	129.1	14.6	18.8	2.4	1.2	0.6	1.1	36.9	58.6
Washington	10.1	0	0	0	0	0	0	6.8	67.3
Watonwan	32.9	3.5	4.3	0.1	0	0.1	0.2	8.5	50.8
Wilkin	406.7	6.8	13.5	0	0	0	0.5	47.7	16.8
Winona	Not Included in Assessment – No Data Available in Surface Hydrology Layer								
Wright	101.7	2.5	1.5	0	0	0.9	1.6	72.3	77.5
Yellow Medicine	407.4	39.9	74.8	2.1	4.9	0.5	1.3	52.5	43.2
State Totals	21,414.7	585.1	984.1	47.0	74.5	28.2	68.3	9724.4	53.8

*Percentage represents the portion of open ditch in each county, based on the GIS open ditch miles total (denoted as GIS Miles), associated with voluntary and natural buffers. It should be noted that this is total miles based on ditch centerlines and that some of these miles are only buffered on one side.

**CREP only available in the Minnesota River basin; therefore, the 0's in many counties is not by choice, but rather lack of opportunity to participate.

The improved detail we obtained for the 13-county area allowed for the confirmation of land uses and ditch locations (Figure 18) – providing a much more accurate estimate of "natural" buffer areas. Land use categories associated with "natural" buffers are summarized in Table 4. The land use values in Table 4 associated with the 13-county evaluation represent approximately 15 percent of the natural buffers suggested in the statewide assessment. Although we believe the numbers provided in the statewide assessment are relatively useful, we must stress that these evaluations are both academic exercises to be used for discussion and to help clarify the overall picture. We limited the natural buffer totals in the 13-county assessment to the verifiable land uses completely associated with a ditch segment. For example, if a 100-meter segment of ditch had forest on one part of it and row crop on another part, the entire segment was not counted as having "natural" buffer. The statewide assessments, due to some advantages of the statewide data layers, were not limited in this way and some segments were counted in more than one column. The statewide natural buffers may be slightly inflated; however, upon discussion of the results by Minnesota State University, Mankato, Water Resources Center and BWSR staff, we believe the estimates are legitimate.

Table 4 also includes questionnaire totals provided by the ditch authorities, the estimated GIS miles from MSU's WRC data layer, the Section 103E.021 buffer miles, voluntary miles, and the conservatively estimated "natural" buffer miles. The total miles of open public drainage ditch reported by the 13 counties on the questionnaire was 2,690.3. The 13-county GIS evaluation indicated 2,598.9 miles and the statewide GIS evaluation noted 2,901 miles in this area of the state. Please recall that different GIS ditch layers were used for the two evaluations (see discussion above).

Substantial differences between the ditch-authority reported and GIS-estimated miles were present in Nicollet and Faribault counties. Faribault County reported 165.8 miles less public drainage ditch than was estimated by the GIS assessment. Nicollet County reported 171.2 miles more public drainage ditch than the GIS evaluation. We were not able to determine a cause for these large differences; however, in the 13-county subset, the overall difference in ditch miles was 3.4 percent. Overall, between 15.1 percent and 15.7 percent of the 13-county ditch miles are buffered by RIM, CREP, and/or CRP. Of the total public drainage ditch miles present, approximately 10.6 percent are buffered on both sides of the ditch by voluntary programs. Approximately 12 percent of the total ditch miles are also buffered with grass strips associated with Section 103E.021. Natural buffer miles are difficult to place a figure on. Our more liberal statewide estimate suggested approximately 22 percent of the ditches in the 13-county were associated with some form of natural buffer. Our more conservative 13-county assessment could only verify approximately 4 percent of the 13-county ditch system in natural buffer outside of voluntary program buffer areas.

Table 4. Summary of results from a GIS assessment of voluntary program and "natural" ditch buffers in a 13-county area of south central Minnesota. Questionnaire miles, as submitted by ditch authorities, are as reported in Section 2 from each county and GIS Miles are based on a 1993 ditch evaluation conducted by the Minnesota State University, Mankato, Water Resources Center.

County	Questionnaire Miles	GIS Miles	103E Buffer Miles††	Voluntary Program Buffer Miles** (% 2-sided†)	Natural Buffer Miles†††	Total GIS Ditch Miles With Buffer	13-county Evaluation % in Buffer	Statewide Evaluation % in Buffer (no 103E buffers)
Blue Earth	161.1	156.1	27.2	25.5 (77)	9.2	61.9	39.6	40.9
Brown	210.4	236.1	11.8	38.5 (72)	7.6	57.9	24.5	38.1
Cottonwood	56.6	44.2	15.6	11.0 (69)	3.5	30.1	68.1	51.6
Faribault	80.7	246.5	6.5	35.3 (71)	6.5	48.3	19.6	29.9
Freeborn	350.0	304.6	121.4	127.8 (73)	16.0	265.2	87.1	47.4
Jackson	119.5	145.9	51.0	21.8 (72)	5.2	78.0	53.5	39.7
Le Sueur	250.3	231.8	0	52.6 (75)	12.2	64.8	27.9	68.3
Martin	188.9	188.8	NA***	19.4 (73)	6.1	25.5***	13.5***	37.9
Nicollet	469.0	297.8	0	37.3 (63)	6.8	44.1	14.8	33.0
Sibley	596.8*	513.5	25.7	52.1 (69)	4.5	82.3	13.8	39.3
Steele	90.3	89.6	43.8	22.0 (69)	7.0	72.8	16.0	40.4
Waseca	91.0	111.0	13.0	29.8 (69)	11.7	54.5	49.1	58.6
Watonwan	25.7	33.0	4.5	8.6 (71)	2.1	15.2	46.1	50.8
Totals	2,690.3	2,598.9	320.5	482.3 (71)	98.4	901.2	34.7	44.3

*Includes miles reported by Sibley County and High Island Watershed District

**Voluntary buffer program miles include lands enrolled in CRP, CREP, and RIM. Total miles, based on centerline measurements are reported, however, <100% of these ditch miles are buffered on both sides. The total ditch miles with buffer on both sides are noted in separate columns.

***NA – Martin County did not report their 103E total buffer miles.

†Percentage of voluntary program buffer ditch miles where voluntary buffers could be verified on both sides of the same ditch segment.

††Total miles of ditch with "in place" 103E required grass buffer strips, as reported by the counties in the questionnaires.

†††Only included ditch miles with verifiable land use with high buffer potential, such as prairie, pasture, hay land, and forest

GIS Analysis Findings

The GIS analysis was intended to provide insight about the implementation status of voluntary buffers along public drainage ditches in the state of Minnesota. The estimates provided below are only as good as the ditch layer data available at the time of this project. In addition to the voluntary buffer evaluation, we also completed a cursory review of land uses that may provide "natural" buffer. Given stakeholder group concerns and input from ditch authorities in northern counties about the application of buffers in non-agricultural areas, it seemed prudent to include a land use assessment here. Some of the findings listed below may seem mundane, but many should help provoke and guide discourse among drainage stakeholders.

1) The statewide surface hydrology layer (channelized streams and ditches) was used to estimate that 21,414.7 miles of public drainage ditch are present in Minnesota, however, data from Winona, Cook, Lake, and Swift counties are not included in that data layer and the data appeared to contain some private ditches. This estimate is higher than the estimates reported in Section 2, based on data from drainage authorities.

2) Based on the statewide GIS evaluation, approximately 7.3 percent of the total ditch miles were associated with CRP buffers, 0.6 percent with CREP, and 0.4 percent with RIM.

3) Table 3 breaks down the CRP, CREP, and RIM buffers and provides an estimate of "natural" buffer (land uses that provide buffer, but are not in a program) for each county. Estimated public ditch proportions protected by buffers ranged from 96.4 percent in Carlton County to 15.8 percent in Goodhue County. The combined voluntary and natural buffers protect an estimated 53.8 percent of the public drainage ditches; however, there are wide differences by county and region of the state.

4) Based on the statewide GIS evaluation, "natural" buffers are substantial in many counties and should be considered in buffer management discussions. For example, natural buffers protect an estimated 93 percent of the ditches in Aitkin County, 94 percent in Cass County, 94 percent in Itasca County, 96 percent in Koochiching County, and 90 percent in Morrison County.

5) Based on the statewide evaluation, the combined buffers are less prevalent in the western and southern portions of the state where row crop agriculture is predominant. For example, combined buffers protect 31.4 percent of Chippewa County public ditches, 25.6 percent in Clay County, 19.4 percent in Dodge County, 20.5 percent in Pennington County, 22.9 percent in Polk County, 18.6 percent in Red Lake County, and 16.8 percent in Wilkin County.

6) Based on a comparison of our statewide and 13-county evaluations, the statewide estimates for natural buffers appear to be quite "liberal" and the 13-county estimates quite "conservative". Regardless, Table 3 gives the reader a "big picture" of buffer status in Minnesota (based on available data). There are substantial differences in the estimates for some counties, while others are reasonably consistent. For example, the two evaluations were different by only 1.3 percent in Blue Earth County, but 41 percent different in Le Sueur County.

7) The 13-county data in south-central Minnesota allowed for a more detailed evaluation of Section 103E.021 buffers in addition to voluntary program buffers and conservatively estimated natural buffers. The 13-county area included Blue Earth, Brown, Cottonwood, Faribault, Freeborn, Jackson, Le Sueur, Martin, Nicollet, Sibley, Steele, Waseca, and Watonwan counties. Approximately 2,600 miles of public drainage ditch are present in this area. Of these ditch miles, an estimated 12 percent are buffered by Minnesota Statutes, 103E.021 grass strips, 19 percent by voluntary programs, and 4 percent by “natural” land uses.

8) Based on the 13-county evaluation, a total of approximately 34.7 percent of the public drainage ditch system is buffered in this area. Buffer proportions were variable by county, ranging from an estimated 13 percent in Martin and Sibley counties to almost 87 percent in Freeborn County.

9) Three areas of buffer concentrations are present in the state of Minnesota (see Figure 17 below). These areas include the Minnesota River basin, the Bois de Sioux Watershed District area, and an area including Freeborn and Steele counties. All three of these areas have benefited from conservation programs, such as CREP (MN River Basin), CRP, CCRP, and RIM, reportedly by grants to facilitate program enrollments for water quality and other environmental objectives, and apparently from dedication to the cause by local government staff, elected officials, and landowners.

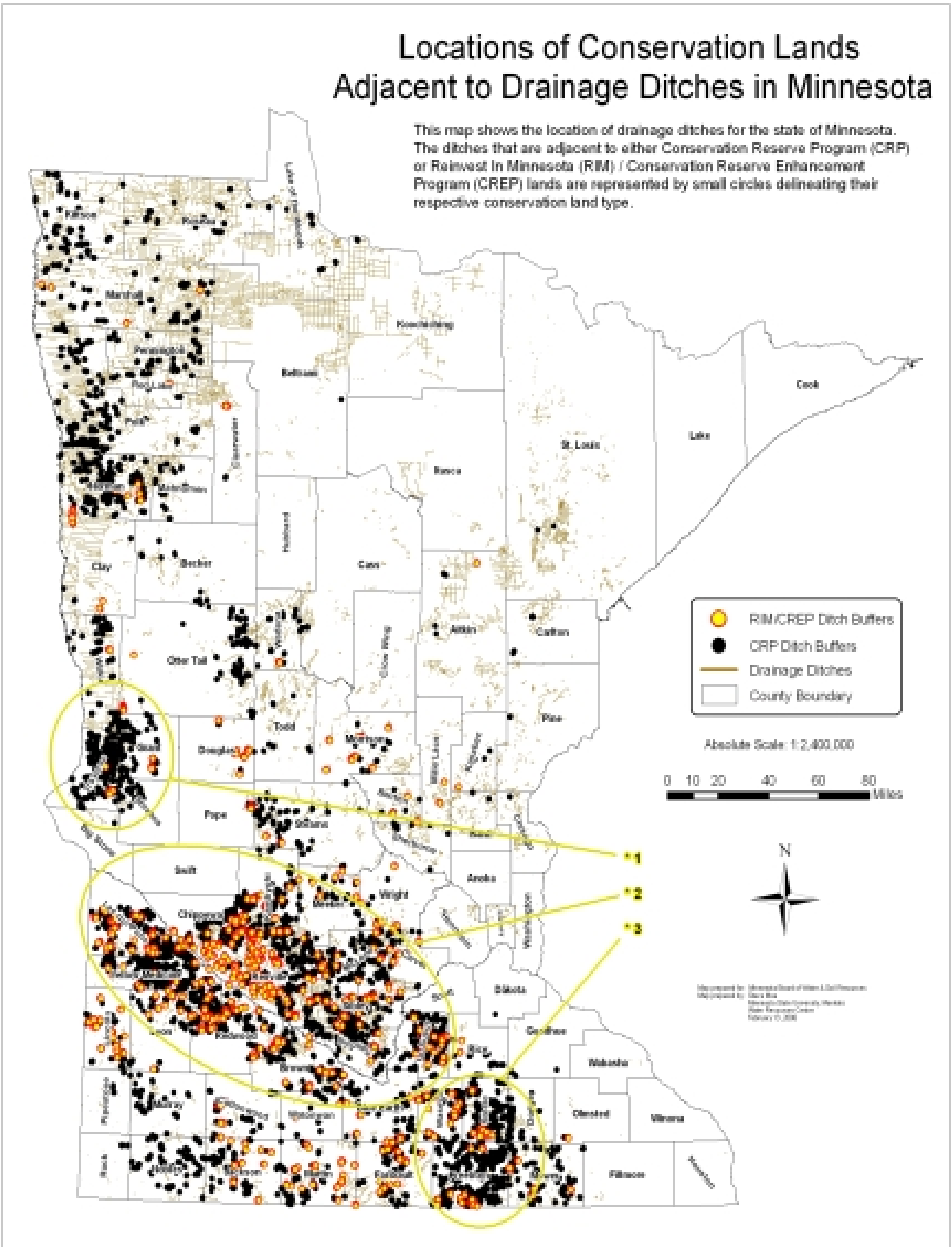


Figure 17. Minnesota map that shows the locations of public drainage ditches and voluntary program buffers. Data were unavailable for Swift, Lake, Winona, and Cook counties. Three areas of buffer concentration (1-3) are noted. Area 2 is the result of a focused effort to promote and establish Minnesota River water quality, including the CREP program. Areas 1 and 3 are likely the result of education and promotion efforts put forward by dedicated staff and elected officials about buffer value. Establishment of buffers in all of these areas was likely facilitated by sufficient staff assistance to get the enrollment processes completed. Includes some private ditch.

