

Minnesota Public Drainage Manual - Engineering and Environmental Considerations

Section VI - New drainage systems, improvements, laterals and other modifications of drainage system

Summary

There are four (4) types of proceedings that constitute a drainage project in [Minn. Stat. Chapter 103E](#): Establishments, Improvements, Improvements of an Outlet, and Laterals. These and other types of drainage activities that require the appointment of an engineer are provided with their respective reference sections:

1. Establishment ([Minn. Stat. § 103E.212](#)) (**Section VI, 1**);
2. Improvement ([Minn. Stat. § 103E.215](#)) (**Section VI, 2**);
3. Improvement of Outlet ([Minn. Stat. § 103E.221](#)) (**Section VI, 3**);
4. Laterals ([Minn. Stat. § 103E.225](#)) (**Section VI, 4**);

Other:

- Impounding, Rerouting and Diverting of Drainage System Waters ([Minn. Stat. § 103E.227](#)) (**Section VI, 5**);

In response to a drainage project petition, the project engineer is responsible for recommending a practical drainage project design, to inform the drainage authority in the preliminary report on issues related to feasibility, and present a fully defined and constructible drainage project in the detailed survey report. Additional detailed recommendations related to engineering tasks for specific project types include:

- Hydrologic and hydraulic analysis (**Section VI, B.1**);
- Ditch/Channel Hydraulic Design (**Section VI, B.2**);
- Bridge/Culvert Hydraulic Analysis and Design (**Section VI, B.3**);
- Erosion Control for Drainage Water Entry to a Public Ditch (**Section VI, B.4**);
- Miscellaneous Structures (**Section VI, B.5**);
- Channel Geometry (**Section VI, B.6**); and
- Vegetated Ditch Buffer Strips (**Section VI, B.7**).

A. General



This section highlights the differences between four types of proceedings that constitute a drainage project.

As discussed in **Section III** of this chapter, there are four types of proceedings that constitute a drainage project in Chapter 103E: Establishments, Improvements, Improvements of an Outlet, and Laterals. They are summarized below along with other types of drainage work that require the appointment of an engineer. The proceedings for these types of projects are discussed in greater detail in **Chapter 2**):

1. New System Establishment (See Minn. Stat. 103E.212)

This type of project involves the establishment of a public drainage system where none had previously existed along with its associated benefited area. The establishment may or may not include a construction project. An establishment proceeding requires both 1) the documenting of the starting point, the general course, and the terminus of the proposed system; and 2) acquisition of required right-of-way adequate to accommodate the channel, ditch, or tile (existing or to be constructed) and the grass strip. In addition, viewers are appointed to determine the benefited area for the new system ([Minn. Stat. § 103E.265](#) & [Minn. Stat. § 103E.305](#)).

2. Improvement (See Minn. Stat. 103E.215)

Improvement projects involve the reconstruction or significant alteration of an established public drainage system having a benefited area on record. Improvement means tiling, enlarging, extending, straightening, or deepening of the established and previously constructed system. Improvement also means replacing an established public open ditch with a tile, or an established public tile with an open ditch. An existing drainage system may only be extended downstream via an improvement proceeding to a more adequate outlet, and then only for one mile. Extensions in an upstream direction from the existing system constitute a Lateral and will be discussed later.

Generally, an Improvement project provides for the upgrading and enhancement of the existing system's hydraulic capacity and drainage ability. Viewers are appointed in order to revise the benefited area and the amount of benefits per acre.

3. Improvement of Outlet (See Minn. Stat. 103E.221)

This proceeding can be used when an overflow of an existing drainage system or watercourse is caused by construction (or proposed construction) of a tributary drainage system (either public or private). It

involves a reconstruction of the overflowed drainage system or constructing diversion channels which will relieve the injured parties. Property benefited in this proceeding is identified and documented by appointed viewers (who may need the assistance of an engineer).

4. Laterals (See Minn. Stat. 103E.225)

A Lateral is any drainage project that creates a branch or extension of an established public drainage system. It often provides a connection or outlet for property already assessed benefits by the existing system. If the property is not currently being assessed benefits to the existing system, then authority has to be obtained to use the existing system as an outlet, in accordance with [Minn. Stat. § 103E.401](#). An outlet fee or some other type of compensation is usually assessed to the proposed Lateral. ([Minn. Stat. § 103E.401, Subd.4](#)).