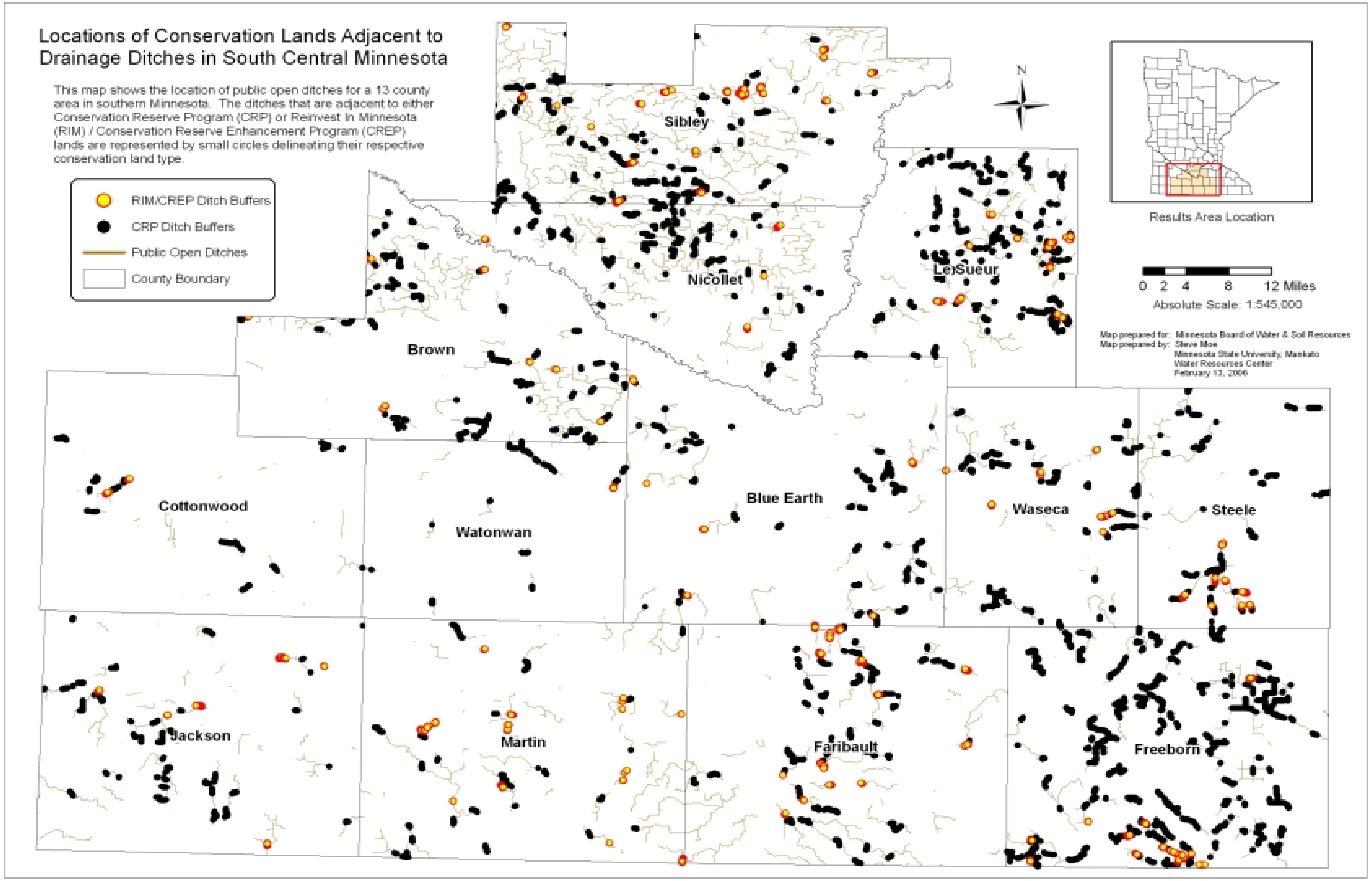


Figure 18. Map of a 13-county area in south-central Minnesota where detailed ditch, buffer, and land use data were available. The map shows the locations of open ditches and voluntary program buffers. Data are inclusive of public open ditch data only. New ditches built since 1993 would not be included in this data set.

Section 4: Benefits of Grass Buffers Along Drainage Ditches — Literature Review

Purpose and Scope

A literature review was conducted to help define the expected benefits of narrow grass buffer strips along drainage ditches, based on published research and related studies. The University of Minnesota, Water Resources Center was contracted by BWSR to conduct this literature review. The principal investigator was Dr. James Anderson, co-director, Water Resources Center, and the primary research assistant was Ms. Yiwen Chiu, a U of M master of science graduate student.

It was anticipated that there is limited literature available specifically addressing narrow grass buffers along drainage ditches or streams. Therefore, the scope of the literature review involved definition of the general benefits of vegetated buffers along watercourses, with a focus on grass buffers, and interpretation of the available research. Definition of the expected benefits of narrow grass buffers along drainage ditches was then based on the limited directly applicable research and inference from a much broader body of related research.

Methods

This literature review started with the analysis of several frequently cited articles that summarize the most commonly denoted benefits of vegetated buffer strips. Results obtained from the first phase of this review established the supposition that grass buffers along drainage ditches provide benefits in four primary categories:

- sediment and erosion control;
- water quality control;
- ecological and habitat benefits; and
- economic benefits.

In the second phase of this study, literature was searched and reviewed for each category of benefits. The review focused primarily on empirical evidence to support these four types of benefits of grass buffers. After reviewing the literature available through the University of Minnesota library system and journal database, papers strongly related to grass buffers or papers in which researchers discussed the application of buffers along a watercourse were selected. The traditional library collection and numerous on-line databases and article indexes provided major groups of literature that supported the study of each primary category of benefits that grass buffers may potentially provide. Some articles do not give direct information about the function of narrow grass buffers, but were still valuable to this literature review. For instance, although the articles "Roadside Wildlife Habitat Legislative Report" (Minnesota Department of Natural Resources, 2005) and "Red River Basin Buffer Initiative Literature Review" (Olson et al., 2005) do not focus on grass buffers along drainage ditches, the objectives are similar, or related, and the references listed in these articles led to deeper sources of valuable literature.

A broad search strategy covering diverse databases was conducted. Most of the articles were acquired on-line or via inter-library loan. Considering the scale of ditch drainage systems and the characteristics of grass buffers, this literature review classified all the benefits of grass buffers along watercourses into the four categories identified above. As a result, 43 significant articles were cited and/or summarized to support the literature review, and a list of literature references and summaries was prepared.

Constraints

The cross sections and layouts of ditches and associated spoil placement can be varied, based on the original or subsequently modified ditch designs, as well as topographic characteristics of adjacent areas. This review has to take into account a wide range of spatial scale and physical conditions of ditch systems. This limits the capability of all the empirical evidence to prove the benefits of narrow grass buffers along drainage ditches in every case. For instance, many ditches are constructed with raised spoil banks along the channels. Grassed buffers applied on these raised spoil banks may provide fewer water quality control and ecological benefits, because runoff from adjacent lands may flow along and periodically through the spoil bank, rather than across it in sheet flow. However, ditch systems might only have a spoil bank on one side of the ditch, or the spoil placement graded into the adjacent topography to slope to the ditch. This latter type of spoil placement is more likely to result in uniform surface runoff or sheet flow, in which case the effectiveness of flow gradient reduction and contact with buffer vegetation in controlling sediments and water quality, and providing other ecological benefits, is increased.

The majority of the articles found in this study focus on one of several criteria that affect the performance of buffer strips, such as vegetation, slope, width, and target contaminants. There is little direct study of grass buffers along drainage ditches and their environmental or ecological benefits. Therefore, a benefit that can be expected with a certain type of ditch and buffer may not necessarily occur for all ditches. This study will not attempt to classify different benefits based on each type of ditch construction and spoil placement, but will identify the benefits that might be provided by grass buffers under general conditions. Individual differences of ditches should be taken into account when interpreting the information contained in this review.

Benefits of Grass Buffers Along Watercourses

(1) Erosion and Sediment Control

Grass buffers can provide significant erosion and sediment control, which are the most commonly studied benefits of grass buffers. Grassed slopes and buffers are widely adopted for helping to maintain sheet flow, reduce flow velocity, trap sediment, and prevent bank erosion. Grass buffers can also trap wind-blown sediment, reducing the amount that gets into watercourses. Stott (2005) proposed that the combination of old roots in the bank and new grasses colonizing the channel bank surface may offer a “best mix” of bank protection in terms of reducing erosion. Angima et al. (2000) also found that tree/grass buffers were effective in providing erosion control and reducing the cost of cattle protein supplements at the same time. Grassed channels and buffers can reduce erosion and control sediment through four mechanisms:

- by trapping: this is a function of dense grass stems;
- by reducing the velocity of surface flow (sediment-bearing storm flows), which allows sediments to settle out of water and be deposited before they reach the channels;
- by stabilizing ditch banks, preventing soil detachment; and
- by moderating water flow in the ditch during storms, effectively reducing bed and bank scour.

It is generally understood that erosion and sediment control is a function of buffer width. Only a few researchers have found buffer width to be less important than other variables (Wenger, 1999). Results obtained from several studies that specifically addressed the effectiveness of narrow grass buffers show that the sediment removal rate can be as high as 90 percent (Table 5). It is predictable that grass buffers along drainage ditches can provide significant sediment control, where sheet flow occurs across the grass buffer.

Table 5. Sediment removal effectiveness of grass buffers estimated by various studies.

Criteria	Sediment Removal (%)	Reference
grassed	80% of sediment, 90–100% of suspended solids	De Laney, 1995
5-meter grass buffer	50–55% of total sediments 55–90% of silt and clay	Daniels and Gilliam, 1996
5-meter grass buffer	90%	Gharabaghi et al., 2002
grass buffer	91% of sediment was deposited in the first 0.6 m	Niebling and Alberts, 1979

The sediment removal effectiveness of grass buffers is also a function of various factors besides width. Das et al. (2004) studied the correlation between grass buffer width and slope length along a ditch by adopting both field and modeling approaches. The author concluded that the responses of different grass buffers varied depending on topographic and soil conditions. However, slope was still the most sensitive factors among all others. The effects of length of slope along a ditch varied significantly due to topography, sediment characteristics, and rainfall depth. Therefore, the length of slope might have to be up to 183 meters (600 ft) to show significant sediment removal under extreme circumstances.

Another factor that may influence the sediment removal rate of grass buffers along drainage ditches is the grass height. Pearce et al. (1997) focused on the interaction between grass buffer width and grass height and found that grass buffers with taller vegetation (10cm) can reduce sediment concentration in runoff water more effectively than short grass (clipped to the soil surface) with an increase of buffer width. This information also indicates a potential benefit to management costs. Maintaining the grass in its natural condition without mowing may increase its ability to reduce sediment. However, this experiment was conducted at a relatively small scale. It is also expected that periodic harvest of a grass buffer is beneficial to grass density and vigor.

While most of the studies focus on the dimensions of grass buffer strips, Rabeni et al. (1995) suggest that some qualitative characteristics, such as topography, which directly affects the pattern of surface flow, can be more important than buffer width. A study by the U.S. Army Corps of Engineers (1991) also suggested that, instead of focusing on the optimal width of buffers for preventing ditch erosion, it is more important to stabilize the channel banks and keep away negative anthropogenic activities.

The sediment removal rate and erosion control effects of grass buffers along drainage ditches are expected to be functions of several main factors including the maintenance of sheet flow across the buffer, width of the buffer, slope, grass density, and grass height. These factors influence how effectively grass buffers can reduce erosion and trap sediment. The presence of a grass buffer can prevent tillage to the edge of the ditch bank and the associated deposition or erosion of soil into the channel, and potential negative effects on channel bank stability.

(2) Water Quality Benefits

Grass buffers can contribute significantly to water quality control by reducing the concentration of contaminants and pollutants in surface runoff water in several ways, including:

- filtering out sediment and other particulate-bound pollutants/contaminants and decreasing the concentration of pollution in surface flow before it reaches a watercourse;

- increasing the infiltration rate within the buffer zone and consequently reducing surface runoff that carries pollutants into watercourses; and
- providing suitable areas for allowing biodegradation or biochemical circulation to occur.

Numerous studies indicate that grass buffers can be effective at filtering sediment-associated pollutants (particulate phosphorus and nitrogen) from surface runoff, due to their high efficiency in trapping sediment where sheet flow occurs across the buffer. Studies indicate lower, but significant, effectiveness in removing soluble nutrients such as nitrate, ammonia, and dissolved P via plant uptake and recycling (Young et al., 1980; Dillaha et al., 1989; Magette et al., 1989; Daniels et al., 1996). Grass buffers contribute to the control of soluble compounds (such as phosphorus) in terms of the slow release of compounds from vegetation to the environment (Osborne et al., 1993).

Biochemical processes associated with nitrogen reduction have also been studied to determine the benefits of grass buffers. Both Groffman et al. (1991) and Schnabel et al. (1997) found that grass buffers showed higher denitrafication rates than other types of vegetative buffers.

Several physical factors of grass buffers can affect the efficiency of water quality control, including the species of grass and the density of grass stems. Two frequently cited reports concluded that grass buffers with a width less than 5 meters still can reduce N or P concentration up to 90 percent (Table 6).

Table 6. The effectiveness of narrow grass buffers for removing N and P

Contaminant	Criteria	Removal (%)	Reference
NO_3-N, NH_4-N, PO_4-P	4.6 m grass buffer	90%	Madison et al. (1992)
Sediment, N, P	4.6 m grass buffer with 11-16% slope	54-70%	Dillaha et al. (1989)

Because grass buffers provide relatively less significant reduction of solute pollutants than for sediment and particulate pollutants, most of the literature aimed to study the effectiveness of reducing toxic compounds by increasing buffer width. For instance, Hatfield et al. (1995) found that grass buffers can remove 10–40 percent of the herbicides (atrazine, cyanazine and metolachlor) with a width of 12.2 meters (40 ft) to 24.4 meter (60 ft).

Grass buffers also show effectiveness in removing other water quality related compounds, such as fecal coliform, but required strips at least 9 meters (30 ft) wide to perform this function (34–74 percent) (Coyne et al., 1995).

It is expected that narrow grass buffers along drainage ditches can help improve water quality through nutrient trapping and recycling, depending primarily upon the existence of sheet flow across the buffer, management of the condition of the grass, and the effectiveness of the grass buffer in preventing negative anthropogenic effects (e.g. tillage to the edge of the ditch channel).

(3) Ecological and Habitat Benefits

According to two studies, a buffer strip should be 30 meters or greater in width to provide the function of reptile and amphibian habitat, and a width greater than 100 meters is recommended (Burbrink et al., 1998; Rudolph et al., 1990). Invertebrates and fish both favor buffer zones wider than 30 meters (Erman et al., 1977), whereas birds normally favor buffers that are wider than 100 meters (Hodges et al., 1996; and Triquet et al., 1990). All of these studies addressed the width of multi-vegetated buffers. Davies et al. (1994) also found that narrow grassy buffers (less than 10 meters wide) remaining after forest harvesting did not significantly protect streams from changes in biomass and diversity of algal, macroinvertebrate,and fish communities.

Another ecological factor associated with vegetated buffers is the effect on stabilizing water temperature. Osborne and Kovacic (1993) concluded that buffer widths of 10–30 meters (33–98 ft) can effectively help to maintain water temperatures in adjacent watercourses. Wenger (1999) conducted a literature review and found that buffers should be wider than 14 meters to generate significant ecological benefits in terms of maintaining water temperature, and at least 100 meters in order to be meaningful habitats.

In addition to providing habitat, grass buffers are beneficial to ecosystems and habitat by improving the chemical environment in several ways, such as 1) trapping and utilizing excess nutrients that can lead to eutrophication of aquatic ecosystems; 2) trapping sediment to prevent turbidity; 3) reducing the concentration, or errant application, of toxic contaminants (e.g., pesticides or herbicides); and 4) minimizing disturbance in watercourses due to human activities on adjoining land.

De Snoo et al. (1998) concluded that a buffer zone 6 meters wide can prevent pesticide drift to an adjacent watercourse. Moreover, even a relatively narrow buffer zone (3 meters) appears to be adequate and reduces drift deposition by 88.7 percent (wind speed 11 m/s). Creating unsprayed buffer zones 3 and 6 meters wide, therefore, can significantly reduce the short-term toxic risks to aquatic organisms and produce a major reduction in pesticide emissions to the surrounding area. These relatively narrow buffer zones may be adequate to protect flora and fauna in watercourses adjacent to agricultural areas. The author suggested that buffer zones, such as unsprayed cereal edges and unsprayed grass strips, are beneficial to the aquatic system and can be well adapted in agricultural systems to meet environmental objectives.

Grass buffers can also provide relatively fast benefits to ditch ecosystems, due to their generally short establishment time after ditch construction. If grass buffers are adjacent to other ecosystems, they can be considered part of the valuable ecotones and wildlife movement corridors connecting terrestrial and aquatic systems. Therefore, Bouldina et al. (2004) proposed that grassed buffers provide functional ecotones between agricultural fields and conveyance systems such as streams and ditches. Although grass buffers might not be able to contribute as much ecological benefit as forested buffers, Edwards et al. (1996) concluded that ungrazed grassland still can increase the biomass of terrestrial invertebrates more than pasture zones. Other factors, such as geographic location (altitude) and channel width, were not found to be significant.

Grass buffers might not be favored by many of the frequently studied biota including birds, amphibians, and mammals. However, several studies showed that small mammal communities associated with agricultural fields were relatively rich and abundant in ungrazed grassy areas such as grass buffers (Anthony, 1999; Furrow, 1994; Hall et al., 1994; Geier et al., 1980; Kirsch, 1997). The main reason is because grass buffers adjacent to croplands are able to provide convenient access to both food sources and water sources. The Minnesota DNR (2005) indicates that narrow roadside corridors are important nesting areas and contribute significantly to habitat for pheasants and other ground-nesting birds. It is expected that narrow grass buffers along drainage ditches can also provide this type of habitat, depending at least in part on the timing of potential grass harvesting. However, it is also said that narrow habitat corridors can make pheasants and other ground-nesting birds easier prey for their predators.

Narrow grass buffer strips can contribute to ecosystems and habitats in terms of buffering the aquatic system against disturbances resulting from anthropogenic activities, providing valuable ecotones and wildlife movement corridors, and helping to reduce water pollution and turbidity that can lead to habitat degradation. These potential benefits depend in part on the adjacent land use, location relative to other wildlife habitat and the presence of sheet flow of runoff from adjacent land across the buffer.

(4) Economic Benefits

Only a few economic benefits provided by grass buffers have been studied. By summarizing the results of three studies, Barrowclough (2003) concluded that there are potential economic benefits due to reduction in ditch maintenance and cleaning costs. This is associated with the trapping of both water-born and wind-blown sediment, as well as channel bank erosion reduction. Based on cost estimates conducted in western Ohio counties, each 10 percent reduction in soil erosion could reduce the costs of ditch maintenance by 11percent. The annual return also showed a gradually increasing trend of reduced maintenance costs in terms of erosion control after the grass buffer was implemented.

Grass buffers are one of the Best Management Practices (BMPs) recommended by the U.S. Environmental Protection Agency that have been used by many local projects. These projects have shown that grass buffers that serve as filter strips are among the most cost-efficient measures for water quality control. In addition to water quality benefits, bank stabilization and habitat benefits for terrestrial animals, the EPA also states that grass buffers provide economic benefits to landowners (EPA, 1999). Increased habitat for wildlife, such as pheasants and other game birds, is expected to provide potential direct and indirect economic benefit for landowners and hunters to the extent that narrow grass buffers can provide these benefits.

Benefits of Narrow Grass Buffers Along Drainage Ditches

Although there are numerous research studies regarding the benefits of vegetated buffer strips, including grass buffers, very limited research has been done focusing on grass buffers along drainage ditches. Nevertheless, certain benefits to drainage systems and the environment from narrow grass buffers along drainage ditches are supported by, or can be inferred from, the available literature, including:

- helping to stabilize ditch banks, including surface erosion control and preventing farming to the edge of the channel, which can reduce ditch maintenance;
- trapping of water-born sediment, where there is sheet flow from adjacent land across the grass buffer;
- trapping of wind-blown sediment, depending on variables such as grass stand management, timing of potential grass harvest and width of the grass buffer;
- improving water quality through trapping of sediment and microbes and recycling of nutrients, primarily where there is sheet flow from adjacent lands across the grass buffer;
- providing narrow strips of wildlife habitat, ecotones, and wildlife movement corridors between potential aquatic and terrestrial habitats in the area of the ditch; and
- providing some buffer of the ditch channel related to the potential application of pesticides and herbicides on adjacent cropland.

In general, narrow grass buffers can be effective in removing pollutants and reducing ditch maintenance associated with sediment transported by water that crosses the buffer as sheet flow and sediment transported by wind; controlling erosion of the ditch bank; buffering the ditch from anthropogenic impacts; and providing limited wildlife habitat and travel corridors. Narrow grass buffers are relatively less effective at removing highly soluble chemicals from runoff, especially when the landscape tends to concentrate runoff from adjacent lands and accelerate flow velocities. The magnitude of potential benefits can vary substantially depending on the topography along a ditch, the width of the grass buffer, and management of the grass buffer. With raised spoil banks along a ditch, the water-born sediment and nutrient trapping benefits of narrow grass buffers may be negligible, because sheet flow from adjacent land does not occur across the grass buffer. In this case, runoff from the adjacent land flows to and along the spoil bank to an open side-inlet ditch, closed conduit side inlet, or ponding area with or without a subsurface drain.

The wind-blown sediment trapping benefits and wildlife habitat benefits of narrow grass buffers are primarily dependent on the grass harvest timing and amount, other maintenance of grass density, and the width of the grass buffer. Narrow grass buffers along drainage ditches are expected to provide a significant buffer of the ditch bank and drainage system from farming to the edge of the channel and some buffer from potential application of pesticides and herbicides on adjacent cropland. Control of ditch bank erosion and stability, as well as potential control of wind-blown and water-born sediment, can significantly reduce ditch maintenance, which reduces the frequency of disturbance of the ditch channel, banks, and grass buffer and the associated costs to the drainage system.

Section 5: Pertinent Requirements, Incentives, and State Roles in the Midwest

Purpose and Summaries

This section summarizes requirements, incentives, and state roles regarding buffers along public drainage ditches in Minnesota and other Midwestern states having substantial agricultural drainage. This information is based on communication with conservation agencies in other states and brief reviews of pertinent drainage laws and policies in these states.

State	Requirements for Public Drainage Ditch Buffers
Minnesota	State drainage law requires minimum 1-rod grass strip from top of ditch bank, when viewers are appointed by a drainage authority, for drainage system establishment, improvement, certain types of repairs or redetermination of benefits.
Iowa	No requirements by state or drainage districts.
Illinois	No requirements by state or drainage districts.
Indiana	No requirements by state or county drainage boards.
Ohio	State requires petitioned ditches, and private ditches that become public via public maintenance or improvement, to install a 4 ft. to 15 ft. sod or seeded berm along the ditch (exact width set by designer, based on water quality needs).
Michigan	No hard requirements by state or county drain commissions.
Wisconsin	State drainage law requires a minimum 20-ft. “drainage district corridor” along all drainage district ditches (both sides, with exceptions) for purposes of access for inspection, surveying, maintaining, repairing, restoring or improving a district ditch and as a buffer against land uses that may adversely affect water quality in a district ditch. (Requirement in place since 1995, still being implemented.)

State	Incentives Available for Public Drainage Ditch Buffers
Minnesota	Conservation Reserve Program (CRP) and Continuous CRP (CCRP); Reinvest in Minnesota Reserve Program (RIM); Conservation Reserve Enhancement Program (CREP); State Cost-Share Program; Private Lands Program – USFWS; some local government buffer incentive programs
Iowa	CRP/CCRP
Illinois	CRP/CCRP, CREP in some watersheds; IL Landowner Incentive Program in Lower Sangamon River Basin Pilot Area (Focus is on endangered, threatened or rare species habitat, can be along drainage ditches.); State Streambank Stabilization Cost-Share Program, can involve drainage ditches and buffers.
Indiana	CRP/CCRP; CREP in 3 watersheds; statewide Lake and River Enhancement Cost-Share Program for various practices including buffers
Ohio	CRP/CCRP; CREP for part of state; Up to 15% reduction in maintenance assessment, if landowner maintains required 4 ft. to 15 ft. berm.; Statewide cost-share program up to 50%, if 2:1 or flatter ditch side slopes and sodded, or seeded berm implemented, but this program has not been funded for about past 10 yrs.
Michigan	CRP/CCRP; CREP in watersheds with substantial agriculture; drainage assessment based on runoff coefficient, which buffers along drainage ditches can reduce
Wisconsin	CRP/CCRP; CREP (buffer can include first 20 ft. from public ditch (drainage district corridor), if drainage board allows.

State	State Role in Implementing and/or Maintaining Public Drainage Ditch Buffers
Minnesota	DNR provides advisory review of all drainage authority projects involving establishment or improvement of a public drainage system. BWSR provides advisory review of all watershed district projects involving establishment or improvement of a public drainage system. Compliance with Sec. 103E.021 is one aspect of these reviews.
Iowa	No direct state role. State Drainage Coordinator position authorized, but never funded.
Illinois	State provides cost-share and technical assistance for Streambank Stabilization Program, which can involve drainage ditches and buffers.
Indiana	Indiana Drainage Handbook (advisory) includes Permanent Maintenance Access (along public ditches) as a BMP (no width specified). Indiana DNR permit required for ditch establishment, improvement or repair for project watershed > 1 sq.mi., which provides opportunity for state to promote use of Permanent Maintenance Access.
Ohio	Soil and Water Conservation Districts provide technical assistance for planning, construction and maintenance of public drainage systems, or counties provide technical assistance and assess the system. Ohio DNR, Division of Soil Conservation, is involved as an advisor for inter-county projects, or as cost-share administrator, for state cost-shared projects, including compliance with Ohio's 4 ft. to 15 ft. seeded berm requirement.
Michigan	Michigan Department of Agriculture, Environmental Stewardship Division involved on all inter-county drainage commissions. Provide pertinent training. Conservation Districts provide technical assistance for drainage projects.
Wisconsin	State Drainage Engineer provides guidance, technical assistance and oversight for public drainage ditches, including access corridors.

This brief comparison indicates that Minnesota, Wisconsin, and Ohio have state requirements for permanent grass strips, ditch corridors, or seeded berms, respectively, along certain public drainage ditches. Iowa, Illinois, Indiana, and Michigan do not have state or local government requirements for vegetated buffers along public drainage ditches at this time.

All of these Midwestern states have applicable federal conservation programs available that can help install buffers along public drainage ditches. Some states have applicable state conservation incentive programs available and/or state-federal partnership programs, such as CREP. It appears that Minnesota has more federal, state, and local conservation incentive programs available than other Midwestern states that include practices for the establishment of buffers along watercourses, including public drainage ditches.

Direct state involvement in public drainage system establishment and maintenance varies substantially in these Midwestern states. It appears that Wisconsin has the most direct state involvement via a State Drainage Engineer position. Indiana requires a drainage permit for project watersheds greater than 1 sq. mile, and both Michigan and Ohio have state agency involvement for inter-county drainage commissions and projects. Soil and water conservation districts in some Midwestern states provide substantial technical assistance for public drainage system design and maintenance. In Minnesota, drainage authorities typically hire private engineers for design and maintenance technical assistance, paid via drainage system assessment.

All of these Midwestern states have some level of state agency involvement in drainage policy administration, as well as drainage information and education.

Wisconsin Buffer Initiative

During the past several years, Wisconsin has invested considerable efforts to address the use of vegetated buffers and other conservation practices in riparian areas for nonpoint pollution control. Although this initiative does not directly address riparian buffers along public drainage ditches, it is a substantial science-based initiative with relevance to this study. Following is a summary of background events and results of the Wisconsin Buffer Initiative to date:

- Beginning in 1999, Wisconsin began to implement revised state requirements for nonpoint pollution control from agricultural and non-agricultural runoff.
- A work group developing rules for implementation of state administrative code recommended mandating of riparian buffers and conservation tillage.
- Arguments for and against this recommendation led to an impasse regarding scientific justification.
- An ad hoc committee of University of Wisconsin scientists and involved stakeholders was formed to review the science available regarding the functioning of riparian buffers.
- In April 2002, this ad hoc committee issued a report titled *"Filter Strips and Buffers on Wisconsin's Private Lands: An Opportunity for Adaptive Management"* (see http://www.drs.wisc.edu/wbi/report.doc).
- In May 2002, the Wisconsin Department of Natural Resources was directed to collaborate with the University of Wisconsin, College of Agricultural and Life Sciences (UW-CALS) on the development of a science-based agricultural buffer standard.
- The UW-CALS was asked to address the recommendations in the April 2002 report and to submit a final report to the Natural Resources Board before December 31, 2005.
- The Wisconsin Buffer Initiative (WBI) was formed to carry out a charge to: "Based on the best available science, where, across the diverse Wisconsin agricultural landscape, would conservation systems and riparian buffers enhance the quality of the state's waters?"
- The WBI was financed in part by federal funds.

Key elements and recommendations of the Wisconsin Buffer Initiative include:

- Watershed prioritization was addressed for the following variables:
  - potential for phosphorus and sediment reduction;
  - biological responsiveness of sediment-sensitive fish; and
  - potential to sustain lake water quality through reduction of phosphorus inputs.
- The WBI ranked 1598 watersheds across Wisconsin, averaging 20 square miles in size, for expected benefits of riparian conservation practices, including buffers.
- Planning and implementation tools, design of conservation systems and riparian buffers, and economic impacts of alternative management practices were evaluated, including two pilot studies.
- Recommendations of the WBI include:
  - An adaptive management approach is recommended to foster continual improvement in natural resource management practices and policies.
  - Focus limited resources on watersheds and problems causing a disproportionate share of water quality degradation and having the most potential for improvement.
  - Utilize a conservation systems design approach, focusing first on upland treatment, complimented by site specific riparian buffers, as necessary.
- The final WBI report is available at: http://www.drs.wisc.edu/wbi/reports/nrbFinalReport.pdf.

Section 6: Study Work Group Discussion Topics and Recommendations

Discussion Topics

The study work group discussed a range of drainage topics, including topics directly related to buffers along public drainage ditches and other topics for which there are perceived issues and ideas to help resolve these issues. Following is a list of topics discussed (not in priority order):

- BMP Manual for public ditches.
- Clearer definition of point of beginning for measuring required grass buffer strips.
- Require grass buffer strip implementation by a defined date.
- Clarify authority to use ditch maintenance funds for grass buffer strip implementation.
- Training for viewers and drainage in general.
- Certification of viewers.
- Enhance, and better enable, federal and state funding for grass buffer strip implementation.
- Require annual reporting by drainage authorities (e.g. improvements, maintenance, enforcement, redeterminations).
- Abandonment procedures.
- Dispute review by other than drainage authority or district court.
- Prioritizing buffer efforts to maximize environmental benefits.
- Landowner / watershed workshops on drainage law, buffers, and ways to integrate programs.
- Enhance drainage authority ability to establish buffers.
- Continuation of a drainage work group (to further discuss these and other drainage topics and make consensus recommendations).

Recommendations

By consensus, the study work group decided to provide several recommendations in regard to public drainage ditch policies and actions. One objective of these recommendations was to help address key impediments to implementation of Section 103E.021 identified by responses to Question 10 of the survey questionnaire sent to all drainage authorities. Another objective was to help address other drainage issues for which there is general agreement about potential solutions, and/or agreement to further discuss.

- *Clarify the definition of the point of beginning for measuring the required grass buffer strips.* This is to promote consistency of interpretation statewide (particularly for drainage systems that cross drainage authority boundaries).

- *Enhance the ability of drainage authorities to establish and maintain buffers.* The benefits of buffers along watercourses are generally accepted. The process and costs for establishment and maintenance of buffers should be streamlined and/or reduced.
    - Give drainage authorities clear authority to appoint viewers for determination of damages (i.e. drainage system costs) for establishment of grass buffers along public drainage ditches, without having to do a redetermination of benefits for the applicable drainage system, or subsystem.

    - Provide, or clarify, authority to use ditch maintenance funds for grass buffer strip implementation, including paying for viewers' determination of associated damages, in accordance with recommendation A.
    - Better enable drainage authorities to piggyback with federal and state conservation programs and funding to establish and maintain grass buffer strips.
    - Increase information and education for affected landowners, drainage authorities, and involved agencies, as well as legal advisors and technical assistance providers to drainage authorities, regarding drainage law, buffers, and ways to integrate programs, purposes, and funding.

- *Develop recommended method(s) for drainage records modernization.* This should be based on the experience of drainage authorities that have already developed modern drainage system inventories. It is recognized that many drainage authorities do not have a modern drainage inventory, and for those that do, the level of detail varies significantly.

- *Develop a Best Management Practice (BMP) Manual for public drainage systems.* The Minnesota Public Drainage Manual is focused on drainage law and process. There is a need for a manual with a focus on drainage system management from pragmatic technical, administrative, and landowner perspectives. This manual should help identify and prioritize drainage management options for differing situations and help to better integrate conservation programs and funding with public drainage systems. This includes prioritizing buffer efforts to maximize environmental benefits. Appropriate research and experience should be utilized to clarify science-based benefits, costs, and applicability of drainage system BMPs.

- *Further consider the pros, cons, and advisability of requiring regular reporting by drainage authorities.* Considerations should include the need, value, and costs of statewide data collection and management.

- *The study work group should continue to discuss these drainage topics during 2006 and seek consensus recommendations to the Legislature, with continued facilitation by BWSR.* This should enable more return on the investment of time and discussion by the broad cross section of entities represented on the study work group.

Appendix 1A: Information Request to Drainage Authorities

- Letter to Drainage Authorities
- Questionnaire – Part 1
- Questionnaire – Part 2

Minnesota Board of Water & Soil Resources

October 24, 2005

Chairpersons
Minnesota County Boards and
Minnesota Watershed District Boards

Re: Public Drainage Ditch Buffer Strip Study

Dear Chairperson,

The 2005 Minnesota Legislature debated a bill that proposed to clarify the required width of grass buffer strips along public drainage ditches. That debate resulted in a directive to the Board of Water and Soil Resources (BWSR) to conduct "an assessment of public drainage system buffers and their use, maintenance and benefits", and report back to the appropriate Senate and House committees in early 2006. An advisory workgroup involving representatives of farm groups, watershed districts, soil and water conservation districts, counties, and conservation organizations, as well as federal agencies implementing voluntary buffer programs, was formed in early September to help define the scope of this study, including the enclosed 2-part questionnaire to Minnesota public drainage authorities.

The current study will use, as a starting point, a related study conducted in 1986 for the Minnesota Legislature. A copy of that report, dated January 1987, is enclosed.

The BWSR has established an agreement with the Minnesota State University, Mankato (MSU-M), Water Resources Center to assist with the current study.

As part of the response to the Minnesota Legislature, I am respectfully requesting the following of all public drainage authorities in Minnesota.

1. Please complete the enclosed, postage-paid point-of-contact postcard and mail it to the MSU-M Water Resources Center, as soon as possible.
2. Please complete the attached 2-part questionnaire and return it to the MSU-M Water Resources Center in the enclosed, postage-paid envelope by December 9, 2005.

If your drainage authority would like an electronic version of the questionnaire, please go to www.bwsr.state.mn.us and click on "Public Drainage Ditch Buffer Strip Study Questionnaire" in the lower right portion of the BWSR home page.

(Note to County Board Chairpersons: The point-of-contact postcard and questionnaire return envelope are included in the County Auditor cc packets.)

When complete, the current public drainage ditch buffer strip study will include the following components:

- Background information and illustrations about drainage needs and systems, because many Legislators may not have experience with drainage systems;
- Historical information about M.S. 103E.021 and the 1986 study;
- A summary of buffer implementation along drainage ditches through voluntary landowner participation in federal and state conservation programs. (GIS-based, to the extent possible.);
- A literature search for research regarding the benefits of grass buffer strips along drainage ditches.

Please direct questions about the questionnaire to:

Shannon Fisher, Director
Minnesota State University - Mankato, Water Resources Center
507-389-5492 or
shannon.fisher@mnsu.edu

General questions about the study can be directed to Al Kean at 651-297-2907 or al.kean@bwsr.state.mn.us .

The participation of your drainage authority in filling out the attached 2-part questionnaire is critical for an accurate assessment and report to the Legislature. Thank you very much, in advance, for your participation!

Sincerely,

Ronald D. Harnack
Executive Director

cc:	County Auditors (with all enclosures)
	County Ditch Inspectors (letter only)
	Shannon Fisher, MSU-Mankato, Water Resources Center

Enclosures:

- Report to the Minnesota Legislature: "Minnesota Public Drainage Ditch Systems", January 1987
- Point-of-Contact Postcard
- Public Drainage Ditch Buffer Strip Study, Questionnaire – Part 1
- Public Drainage Ditch Buffer Strip Study, Questionnaire – Part 2
- Questionnaire Return Envelope

Public Drainage Ditch Buffer Strip Study
Questionnaire – Part 1

Drainage Authority: ____ **Date:** _______________
(County or Watershed District Name)

Contact Person: ____________________________ **Title:** ____________________________________

Telephone No.: ______________________ **Email Address:** __________________________________

1. What type of public drainage system inventory and/or records does your drainage authority have? *(Please check all that apply.)* a. _____ Inventory b. _____ Records Only
   c. GIS based _____
   d. Electronic database _____
   f. Spreadsheet(s) _____
   f. Paper files and master map _____
   g. Paper files only _____
   i. Other (please describe) _____ ____

a. How many miles of open public drainage ditches are under your jurisdiction? __________ miles
   (Please provide miles here and below to the nearest 0.1 mile.)

3. How many ditch projects or proceedings under your jurisdiction, since the SWCB survey in 1986, have triggered the appointment of viewers and the requirement for installation of permanent grass buffer strips in accordance with Minnesota Statutes 103E.021? *(Please indicate the number for each type.)*
   a. Establishment of a new public drainage ditch. _____ projects or proceedings
   b. Improvement of an existing public drainage ditch. _____ projects or proceedings
   c. Ditch repair in accordance with 103E.715, Subd. 6. _____ projects or proceedings
   d. Redetermination in accordance with 103E.351. _____ projects or proceedings
   e. Other (Please define.) _____ projects or proceedings

4. How many miles of public drainage ditches under your jurisdiction are required to have a one-rod, or wider, permanent grass buffer strip, in accordance with 103E.021?
   a. On one side of the ditch. __________ miles
   b. On both sides of the ditch. __________ miles

5. How many miles of public drainage ditches identified in question 4 have had the required grass buffer strip(s) installed?
   a. On one side of the ditch. __________ miles
   b. On both sides of the ditch. __________ miles

6. Of the grass buffer strips installed in accordance with 103E.021 under your jurisdiction, how many miles are currently in place?
   a. On one side of the ditch. __________ miles
   b. On both sides of the ditch. __________ miles

7. Does your drainage authority have rules or policies for the harvest of grass buffer strips by the landowner and/or assigns, in accordance with 103E.021, Subd. 2? *(Please mark the most applicable category.)*
   a. Yes – rules or policies are in place. _____
   b. Rules or policies are under development. _____
   c. No – rules or policies are not in place or under development at this time. _____

8. Does your drainage authority have a program for regular inspection of ditches and required grass buffer strips, in accordance with 103E.021, Subd. 4 and 103E.705, Subd. 2?
   a. Yes _____
   b. No _____

9. How many times, since the SWCB survey in 1986, has your drainage authority taken the following grass buffer strip compliance actions in accordance with 103E.021, Subd. 4. and 103E.705, Subd. 2.? *(Please provide a number for each category.)*
   a. Sent a compliance notice to a noncompliant property owner. _____ times since 1986
   b. Issued an order to have the work performed necessary to bring a noncompliant property into compliance with 103E.021. _____ times since 1986
   c. Sent a statement of the expenses incurred to bring a property into compliance to the county auditor and the property owner. _____ times since 1986

10. What, if any, impediments to implementation of 103E.021 grass buffer strips are experienced by your drainage authority? *(Please mark all that apply.)*
    a. Drainage system landowner concerns about costs of permanent easement acquisition and loss of cropland vs. benefits of grass buffers. _____
    b. Cost of redetermination of benefits. _____
    c. Grass buffer strips only being required when viewers are appointed. _____
    d. Interpretation by drainage authority attorney that the drainage system can't pay to restore vegetation affected by spoil placement on CRP contract land. _____
    e. Other impediment. *(Please define.)* _____

    ____

    ____

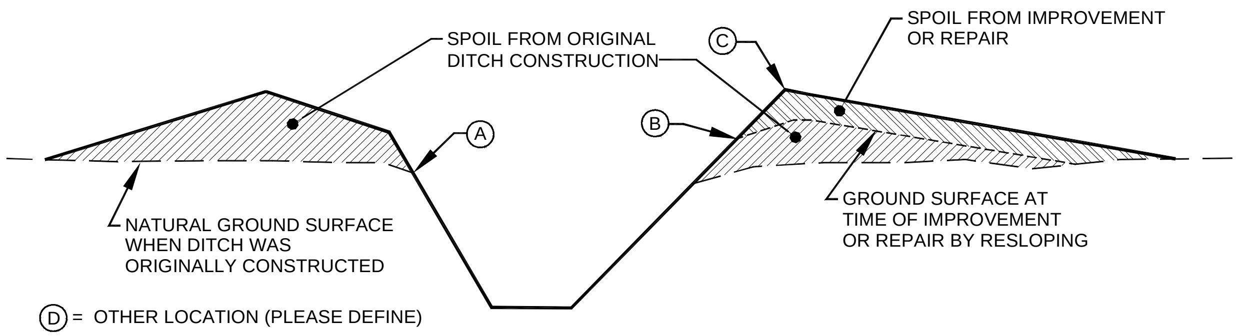
11. Does your drainage authority have a plan and/or procedures in place to update drainage ditch benefit determinations on a routine basis? _____ Yes _____ No
    If yes, please briefly describe the plan or procedures. ________________________________

    ____

    ____

12. Where does your drainage authority define the top edge of the channel of the ditch when applying the grass buffer strip width requirement of 103E.021? *(For new ditches, as well as improvements or repairs, please indicate the applicable letter from the sketch below of the location of the top edge of the channel used by your drainage authority and/or describe another location at D below.)*

    a. For new ditches. _____ b. For ditch improvements or repairs. _____



    ____

    ____

13. Approximately how many miles of public drainage ditches under your jurisdiction are currently buffered through voluntary conservation programs such as CRP, RIM, CREP, or another program?
    a. On one side of the ditch. __________ miles
    b. On both sides of the ditch. __________ miles

14. Any additional comments about grass buffer strips or 103E.021? ______________________________

    ____

    ____

Public Drainage Ditch Buffer Strip Study Questionnaire – Part 2

Drainage Authority:								
Ditch Location: County or Joint Counties	Name or Number of Ditch Project Requiring Grass Buffer Strip(s) Since 1986	Project Type (Establishment= E, Improvement = I, or Repair Requiring Viewers = R)	Year Completed	Ditch Length (miles)	Grass Strip(s) Installed, One Side (miles)	Grass Strip(s) Installed, Both Sides (miles)	Grass Strip(s) Currently In Place, One Side (miles)	Grass Strip(s) Currently In Place, Both Sides (miles)
			Totals					

Appendix 1B: Raw Data Responses to Questionnaire – Part 1

County	Survey	1a	1b	1c	1d	1e	1f	1g	1h	est.	2	3a	3b	3c	3d	3e	4a	4b	5a	5b	6a	6b	7a	7b	7c	8a	8b	9a	9b	9c	10a	10b	10c	10d	10e	11	12a	12b	13a	13b	14
Aitkin	R		x			X	x			x	590.0	0	0	0	0	0	0	0	na	na	na	na			x		x	na	na	na					x	n	na	na	0	550	n
Anoka	R	x	x				x				133.2	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0			x		x	n	na	na	na	na	y
Becker	R		x				x	x			12.0	0	0	0	0	0	0	0	0	0	0	0			x	x		0	0	0		x				n	na	na	0	0	n
Beltrami	R		x				x			x	900.0	0	0	0	0	0	1	6	1	6	1	6			x	x		0	0	0	x					n	a	b	0	0	y
Benton	R	x						x			57.7	0	0	1	0	0	0	7.2	0	7.2	0	7.2			x	x		0	0	0						n	na	c	0	0	y
Big Stone	R		x				x			x	200.0	0	0	8	8	0	5	50	1.5	12	1.5	12			x	x		0	1	3	x	x				n	c	c	na	na	n
Blue Earth	R	x		x	x	X	x				161.1	2	4	6	0	1	0	31.8	0	27.2	0	27.2	x			x		3	0	0	x	x	x			n	a	a	na	na	n
Brown	R						x				210.4	0	1	0	8	0	0	11.78	0	11.78	0	11.78				x		0	0	0	x	x				n	c	c	na	na	n
Carlton	N																																								
Carver	R			x	x		x				77.2	0	0	0	0	0	0	21	0	21	0	21			x		x	3	0	0		x	x		x	n	b	c	3.2	1.6	y
Cass	R				x				x		na	0	0	0	0	1	0	0	0	0	0	0			x		x	0	0	0						n	na	na	0	0	n
Chippewa	R	x		x	x		x				460.0	na	na	na	na	na	0	23.3	0	23.3	0	13.3			x	x		19	0	0	x	x	x			n	c	c	0	125	n
Chisago	R							x		x	70.0	0	0	0	0	0	Na	na	na	na	na	na			x		x	0	0	0						n	na	na	na	na	n
Clay	F																																								
Clearwater	R		x					x			2.9	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0		x			x	n	a	a	na	na	n
Cook	N																																								
Cottonwood	R							x			56.6	0	5	0	0	0	0	15.6	0	15.6	0	15.6			x		x	0	0	0						n	a	b	30	0	n
Crow Wing	R							x			80.0	0	0	0	0	0	0	0	0	0	na	na			x		x	0	0	0						n	na	na	na	na	y
Dakota	R		x				x	x			11.5	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	d	d	2.5	1.25	n
Dodge	R	x		x		x					37.9	0	0	0	1	0	0	30.6	0	30.6	0	30.6			x	x		11	0	0			x			n	na	c	1.2	0.6	y
Douglas	R	x		x			x				158.0	0	0	0	4	2	37	83	37	10	63	63			x	x		0	0	0	x	x	x			n	na	c	na	na	y
Faribault	R										80.7	1	3	0	0	0	0	21.75	0	6.45	0	6.45			x		x	0	0	0	x	x				y	c	c	na	na	n
Fillmore	N																																								
Freeborn	R	x	x			x	x	x		x	350.0	1	11	0	12	0	0	350	0	121.4	0	121.4			x	x		2	0	0						y	c	c	10	0	y
Goodhue	R		x				x				2.2	0	0	0	0	1	0	0	na	na	na	na			x		x	0	0	0		x	x	x		n	na	a	0.2	0	n
Grant	R							x			128.7	na	na	na	na	na	0	5.9	0	na	na	na			x		x	0	0	0	x					n	na	na	na	na	n
Hennepin	R		x				x				57.0	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	na	0.2	0	n
Houston	R		x				x				11.0	0	0	0	0	0	0	0	na	na	na	na			x		x	na	na	na						n	c	na	na	na	n
Hubbard	R							x			na	na	na	na	na	na	Na	na	na	na	na	na						na	na	na						na	na	na	na	na	n
Isanti	F																																								
Itasca	N																																								
Jackson	R	x		x			x				119.5	0	3	0	2	0	0	119.5	0	51	0	51			x	x		na	na	na						na	b	b	na	na	n
Kanabec	F																																								
Kandiyohi	R				x		x			x	500.0	1	0	0	0	0	31.4	10.2	15.2	5	15.2	5			x	x		0	0	0	x	x				n	a	na	180	90	n
Kittson	R	x					x	x			238.3	0	0	0	0	0	0	5	0	5	0	5			x		x	0	0	0	x	x	x			n	a	b	0	10.6	n
Koochiching	R		x						x	x	486.5	0	0	0	0	0	0	4.25	0	4.25	0	4.25			x		x	0	0	0						n	c	c	na	na	n
Lac qui Parle	R						x				391.0	0	5	0	2	0	0	7.5	0	0	0	7.5			x	x		1	0	0		x				n	c	c	na	na	n
Lake	R		x					x			0.3	0	0	0	0	0	0	0	0	0	0	0			x	x		0	0	0						n	na	na	0	0	n
Lake of the Woods	R			x				x			650.5	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0		x				n	na	na	0	0	n
Le Sueur	R		x					x			250.3	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0	x	x	x			n	na	na	0	0	n
Lincoln	R			x			x				105.0	0	5	1	1	0	0	50	0	50	10	30		x		x		1	0	0	x					n	c	c	na	na	y
Lyon	R		x	x	x	x	x				162.4	0	6	1	6	0	0	38.9	0	38.9	0	38.9			x	x		0	0	0	x	x				n	a	c	0	9	n
Mahnomen	R		x					x	x		100.7	0	0	0	0	0	23.9	76.8	0	0	na	na			x		x	0	0	0	x	x				n	b	c	na	na	n
Marshall	R						x				na	0	0	0	0	0	2	0	2	0	2	0			x		x	0	0	0						n	na	na	na	na	y
Martin	R			x		x	x	x			188.9	10	10	3	0	9	na	na	na	na	na	na		x			x	1	1	1	x	x				y	a	a	na	na	n
McLeod	R		x	x			x				201.5	0	0	0	0	0	0	12.3	0	na	0	na			x		x	0	0	0						n	a	b	0	0.5	n
Meeker	R	x				x	x				175.0	0	0	0	0	0	0	15	0	10	0	5	x				x	0	0	0		x				n	b	c	10	20	n
Mille Lacs	R							x			27.0	0	0	0	0	0	0	0	na	na	na	na			x		x	0	0	0			x			n	na	na	0	8	n
Morrison	R							x			na	0	0	0	0	0	na	na	na	na	na	na			x		x	0	0	0						n	na	na	na	na	y
Mower	R					x	x				27.0	0	0	5	5	0	0	21	0	21	0	21		x		x		1	0	0		x				n	na	c	na	na	n

County	Survey	1a	1b	1c	1d	1e	1f	1g	1h	est.	2	3a	3b	3c	3d	3e	4a	4b	5a	5b	6a	6b	7a	7b	7c	8a	8b	9a	9b	9c	10a	10b	10c	10d	10e	11	12a	12b	13a	13b	14
Murray	R			x	x			x			95.7	0	7	8	8	0	1	14.9	1	14.875	1	13.875			x	x		0	0	0		x				n	na	c	na	na	n
Nicollet	R		x				x				469.0	0	0	0	0	0	0	0	0	0	0	0				na	na	0	0	0						n	na	na	na	na	n
Nobles	R						x				47.0	0	0	0	0	0	0	0	0	0	0	0			x	x		0	0	0		x	x			n	c	c	na	na	n
Norman	R						x		x		138.7	0	0	0	0	0	na	na	na	na	na	na				x		na	na	na	x	x	x		x	n	na	na	na	na	y
Olmsted	F																																								
Otter Tail	R		x				x			x	190.0	0	0	2	0	0	na	na	na	na	na	na			x	x		0	0	0					x	n	na	c	0	0	y
Pennington	F																																								
Pine	R	(Fire destroyed most records)							x		na	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	na	0	0	n
Pipestone	R						x				14.9	0	0	0	0	0	0	0	0	0	3.8	9.2			x		x	0	0	0		x				n	c	c	1	0	n
Polk	R	x	x			x	x		x		809.6	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						y	na	na	250	0	y
Pope	R		x				x	x	x		67.7	1	1	6	5	0	0	23.4	0	23.4	0	23.4			x	x		0	0	0	x	x	x			n	a	a	0	20	y
Ramsey	R	x	x	x			x	x			1.5	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	na	0	0	n
Red Lake	R									x	175.0	na	na	na	na	na	na	na	na	na	na	na						na	na	na						na	na	na	na	na	n
Redwood	R	x	x			x	x		x		521.3	1	6	0	0	0	0	22.7	0	22.7	0	22.7	x			x		2	0	0	x	x				n	b	c	90	106	n
Renville	R	x			x	x	x				787.5	0	1	0	5	0	0	7	0	7	0	7			x		x	0	0	0	x	x	x			n	c	c	0	42	n
Rice	R						x	x			72.0	0	0	0	0	0	na	na	na	na	na	na			x	x		4	0	0	x	x				n	na	na	na	na	n
Rock	R		x				x				4.0	0	0	0	0	0	0	4	0	4	0	4			x	x		2	0	0	x					n	c	c	0	0	n
Roseau	R		x								831.4	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	na	20	0	n
St. Louis	R		x				x	x			546.0	0	0	0	0	0	0	0	na	na	na	na			x		x	0	0	0						n	a	b	100	50	n
Scott	R	x		x			x	x			54.3	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	na	2.4	5	n
Sherburne	R		x				x				150.4	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	c	0	0	n
Sibley	R	x	x				x				550.0	1	5	0	0	0	0	25.7	0	25.7	0	25.7			x		x	0	0	0	x	x				y	c	c	94	0	y
Stearns	R			x	x		x				45.0	0	0	0	0	0	na	na	na	na	na	na				x		na	na	na	x	x	x	x		y	na	na	na	na	n
Steele	R							x			90.3	0	2	0	2	0	0	43.8	0	43.8	0	43.8	x			x		4	3	0			x			n	c	c	0	32	n
Stevens	R		x				x				97.7	0	1	0	2	0	4	10.5	4	10.5	4	10.5			x		x	0	0	0	x	x	x		x	n	c	c	na	na	n
Swift	R	x		x	x	x	x				280.0	1	2	1	2	0	50	86	50	86	30	75	x			x		2	1	0	x	x				n	c	c	na	na	n
Todd	R	x		x					x	x	366.0	0	0	0	0	0	0	0	na	na	na	na		x				0	0	0					x	n	na	na	na	na	n
Traverse	N																																								
Wabasha	N																																								
Wadena	R										204.8	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	c			n
Waseca	R						x				91.0	0	0	0	2	0	0	13	0	13	0	13	x				x	2	2	0	x	x	x	x		n	c	c	8.1	19.6	n
Washington	N																																								
Watonwan	R	x	x				x				25.7	0	0	0	6	0	0	7.2	0	4.5	0	4.5			x	x		0	0	0	x	x				n	c	c	0	1	n
Wilkin	F																																								
Winona	R		x								1.5	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	na	0	0	y
Wright	R		x	x			x				89.7	0	0	0	2	1	0	8.5	0	2.9	0	2.9			x		x	0	0	0	x	x	x			n	a	b	1.3	1.7	y
Yellow Medicine	R		x				x				350.0	0	0	0	0	0	0	6	0	6	0	6			x	x		0	0	0		x	x			n	c	c	na	na	n
Watershed District																																									
Bear Valley	N																																								
Belle Creek	N																																								
Bois de Sioux	R	x	x	x	x	x	x	x		x	400.0	0	0	1	1	0	3	3	3	3	3	3			x	x		1	0	0	x	x	x			y	c	c	na	na	n
Browns Creek	N																																								
Buffalo Creek	R		x					x			6.0	0	0	0	0	0	0	6	0	6	0	6	x				x	0	0	0	x			x		n	a	b	na	na	y
Buffalo-Red River	R	x				x	x				370.7	7	19	0	12	0	86.6	37.8	86.6	37.8	86.6	37.8			x	x		15	2	0	x	x	x			y	c	c	75	50	y
Capitol Region	N																																								
Carnelian-Marine	N																																								
Clearwater River	N																																								
Comfort Lake – Forest Lake	N																																								
Coon Creek	R	x					x		x		125.0	0	0	0	0	0	0	0	0	0	0	0	x			x		0	0	0						n	na	na	0	0	y
Cormorant Lakes	N																																								
Crooked Creek	N																																								
Heron Lake	N																																								

Watershed District	Survey	1a	1b	1c	1d	1e	1f	1g	1h	est.	2	3a	3b	3c	3d	3e	4a	4b	5a	5b	6a	6b	7a	7b	7c	8a	8b	9a	9b	9c	10a	10b	10c	10d	10e	11	12a	12b	13a	13b	14
High Island Creek	R				x						46.8	4	0	0	0	0	0	7.8	0	7.8	0	4.7	x			x		20	0	0	x	x	x			n	c	c	0	9.4	y
Joe River	F																																								
Kanaranzi – Little Rock	N																																								
Lac qui Parle – Yellow Bank	R									x	9.0							Remainder of information included in Lac qui Parle County report above.																							
Lower Minnesota River	N																																								
Middle Fork Crow River	N																																								
Middle/Snake/Tamarac	R	x			x	x	x				323.0	3	2	4	4	0	na	na	na	na	na	na			x	x		0	0	0	x	x				n	a	a	na	na	n
Minnehaha Creek	R	x		x	x		x				23.2	0	0	0	0	0	0	0	0	0	0	0			x	x		0	0	0					x	n	na	na	0	0	n
Nine Mile Creek	R		x								4.1	0	0	0	0	0	0	0	0	0	0	0			x		x	0	0	0						n	na	na	0	0	y
North Fork Crow River	R		x			x	x	x			161.9	0	3	3	3	0	0	109.6	0	109.6	0	109.6	x			x		0	0	0	x	x	x			n	a	a	0	20	y
Okabena – Ocheda	N																																								
Pelican River	R			x			x				16.0	0	0	0	0	0	0	16	0	0	0	0			x		x	0	0	0	x	x	x			n	c	c	0	0	n
Prior Lake – Spring Lake	N																																								
Ramsey/Washington Metro	N																																								
Red Lake	R	x	x				x	x		x	273.6	4	7	0	0	0	53.2	14.3	53.2	14.3	53.2	14.3			x	x		0	0	0	x	x				n	c	c	44	200	n
Rice Creek	R	x		x	x	x	x				143.7	0	0	4	0	0	0	0	0	13	0	13	x			x		0	2	0	x	x	x			y	c	c	0	80	n
Riley/Purgatory/Bluff Creek	N																																								
Roseau River	R							x		x	80.5	0	0	0	0	0	0	0	0	0	0	0			x	x		0	0	0		x				n	na	na	na	na	n
Sand Hill River	R		x	x	x	x	x				55.8	2	2	0	0	0	27.8	3.5	29.5	3.5	29.5	3.5	x			x		2	0	0	x	x	x			n	na	na	2	0	y
Sauk River	R		x			x	x	x			80.3	0	1	2	2	0	0	23.1	0	23.1	0	23.1		x		x		1	0	0	x	x	x			n	a	a	10	55	y
Shell Rock River	N																																								
South Two River	N																																								
South Washington	N																																								
Stockton – Rollingstone	N																																								
Thirty Lakes	N																																								
Turtle Creek	R	x	x		x	x	x	x			69.4	1	1	1	4	0	0	69.4	0	68.6	0	68.6			x	x		0	0	0						y	c	c	0	5	Y
Two River	R	x	x	x			x				73.0	0	1	0	0	0	2.5	0	0	0	0	0			x	x		0	0	0						n	a	c	na	na	N
Upper Minnesota River	N																																								
Valley Branch	N																																								
Warroad	N																																								
Wild Rice	R						x	x		x	375.0	4	0	0	2	0	0	193	0	193	0	183			x	x		na	na	na	x	x	x			n	a	a	na	na	N
Yellow Medicine River	R		x	x			x				34.5	na	na	na	na	na	0	34.5	0	34.5	0	34.5	x			x		12	3	0	x					n	a	a	0	0	Y
Summary Information		28	43	25	17	20	64	33	10	15	17311.1	44	114	57	111	15	328.4	1809.1	284.0	1256.3	303.8	1265.9	13	5	69	46	43	109	15	4	41	48	29	4	9				935.1	1513.25	
Received Survey	94																																		Yes ->	10					
No Ditches/Ditch Authority	32																																		No->	80				Yes ->	28
Failed to Respond	7																																							No ->	65
																																					19	10	<-a		
* Red Lake County information not included in the assessment (due to late arrival of data)																																					5	8	<-b		
Data Entry Codes:	General: na = Not Available and/or Not Reported x = response provided on questionnaire y = yes n = no																																				27	4	<-c		
	Survey Codes: R = Received Questionnaire N = No Public Ditches and/or Ditch Authority F = Failed to Return Survey																																								

Appendix 1C: Drainage Authority Point-of-Contact

County	Name	Title	Contact No.	Contact email
Aitkin	Welle, John	County Engineer	218-927-3741	jwelle@co.aitkin.mn.us
Anoka	Olson, Jon	Public Service Division Manager	763-323-5789	jon.olson@co.anoka.mn.us
Becker	Brekken, Keith	County Auditor	218-846-7301	kgbrekk@co.becker.mn.us
Beltrami	Geving, Ed	Maintenance Supervisor	218-333-8173	ed.geving@co.beltrami.mn.us
Benton	Kozel, Robert	County Engineer	320-968-5051	bkozel@co.benton.mn.us
Big Stone	Anderson, Nick	County Engineer	320-839-2594	nanderson@co.big-stone.mn.us
Blue Earth	Austinson, Craig	Ditch Manager	507-304-4253	craig.austinson@co.blue-earth.mn.us
Brown	Helget, Marlin	County Auditor-Treasurer	507-233-6617	NA
Carlton	Olson, Wayne	County Engineer	218-384-9150	wayne.olson@co.carlton.mn.us
Carver	Wanous, Mike	SWCD Manager	952-442-5101	mike.wanous@mn.nacdnet.net
Cass	Anderson, Sharon	County Auditor-Treasurer	218-547-7260	sharon.k.anderson@co.cass.mn.us
Chippewa	Clauson, Jon	County Auditor-Treasurer	320-269-7447	jclauson@co.chippewa.mn.us
Chisago	Freed, Dennis	County Auditor	651-213-0424	djfreed@co.chisago.mn.us
Clay	No Contact Provided			
Clearwater	Sauve, Dan	County Engineer	218-694-6132	dan.sauve@co.clearwater.mn.us
Cook	Powers, Braidy	County Auditor-Treasurer	218-387-3646	braidy.powers@co.cook.mn.us
Cottonwood	Johnson, Jan	County Auditor-Treasurer	507-831-1342	jan.h.johnson@co.cottonwood.mn.us
Crow Wing	Blanck, Duane	County Engineer	218-824-1110	duane.blanck@co.crow-wing.mn.us
Dakota	Jaschke, John	Water Resource Manager	952-891-7011	john.jaschke@co.dakota.mn.us
Dodge	Hruska, Jim	Ditch Inspector	507-374-6364	jim.hruska@mn.nacdnet.net
Douglas	Anderson, Tom	Drainage and Ag Inspector	320-763-6001	tom.anderson@mail.co.douglas.mn.us
Faribault	Thompson, John	County Auditor	507-526-6211	john.thompson@co.faribault.mn.us
Fillmore	No designated ditch authority – No public drainage system			
Freeborn	Distad, Dennis	County Auditor-Treasurer	507-377-5121	dennis.distad@co.freeborn.mn.us
Goodhue	Isakson, Greg	County Engineer	651-385-3025	NA
Grant	Van Santen, Chad	County Auditor	218-685-4520	chad.vansanten@co.grant.mn.us
Hennepin	Settles, Joel	Unit Supervisor	612-348-6157	joel.settles@co.hennepin.mn.us
Houston	Tuck, Ralph	Root River SWCD Manager	507-724-5261	ralph.tuck@mn.nacdnet.net
Hubbard	Heeren, Pam	County Auditor-Treasurer	218-732-3196	pheeren@co.hubbard.mn.us
Isanti	No Contact Provided			
Itasca	No designated ditch authority – No public drainage systems			
Jackson	Pribyl, Ben	County Auditor-Treasurer	507-847-2763	ben.pribyl@co.jackson.mn.us
Kanabec	No Contact Provided			
Kandiyohi	Reimer, Rick	SWCD Program Coordinator	320-235-3906	rick.reimer@mn.nacdnet.net
Kittson	Bengtson, Kelly	County Engineer	218-843-2686	kbengtson@co.kittson.mn.us
Koochiching	Hummitzsch, Dennis	Land Commissioner	218-283-1126	dennis.hummitzsch@co.koochiching.mn.us
Lac qui Parle	Ellefson, Darrel	Environmental Officer	320-598-3132	darrel.ellefson@lqpco.com
Lake	Goodman, Alan	County Engineer	218-834-8380	al.goodman@co.lake.mn.us
Lake of the Woods	Hasbargen, Bruce	Public Works Director	218-634-1767	bruce_h@co.lake-of-the-woods.mn.us
Le Sueur	Germscheid, Ron	County Auditor	507-357-8221	rgermscheid@co.le-sueur.mn.us
Lincoln	Olsen, Robert	Ditch Inspector	507-694-1344	lcenviro@frontiernet.net
Lyon	Hammer, Todd	Ditch Inspector	507-532-8208	todd.hammer@co.lyon.mn.us
Mahnomen	Large, Jonathan	County Engineer	218-935-2296	jon.large@co.mahnomen.mn.us
Marshall	Aune, Lon	County Engineer	218-745-4381	lon.aune@marshall.mn.us
Martin	Mosloski, Deb	Drainage Specialist	507-238-3130	deb.mosloski@co.martin.mn.us
McLeod	Berggren, Roger	Ditch Inspector	320-864-1214	roger.berggren@co.mcleod.mn.us
Meeker	Loch, Barb	County Auditor	320-693-5212	barb.loch@co.meeker.mn.us
Mille Lacs	Larson, Richard	County Engineer	320-983-8201	dick.larson@co.mille-lacs.mn.us
Morrison	Nygren, Russ	County Auditor	320-632-0130	russn@co.morrison.mn.us
Mower	Morrison, Rick	Drainage Inspector	507-434-2603	rick.morrison@mn.nacdnet.net
Murray	Spaeth, Gary	County Auditor-Treasurer	507-836-6148	gspaeth@co.murray.mn.us
Nicollet	Bruns, Robert	County Auditor	507-934-0350	bbruns@co.nicollet.mn.us
Nobles	Schnieder, Stephen	Public Works Director	507-376-3109	sschnieder@co.nobles.mn.us
Norman	Alm, Mick	County Engineer	218-784-7126	mick.alm@co.norman.mn.us

County	Name	Title	Contact No.	Contact email
Olmsted	No Contact Provided			
Otter Tail	Wasvick, Randy	County Ag / Ditch Inspector	218-998-8095	rwasrick@co.otter-tail.mn.us
Pennington	No Contact Provided			
Pine	Stieben, John	County Coordinator	320-629-5685	jgstiebe@co.pine.mn.us
Pipestone	Krier, Kyle	Zoning Administrator	507-825-6765	kyle.krier@mn.nacdnet.net
Polk	Beauchane, Jody	County Drainage Inspector	218-281-3952	jody.beauchane@co.polk.mn.us
Pope	Kuseske, Allan	County Drainage Inspector	320-346-2869	nfcrwsd@tds.net
Ramsey	Petersen, Tom	RCD Manager	651-266-7272	tom.petersen@co.ramsey.mn.us
Red Lake	No Contact Provided			
Redwood	Lang, Brent	Drainage Inspector	507-637-4023	brent_l@co.redwood.mn.us
Renville	Zupke, Larry	Drainage Inspector	320-522-1339	larry_z@co.renville.mn.us
Rice	Windschitl, Fran	County Auditor-Treasurer	507-332-6122	fwindschitl@co.rice.mn.us
Rock	Sehr, Mark	County Engineer	507-283-5010	mark.sehr@co.rock.mn.us
Roseau	Ketring, Brian	County Engineer	218-463-2063	bketring@co.roseau.mn.us
St. Louis	Goetzman, Jeff	Resident Engineer	218-625-3873	goetzmanj@co.st-louis.mn.us
Scott	Hentges, Jim	County Surveyor	952-496-8362	jhentges@co.scott.mn.us
Sherburne	Norgren, John	Drainage Technician	763-241-7184	NA
Sibley	Majeski, Jeff	Env. Services Director	507-237-4091	jeffm@co.sibley.mn.us
Stearns	Kron, Dennis	County Surveyor	320-656-3906	denny.kron@co.stearns.mn.us
Steele	Grunwald, Dennis	County Ditch Inspector	507-444-7645	NA
Stevens	Giese, Brian	County Engineer	320-589-7430	briangiese@co.stevens.mn.us
Swift	Johnson, Micheal	Co. Drainage Inspector	320-843-5341	mike.johnson@co.swift.mn.us
Todd	Busch, Karen	County Auditor-Treasurer	320-732-4473	karen.busch@co.todd.mn.us
Traverse	No designated ditch authority – No public drainage systems			
Wabasha	Leisen, Jerry	County Auditor-Treasurer	651-565-2648	jleisen@co.wabasha.mn.us
Wadena	West, Char	County Auditor-Treasurer	218-631-7650	charleen.west@co.wadena.mn.us
Waseca	Manthe, Joan	County Auditor	507-835-0610	joan.manthe@co.waseca.mn.us
Washington	No designated ditch authority – No public drainage systems			
Watonwan	Kuhlman, Donald	County Auditor	507-375-2500	don.kuhlman@co.watonwan.mn.us
Wilkin	No Contact Provided			
Winona	MacLennan, Cherie	County Auditor	507-457-6470	cmaclennan@co.winona.mn.us
Wright	Saxton, Kerry	SWCD Manager	763-682-1970	kerry.saxton@mn.nacdnet.net
Yellow Medicine	Kolhei, John	County Ditch Inspector	320-669-1174	ymditch@mvtvwireless.com
District	**Name**	**Title**	**Contact No.**	**Contact email**
Bear Valley	Huneke, Paul	Chair	651-923-4937	NA
Belle Creek	No designated ditch authority – No public drainage systems			
Bois de Sioux	Roeschlein, Jon	Administrator	320-563-4185	bdswd@frontiernet.net
Browns Creek	Kill, Karen	Administrator	651-275-1136	karen.kill@mnwcd.org
Buffalo Creek	Phillips, Larry	Treasurer	320-864-4142	NA
Buffalo-Red River	Albright, Bruce	Administrator	218-354-7710	brrwd@bvillemn.net
Capitol Region	No designated ditch authority – No public drainage systems			
Carnelian-Marine	No designated ditch authority – No public drainage systems			
Clearwater River	Anderson, C. Merle	Administrator	320-202-0554	merleanderson@cloudnet.com
Comfort Lake – Forest Lake	No designated ditch authority – No public drainage systems			
Coon Creek	Kelly, Tim	Administrator	763-755-0975	tkelly@cooncreekwd.org
Cormorant Lakes	No designated ditch authority – No public drainage systems			
Crooked Creek	Pohlman, Wilfred	Board Chairperson	507-725-2136	NA
Heron Lake	Voit, Jan	Administrator	507-793-2462	hlwd@roundlk.net
High Island Creek	Schrupp, Calvin	Ditch Inspector	507-237-5208	NA
Joe River	No Contact Provided			
Kanaranzi – Little Rock	No designated ditch authority – No public drainage systems			
Lac qui Parle – Yellow Bank	Ellefson, Darrel	Environmental Officer	320-598-3132	darrel.ellefson@lqpco.com
Lower Minnesota River	Schwalbe, Terry	Administrator	952-227-1037	terrys@lowermn.com

District	**Name**	**Title**	**Contact No.**	**Contact email**
Middle Fork Crow River	Latham, Ann	Administrative Assistant	320-796-0888	middlefork@charterinternet.com
Middle – Snake – Tamarac River	Drees, Nick	Administrator	218-745-4741	mrsrwd@wiktel.com
Minnehaha Creek	Evenson, L. Eric	Administrator	952-471-0590	eevenson@minnehahacreek.org
Nine Mile Creek	Bigalke, Kevin	Administrator	952-835-2078	resource_inovations@yahoo.com
North Fork Crow River	Kuseske, Allan	Administrator	320-346-2869	nfcrwsd@tds.net
Okabena – Ocheda	No designated ditch authority – No public drainage systems			
Pelican River	Guetter, Tera	Administrator	218-846-0436	tguetter@lakesnet.net
Prior Lake – Spring Lake	No designated ditch authority – No public drainage systems			
Ramsey – Washington Metro	Aichinger, Clifton	Administrator	651-704-2089	cliff@rwmwd.org
Red Lake	Jesme, Myron	Administrator	218-681-5800	jesme@wiktel.com
Rice Creek	Hobbs, Steve	Administrator	763-398-3071	shobbs@ricecreek.org
Riley – Purgatory – Bluff Creek	Bigalke, Kevin	Administrator	952-835-2078	resource_inovations@yahoo.com
Roseau River	Sand, Rob	Administrator	218-463-0313	rrwd@macable.net
Sand Hill River	Wilkens, Daniel	Administrator	218-945-3204	shrwd@gvtel.com
Sauk River	Klocker, Julie	Administrator	320-352-2231	julie@srwdmn.org
Shell Rock River	Miller, Harley	Manager	507-373-0900	harlake@clear.lakes.com
South Two River	No designated ditch authority – No public drainage systems			
South Washington	No designated ditch authority – No public drainage systems			
Stockton – Rollingstone	No designated ditch authority – No public drainage systems			
Thirty Lakes	No designated ditch authority – No public drainage systems			
Turtle Creek	Penkava, Steve	District Engineer	507-373-4876	stevep@jhseng.com
Two River	Money, Dan	Administrator	218-843-3333	daniel.money@mn.nacdnet.net
Upper Minnesota River	Radermacher, Diane	Administrator	320-839-3411	dianne.radermacher@mn.nacdnet.net
Valley Branch	No designated ditch authority – No public drainage systems			
Warroad	Battles, Rick	NA	218-386-3507	NA
Wild Rice	Bents, Jerry	District Engineer	218-784-5501	wrwd@loretel.net
Yellow Medicine River	Renken, Terry	Administrator	507-872-6720	ymrw@starpoint.net

Appendix 2: Literature Review Reference List and Summaries

(1) Erosion and Sediment Control

1. De Laney, T.A., 1995. Benefits to downstream flood attenuation and water quality as a result of constructed wetlands in agricultural landscapes. Journal of Soil Water Conservation 50: 620–626.

   [Summary] The author stated that grassed buffer strips can lessen impact from agricultural runoff by alleviation of up to 80% of sediment in the water column and 90–100% of suspended solids entering water bodies.

2. Stott, T., 2005. Natural recovery from accelerated forest ditch and stream bank erosion five years after harvesting of plantation forest on Plynlimon, mid-Wales. Earth Surface Processes and Landforms 30: 349–357

   [Summary] By studying the vegetation recolonization process along the ditch system, the author found that the combination of old roots in the bank and new grasses colonizing the surface may offer a 'best mix' of bank protection in terms of reducing erosion.

3. Angima, S.D., M.K. O'Neill, A.K. Omwega, and D.F. Stott, 2000. Use of tree/grass hedges for soil erosion control in the Central Kenyan Highlands. Journal of Soil and Water Conservation 55 (4): 478–482.

   [Summary] Serial combinations of hedges along agricultural ditch systems were studied to determine better strategies of planting different grass species to meet varied demands of agricultural practices. The author concluded that grass buffers are highly effective in providing erosion control and reducing the cost of cattle protein supplements at the same time.

4. Daniels, R. B. and J. W. Gilliam, 1996. Sediment and chemical load reduction by grass and riparian filters. Soil Science Society of America Journal 60: 246–251.

   [Summary] The author conducted a series of field experiments and published one of the most highly cited papers in sediment, nitrogen and phosphorus removal effectiveness of buffer strips. The experimental result of this two-year research indicated that the sediment removal rate can vary due to the vegetation type of the buffer strip. The data from this study suggest that the 5-meter wide grass buffer strips can effectively reduce of total sediments in runoff water by 50–55%. The removal rate of silt and clay varied, but was as great as 55–90%. The PO_4 removal rate of 5-meter grass buffers was relatively less significant, but 30–45% of PO_4, 55–60% of TP was still reduced from the runoff water, whereas 55–80% of NO_3 and 20–45% of NH_4 were removed. Although the effectiveness varied with the erosiveness of the watershed and the storm intensity, grass buffer strips were still highly recommended to reduce non-point source pollution, and especially to control sediment.

5. Gharabaghi, B; R.P. Rudra, H.R. Whiteley, W.T. Dickingson, 2002. Development of a management tool for vegetative filter strips. Best modelling practices for urban water systems (Ed. W. James) volume 10 in the monograph series: 289–302.

   [Summary] In an experimental study of grass filter strip efficiencies, the authors found that most of the sediment is trapped in the first 5 meters of the grass buffer. Most of the trapped sediment is larger than 40 microns in diameter. The smaller particles remain in suspension and are harder filter out with grass buffers. If grass buffers are wide enough, small particles can be removed more effectively due to the process of infiltration. Therefore, grass buffers wider than 20 meters will remove up to 90% of sediment. However, the sediment removal efficiency will not increase much in filter strip widths greater than 10 m.

6. Niebling, W.H.; E.E. Alberts, 1979. Composition and yield of soil particles transported through sod strips. Presented at ASAE and CSAE, Paper no. 79-2065, St Joseph, MI, 12 pp.

   [Summary] The author found that 91% of incoming sediment to a grass filter strip was deposited in the first 0.6 meters.

7. Das, C., W.J. Capehart, H.V. Mott, P.R. Zimmerman, and T.E. Schumacher, 2004. Assessing regional impacts of conservation reserve program-type grass buffer strips on sediment load reduction from cultivated lands. Journal of Soil and Water Conservation 59(4): 134–141.

   [Summary] This paper studied the correlation between grass buffer width and slope length along a watercourse by adopting both field and modeling approaches. The simulation results indicated that sediment reduction percentage was a function of slope length, slope, soil texture, and the process of sediment yield. With different types of storm events, the different combinations of previously listed factors can have different response in terms of sediment reduction effectiveness. The author concluded that the responses of different grass buffers varied depending on topographic and soil condition. However, slope is still the most sensitive factors among all others. Therefore, the length of slope along a watercourse might have to be up to 600 ft to provide significant effects under extreme circumstances. However, the area of buffer strips (ratio of grass-protected slope length to entire ditch length) should be considered.

8. Pearce R. A., M. J. Tricia, W. C. Leininger. J. L. Smith and G. W. Frasier, 1997. Efficiency of grass buffer strips and vegetation height on sediment filtration in laboratory rainfall simulations. Journal of Environmental Quality 26:139–144.

   [Summary] This study focused on the interaction between grass buffer length and grass height, and found a significant result. The results indicate that grass buffers with taller vegetation (10cm) can reduce sediment concentration in runoff water more effectively than those with short grass (clipped to soil surface) with the increase of buffer length (up to 50 cm). However, this experiment might not provide sufficient information regarding the effectiveness after scale-up.

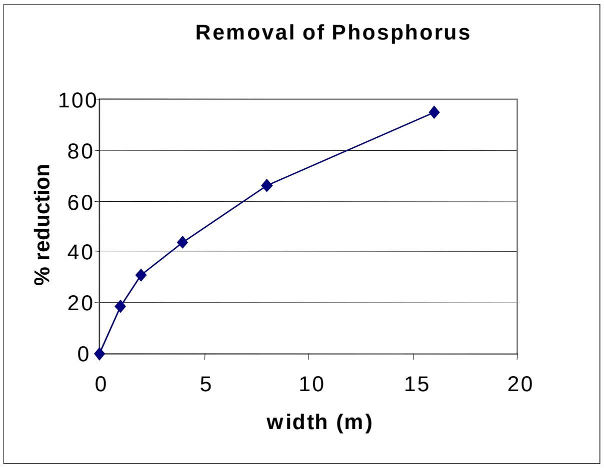
(2) Water Quality Benefits

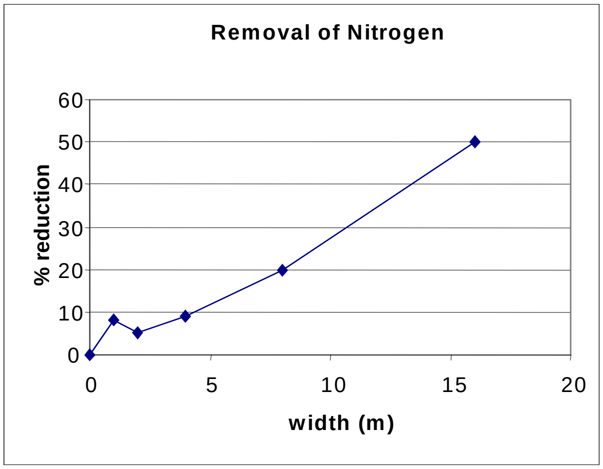
9. Bouldina, J. L., J.L. Farrisa, M.T. Mooreb, and C.M. Cooper, 2004. Vegetative and structural characteristics of agricultural drainages in the Mississippi Delta landscapes. Environmental Pollution 132: 403–411.

   [Summary] This paper demonstrated that grassed buffer strips are one of the critical factors in the reduction of runoff related contaminants from adjacent fields. Grassed buffer strips edging agricultural conveyance structures can enhance mitigation of non-point contamination prior to water leaving conveyance systems, thereby increasing effectiveness of combined mitigation of buffer strips and vegetated ditches.

10. Vought, LB-M., J. Dahl, C.L. Pedersen, and J.O. Lacoursiere, 1994. Nutrient retention in riparian ecotones. Ambio 23 (6): 342–348.

[Summary] The results of this research indicated that nitrogen and phosphorus in runoff had a positive relationship with buffer width. A 16.5-ft- (or 5-meter-) wide grass buffer can reduce phosphorus in runoff by approximately 42%, whereas 10% of nitrogen can be removed. Stem density of the vegetation in the various buffer strips studied was also found to ffect the pollutant removal rate significantly. Grass buffers, according to this study, can effectively remove as much as 98% of suspended sediment in runoff water; however, they display relatively less effectiveness in reducing total-P (22%).





11. Daniels, R. B. and J. W. Gilliam, 1996. Sediment and chemical load reduction by grass and riparian filters. Soil Science Society of America Journal 60: 246–251.

[Summary] The study concluded that a 16.5-ft grass buffer can remove 85% of nitrate and 58%–65% of phosphorus from runoff flow.

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14. Hatfield, J. L., S. K. Mickelson, J. L. Baker, K. Arora, D. P. Tierney, and C. J. Peter, 1995. Buffer strips: Landscape modification to reduce off-site herbicide movement. In: Clean Water, Clean Environment, 21st Century: Team Agriculture, Working to Protect Water Resources, Vol. 1. St. Joseph, MI: American Society of Agricultural Engineers.

15. Meleason, M.A.; J. M. Quinn, 2004. Influence of riparian buffer width on air temperature at Whangapoua Forest, Coromandel Peninsula, New Zealand. Forest Ecology and Management.

16. Dillaha, T. A., R. B. Reneau, S. Mostaghimi, and D. Lee, 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Transactions of the ASAE 32(2):513–519.

[Summary] Studied the removal rate of various pollutants, including NO3-N, NH4-N, and PO4-P. The results indicated that a grass buffers as narrow as 4.6 meters can perform significant reduction of these pollutants up to 90%.

17. Magette, W.L.; R.B. Brinsfield, R.E. Palmer, J.D. Wood, 1989. Nutrient and sediment removal by vegetated filter strips. Transactions of the American Society of Agricultural Engineers 32: 663–667.

18. Young, R.A., T. Huntrods, W. Anderson, 1980. Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff. Journal of Environmental Quality 9: 483–487.

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(3) Ecological and Habitat Benefits

21. De Snoo, G.R. and P.J. de Wit, 1998. Buffer zones for reducing pesticide drift to ditches and risks to aquatic organisms. Ecotoxicology and Environmental Safety 41: 112–118.

[Summary] It is concluded that a buffer zone 6 m wide can prevent pesticide drift to the adjacent ditch. Moreover, even a relatively narrow buffer zone 3 m wide appears to be adequate; even at a wind speed of 11 m/s, drift deposition is reduced by 88.7%. Creating unsprayed buffer zones 3 and 6 m wide also significantly reduces the short-term toxic risk to aquatic organisms. Creation of a 3- to 6-m-wide unsprayed zone along the crop edge can produce a major reduction in pesticide emissions to the surrounding area. These relatively narrow buffer zones may be adequate to protect flora and fauna in agricultural areas. However, on sites adjacent to nature reserves, wider buffer zones may be needed. The author suggested that buffer zones, such as unsprayed cereal edges and unsprayed grass strips, could be adopted in agricultural systems to meet the requirements.

22. Edwards, E.D. and A.D. Huryn, 1996. Effect of riparian land use on contributions of terrestrial invertebrates to streams. Hydrobiologia 337: 151–159.

[Summary] By conducting field surveys and modeling estimates, the author concluded that pasture zones have less terrestrial invertebrate biomass than ungrazed-grass-buffered channels and forested streams.

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(4) Economic Benefits

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[Summary] By summarizing the research of Forster and Abrahim (1985) and the Ohio Department of Agriculture (1996), Barrowclough (2003) concluded that there are potential economic benefits of grass buffers due to reduction in ditch maintenance and cleaning costs. Based on the cost estimation conducted in western Ohio counties, each 10% reduction in soil erosion could reduce the costs of ditch maintenance by 11%. The annual return also showed a gradually increasing trend in cost reduction of maintenance in erosion and sediment control after the grass buffer was implemented.

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Appendix 3: Miles of Public Drainage Ditch Associated with Various Land Use Categories

Ditch locations are based on a surface hydrology data layer developed by the Department of Natural Resources. Land use estimates are based on the USGS 1992 National Land Cover Dataset. The figures in this table may contain some private ditch miles; however, total private ditch miles are likely minimal. Land use types included in each category are noted in the footnotes below the table.

Miles of Public Drainage Ditch Associated with Various Land Uses (% of total ditch miles for county is noted)																			
	Low or Unknown Buffer Potential									Moderate to High Buffer Potential									
County	GIS Miles	Row Crop	% Row Crop	Small Grain	% Small Grain	Urban	% Urban	Industrial	% Industrial	Forest	% Forest	Wetland	% Wetland	Hay	% Hay	Shrub	%Shrub	Total Natural Buffer	% Total Natural Buffer
Aitkin	574.4	15.7	2.7	14.7	2.6	0.3	0.1	5.3	0.9	46.7	8.1	449.9	78.3	36.3	6.3	5.2	0.9	538.1	93.7
Anoka	3.3	0.0	0.0	0.0	0.0	1.0	30.3	0.4	12.1	0.4	12.1	1.2	36.4	0.2	6.1	0.0	0.0	1.8	54.5
Becker	125.3	33.4	26.7	0.8	0.6	1.2	1.0	0.6	0.5	10.1	8.1	55.4	44.2	20.1	16.0	0.1	0.1	85.7	68.4
Beltrami	985.1	0.0	0.0	18.0	1.8	0.9	0.1	23.1	2.3	48.9	5.0	765.0	77.7	56.8	5.8	14.2	1.4	884.9	89.8
Benton	147.1	22.4	15.2	0.1	0.1	1.2	0.8	0.4	0.3	6.9	4.7	76.6	52.1	38.9	26.4	0.0	0.0	122.4	83.2
Big Stone	25.6	16.4	64.1	0.1	0.4	0.0	0.0	0.1	0.4	1.3	5.1	4.9	19.1	2.6	10.2	0.0	0.0	8.8	34.4
Blue Earth	155.0	88.2	56.9	0.0	0.0	0.6	0.4	1.4	0.9	6.8	4.4	13.8	8.9	16.4	10.6	0.0	0.0	37.0	23.9
Brown	237.5	142.2	59.9	0.0	0.0	0.1	0.0	0.3	0.1	3.2	1.3	5.5	2.3	40.4	17.0	0.3	0.1	49.4	20.8
Carlton	127.6	3.6	2.8	0.0	0.0	0.1	0.1	0.7	0.5	12.1	9.5	100.5	78.8	8.1	6.3	0.1	0.1	120.8	94.7
Carver	113.5	30.9	27.2	0.0	0.0	0.2	0.2	0.4	0.4	15.5	13.7	34.1	30.0	25.9	22.8	0.0	0.0	75.5	66.5
Cass	162.1	7.0	4.3	0.3	0.2	0.1	0.1	0.7	0.4	17.8	11.0	113.7	70.1	19.5	12.0	1.0	0.6	152.0	93.8
Chippewa	261.0	179.5	68.8	0.3	0.1	0.2	0.1	0.4	0.2	5.7	2.2	3.2	1.2	24.9	9.5	0.1	0.0	33.9	13.0
Chisago	136.9	40.0	29.2	0.3	0.2	1.5	1.1	0.4	0.3	16.1	11.8	37.3	27.2	39.9	29.1	0.3	0.2	93.6	68.4
Clay	398.3	283.1	71.1	9.5	2.4	6.5	1.6	4.6	1.2	11.3	2.8	18.9	4.7	68.5	17.2	0.0	0.0	98.7	24.8
Clearwater	150.0	33.8	22.5	15.5	10.3	0.0	0.0	1.7	1.1	9.1	6.1	56.2	37.5	32.9	21.9	0.4	0.3	98.6	65.7
Cook	Not Included in Assessment – No Data Available in Surface Hydrology Layer																		
Cottonwood	73.1	33.2	45.4	0.4	0.5	0.2	0.3	1.3	1.8	2.0	2.7	3.4	4.7	17.3	23.7	0.0	0.0	22.7	31.1
Crow Wing	54.2	1.6	3.0	0.0	0.0	0.6	1.1	0.3	0.6	11.3	20.8	35.6	65.7	0.0	0.0	0.1	0.2	47.0	86.7
Dakota	2.7	0.2	7.4	0.0	0.0	0.4	14.8	0.1	3.7	0.1	3.7	1.2	44.4	0.3	11.1	0.0	0.0	1.6	59.3
Dodge	104.9	80.2	76.5	0.0	0.0	0.5	0.5	2.0	1.9	2.1	2.0	1.8	1.7	3.5	3.3	0.0	0.0	7.4	7.1
Douglas	48.7	9.9	20.3	0.1	0.2	0.1	0.2	0.1	0.2	4.6	9.4	21.3	43.7	10.5	21.6	0.1	0.2	36.5	74.9
Faribault	242.0	163.6	67.6	0.0	0.0	0.2	0.1	6.2	2.6	9.7	4.0	3.7	1.5	18.2	7.5	0.0	0.0	31.6	13.1
Fillmore	7.3	3.8	52.1	0.0	0.0	0.1	1.4	0.2	2.7	0.2	2.7	1.2	16.4	1.3	17.8	0.0	0.0	2.7	37.0
Freeborn	371.4	177.6	47.8	0.0	0.0	0.1	0.0	6.3	1.7	8.1	2.2	6.8	1.8	11.6	3.1	0.0	0.0	26.5	7.1
Goodhue	7.6	6.0	78.9	0.0	0.0	0.0	0.0	0.1	1.3	0.1	1.3	0.2	2.6	0.0	0.0	0.1	1.3	0.4	5.3
Grant	142.2	72.9	51.3	1.3	0.9	0.2	0.1	4.9	3.4	1.4	1.0	4.9	3.4	8.2	5.8	0.0	0.0	14.5	10.2
Hennepin	68.3	4.5	6.6	0.0	0.0	17.0	24.9	4.3	6.3	4.5	6.6	31.8	46.6	5.4	7.9	0.0	0.0	41.7	61.1
Houston	0.9	0.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	11.1	0.5	55.6	0.1	11.1	0.0	0.0	0.7	77.8
Hubbard	24.0	0.4	1.7	0.1	0.4	0.0	0.0	0.7	2.9	2.2	9.2	19.1	79.6	1.4	5.8	0.2	0.8	22.9	95.4
Isanti	136.7	16.0	11.7	0.1	0.1	0.8	0.6	0.4	0.3	18.7	13.7	85.5	62.5	14.7	10.8	0.0	0.0	118.9	87.0
Itasca	129.4	2.6	2.0	0.0	0.0	0.3	0.2	4.7	3.6	18.1	14.0	97.3	75.2	5.0	3.9	1.3	1.0	121.7	94.0
Jackson	177.3	102.4	57.8	0.0	0.0	0.4	0.2	3.1	1.7	3.8	2.1	6.2	3.5	32.4	18.3	0.0	0.0	42.4	23.9
Kanabec	115.7	11.7	10.1	0.1	0.1	0.2	0.2	0.3	0.3	11.9	10.3	70.6	61.0	20.4	17.6	0.1	0.1	103.0	89.0
Kandiyohi	563.7	318.1	56.4	0.2	0.0	3.0	0.5	3.4	0.6	24.7	4.4	69.7	12.4	70.7	12.5	0.0	0.0	165.1	29.3
Kittson	499.5	234.6	47.0	53.4	10.7	1.2	0.2	6.4	1.3	45.1	9.0	46.8	9.4	72.0	14.4	7.1	1.4	171.0	34.2
Koochiching	576.8	7.0	1.2	0.6	0.1	0.2	0.0	16.1	2.8	22.5	3.9	493.1	85.5	10.4	1.8	26.0	4.5	552.0	95.7
Lac qui Parle	333.8	182.7	54.7	0.1	0.0	1.0	0.3	2.1	0.6	5.5	1.6	15.6	4.7	40.2	12.0	0.0	0.0	61.3	18.4
Lake	Not Included in Assessment – No Data Available in Surface Hydrology Layer																		
Lake of the Woods	686.0	63.6	9.3	20.4	3.0	0.1	0.0	11.2	1.6	18.9	2.8	511.3	74.5	51.0	7.4	5.4	0.8	586.6	85.5
Le Sueur	242.5	75.2	31.0	0.0	0.0	0.8	0.3	0.5	0.2	14.0	5.8	44.6	18.4	43.9	18.1	0.1	0.0	102.6	42.3
Lincoln	104.3	38.9	37.3	0.3	0.3	0.1	0.1	0.8	0.8	4.1	3.9	13.4	12.8	31.1	29.8	0.0	0.0	48.6	46.6
Lyon	140.4	82.9	59.0	0.0	0.0	2.6	1.9	2.4	1.7	3.5	2.5	4.5	3.2	19.7	14.0	0.0	0.0	27.7	19.7
Mahnomen	180.0	111.6	62.0	7.4	4.1	0.1	0.1	0.5	0.3	8.0	4.4	28.0	15.6	16.8	9.3	0.0	0.0	52.8	29.3
Marshall	1371.0	653.6	47.7	193.1	14.1	1.4	0.1	15.4	1.1	53.6	3.9	245.9	17.9	165.1	12.0	0.9	0.1	465.5	34.0
Martin	202.6	121.2	59.8	0.0	0.0	0.3	0.1	5.0	2.5	5.4	2.7	8.5	4.2	35.5	17.5	0.0	0.0	49.4	24.4
McLeod	258.4	104.8	40.6	0.1	0.0	1.3	0.5	0.8	0.3	12.1	4.7	51.6	20.0	44.9	17.4	0.1	0.0	108.7	42.1
Meeker	199.2	68.4	34.3	0.4	0.2	1.4	0.7	0.4	0.2	10.0	5.0	68.8	34.5	34.3	17.2	0.0	0.0	113.1	56.8

County	GIS Miles	Row Crop	% Row Crop	Small Grain	% Small Grain	Urban	% Urban	Industrial	% Industrial	Forest	% Forest	Wetland	% Wetland	Hay	% Hay	Shrub	%Shrub	Total Natural Buffer	% Total Natural Buffer
Mille Lacs	122.4	15.9	13.0	0.2	0.2	0.4	0.3	0.7	0.6	6.7	5.5	63.5	51.9	35.2	28.8	0.0	0.0	105.4	86.1
Morrison	212.9	14.4	6.8	1.7	0.8	0.7	0.3	1.7	0.8	15.9	7.5	134.5	63.2	40.5	19.0	0.1	0.0	191.0	89.7
Mower	247.6	169.6	68.5	0.0	0.0	0.8	0.3	5.2	2.1	7.7	3.1	15.1	6.1	19.8	8.0	0.0	0.0	42.6	17.2
Murray	95.5	45.2	47.3	0.0	0.0	0.0	0.0	1.0	1.0	5.1	5.3	10.8	11.3	19.2	20.1	0.0	0.0	35.1	36.8
Nicollet	296.7	191.4	64.5	0.0	0.0	0.8	0.3	0.2	0.1	5.3	1.8	12.0	4.0	41.1	13.9	0.1	0.0	58.5	19.7
Nobles	131.9	68.8	52.2	0.0	0.0	2.9	2.2	3.8	2.9	0.9	0.7	6.7	5.1	24.7	18.7	0.0	0.0	32.3	24.5
Norman	842.5	507.7	60.3	56.0	6.6	0.9	0.1	7.3	0.9	55.7	6.6	31.2	3.7	97.3	11.5	0.2	0.0	184.4	21.9
Olmsted	11.8	6.5	55.1	0.0	0.0	0.1	0.8	0.1	0.8	0.7	5.9	2.4	20.3	1.7	14.4	0.0	0.0	4.8	40.7
Otter Tail	286.8	41.3	14.4	3.6	1.3	0.2	0.1	0.5	0.2	20.5	7.1	160.3	55.9	36.3	12.7	0.1	0.0	217.2	75.7
Pennington	470.9	242.8	51.6	119.5	25.4	2.1	0.4	4.0	0.8	10.5	2.2	22.1	4.7	48.7	10.3	0.3	0.1	81.6	17.3
Pine	153.2	11.6	7.6	0.1	0.1	7.1	4.6	0.9	0.6	15.7	10.2	91.1	59.5	26.4	17.2	0.2	0.1	133.4	87.1
Pipestone	25.0	10.6	42.4	0.2	0.8	0.5	2.0	2.3	9.2	0.7	2.8	0.3	1.2	8.0	32.0	0.0	0.0	9.0	36.0
Polk	1210.3	795.1	65.7	87.6	7.2	1.4	0.1	17.0	1.4	33.5	2.8	93.4	7.7	94.0	7.8	0.6	0.0	221.5	18.3
Pope	18.8	4.4	23.4	0.0	0.0	0.1	0.5	0.1	0.5	0.7	3.7	9.3	49.5	3.2	17.0	0.0	0.0	13.2	70.2
Ramsey	38.0	1.6	4.2	0.0	0.0	14.3	37.6	3.3	8.7	2.3	6.1	13.8	36.3	2.4	6.3	0.4	1.1	18.9	49.7
Red Lake	243.6	129.9	53.3	63.6	26.1	0.5	0.2	0.7	0.3	6.1	2.5	6.2	2.5	23.7	9.7	0.1	0.0	36.1	14.8
Redwood	274.9	147.5	53.7	0.2	0.1	0.9	0.3	0.3	0.1	2.4	0.9	1.2	0.4	37.3	13.6	0.0	0.0	40.9	14.9
Renville	719.9	488.3	67.8	0.4	0.1	1.6	0.2	1.0	0.1	14.5	2.0	33.9	4.7	69.2	9.6	0.3	0.0	117.9	16.4
Rice	55.9	16.2	29.0	0.0	0.0	0.2	0.4	0.1	0.2	5.1	9.1	13.9	24.9	11.3	20.2	0.1	0.2	30.4	54.4
Rock	9.1	5.4	59.3	0.0	0.0	0.1	1.1	0.6	6.6	0.1	1.1	0.1	1.1	1.4	15.4	0.0	0.0	1.6	17.6
Roseau	1269.5	472.7	37.2	144.3	11.4	1.6	0.1	17.6	1.4	58.3	4.6	352.0	27.7	197.5	15.6	11.9	0.9	619.7	48.8
Scott	3.6	0.9	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	8.3	1.7	47.2	0.3	8.3	0.0	0.0	2.3	63.9
Sherburne	160.3	12.8	8.0	0.5	0.3	3.7	2.3	0.8	0.5	16.8	10.5	102.2	63.8	20.7	12.9	0.1	0.1	139.8	87.2
Sibley	521.3	310.9	59.6	0.3	0.1	1.4	0.3	0.7	0.1	9.2	1.8	45.6	8.7	90.0	17.3	0.1	0.0	144.9	27.8
St. Louis	798.3	36.0	4.5	0.7	0.1	4.4	0.6	21.0	2.6	129.6	16.2	555.2	69.5	34.4	4.3	16.1	2.0	735.3	92.1
Stearns	317.7	77.3	24.3	0.4	0.1	1.3	0.4	0.7	0.2	14.3	4.5	140.9	44.4	64.2	20.2	0.1	0.0	219.5	69.1
Steele	223.8	130.2	58.2	0.0	0.0	0.3	0.1	3.2	1.4	10.7	4.8	10.4	4.6	13.4	6.0	0.0	0.0	34.5	15.4
Stevens	74.2	44.8	60.4	1.5	2.0	0.0	0.0	0.0	0.0	1.6	2.2	8.3	11.2	3.2	4.3	0.0	0.0	13.1	17.7
Swift	Not Included in Assessment – No Data Available in Surface Hydrology Layer																		
Todd	261.8	22.1	8.4	1.4	0.5	1.1	0.4	0.9	0.3	22.3	8.5	154.6	59.1	57.6	22.0	0.1	0.0	234.6	89.6
Traverse	321.8	182.5	56.7	3.4	1.1	0.3	0.1	6.6	2.1	3.6	1.1	4.6	1.4	13.0	4.0	0.0	0.0	21.2	6.6
Wabasha	2.3	0.5	21.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	73.9	0.1	4.3	0.0	0.0	1.8	78.3
Wadena	237.2	19.9	8.4	1.2	0.5	0.4	0.2	0.4	0.2	21.2	8.9	144.9	61.1	43.1	18.2	0.2	0.1	209.4	88.3
Waseca	129.1	49.6	38.4	0.0	0.0	3.1	2.4	0.7	0.5	3.9	3.0	16.4	12.7	16.6	12.9	0.0	0.0	36.9	28.6
Washington	10.1	0.8	7.9	0.0	0.0	2.2	21.8	0.4	4.0	0.5	5.0	4.4	43.6	1.9	18.8	0.0	0.0	6.8	67.3
Watonwan	32.9	15.7	47.7	0.0	0.0	0.1	0.3	0.1	0.3	1.5	4.6	1.3	4.0	5.6	17.0	0.1	0.3	8.5	25.8
Wilkin	406.7	299.1	73.5	15.1	3.7	0.1	0.0	11.7	2.9	3.8	0.9	12.3	3.0	31.6	7.8	0.0	0.0	47.7	11.7
Winona	Not Included in Assessment – No Data Available in Surface Hydrology Layer																		
Wright	101.7	21.9	21.5	0.0	0.0	2.8	2.8	0.3	0.3	7.4	7.3	42.7	42.0	22.1	21.7	0.1	0.1	72.3	71.1
Yellow Medicine	407.4	219.5	53.9	0.1	0.0	0.4	0.1	0.7	0.2	5.9	1.4	6.2	1.5	40.3	9.9	0.1	0.0	52.5	12.9
Statewide Totals	21414.7	8477.1	39.6	839.7	3.9	107.3	0.5	257.1	1.2	1059.2	4.9	6056.3	28.3	2514.3	11.7	94.6	0.4	9724.4	45.4

Land Use Categories: Row Crop – Areas used for the production of crops, such as corn, soybeans, sugar beets, potatoes, and vegetables
Small Grain – Areas used for the production of crops such as wheat, barley, oats, and flax.
Urban – Areas characterized by residential areas with a high percentage of constructed materials (e.g. asphalt, concrete, buildings, and manicured landscapes.
Industrial – Includes infrastructure (e.g. roads, railroads, etc.) and highly developed areas used for extractive mining, manufacturing, and commercial ventures.
Forest – Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall) and where tree canopy accounts for 25-100 percent of the cover.
Wetland – Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al. (may include some perpetually water covered soils).
Hay – Areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover, includes alfalfa and grass-based hay land, pastures, and some native prairie.
Shrub – Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking. Category also includes some transitional zones between other categories listed above.

Appendix 4: Summary of Major Conservation Programs with Riparian Buffer Practices

Factor > Program	Admin. Agency	Eligible Lands	Sign-up	Payment Methods	Agreement Type	Agreement Duration
Conservation Reserve Program (CRP)	USDA - Farm Services Agency (FSA)	Sensitive cropland and certain marginal pasture	Periodic	Annual rental payments, based on soil productivity and competitive bids, initial incentive payment(s), and practice cost-share	Contract	10 - 15 years
Continuous Conservation Reserve Program (CCRP)	USDA - Farm Services Agency (FSA)	Sensitive cropland and certain marginal pasture, <5-acre restorable wetlands	Continuous for priority lands and practices	Annual rental payments, based on soil productivity, initial incentive payment(s), and practice cost-share	Contract	10 - 15 years
Reinvest in Minnesota Reserve Program (RIM)	Minnesota Board of Water and Soil Resources (BWSR)	Marginal ag land and restorable wetlands	Periodic by priority area when funding available	Percent of assessed market value, and practice cost-share	Conservation Easement	Limited Duration and Perpetual
Conservation Reserve Enhancement Program (CREP)	FSA and BWSR	Certain marginal ag land, restorable wetlands, well head protection areas	Continuous for priority areas during program period	CCRP methods, CREP bonus, RIM easement payment and practice cost-share	Contract and Conservation Easement	CRP: 10-15 yrs and RIM: 45-year or Perpetual
Wetland Reserve Program (WRP)	USDA -Natural Resources Conservation Service (NRCS)	Restorable drained wetlands and some adjacent uplands	Continuous when funding available	Appraised land value and practice cost-share	Conservation Easement	Perpetual in Minnesota
RIM / WRP	BWSR and NRCS	Restorable drained wetlands and some adjacent uplands	Periodic when funding available	Appraised land value, RIM easement payment and practice cost-share	Conservation Easements	30-year WRP with perpetual RIM