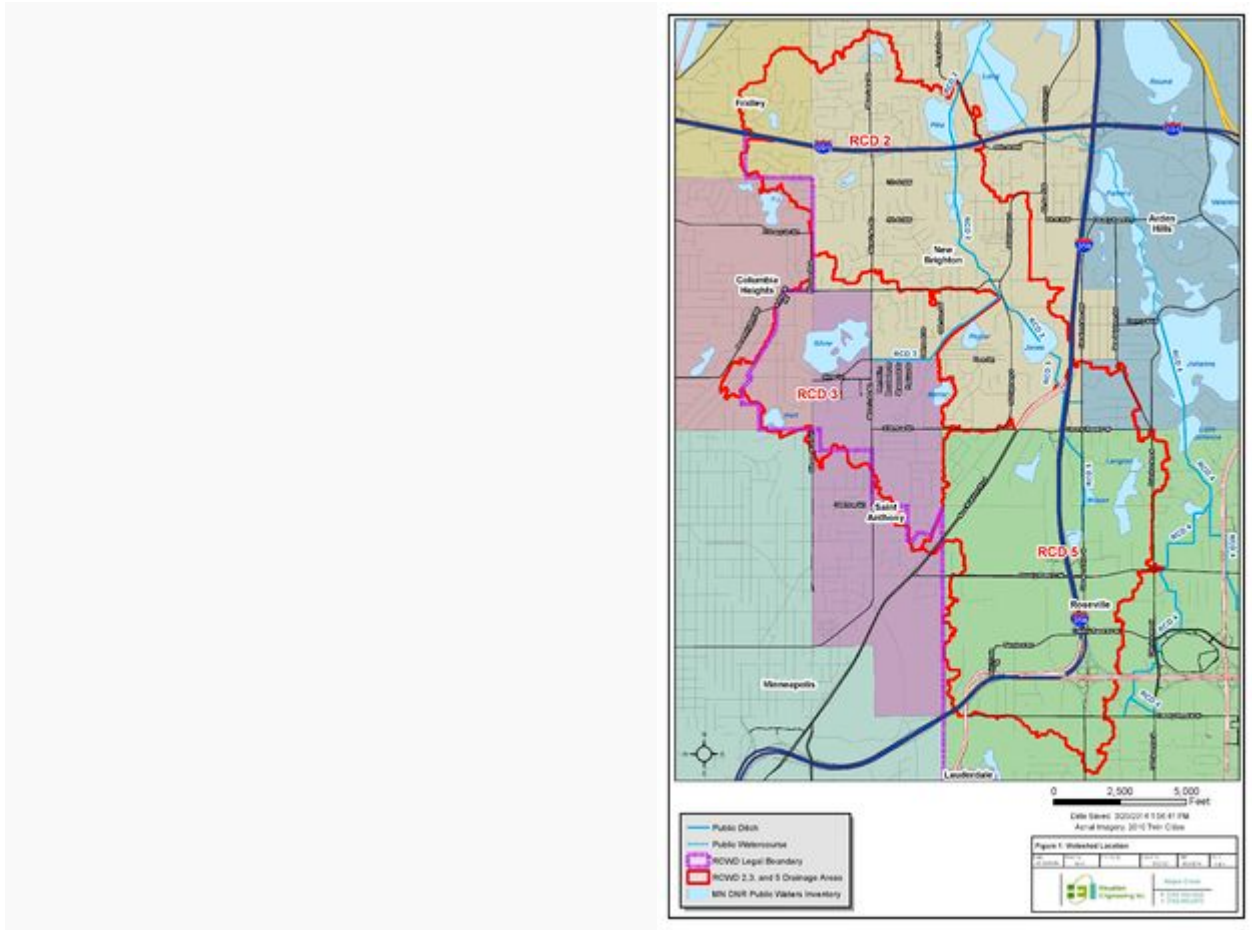
5. Impounding, Rerouting, and Diverting Drainage System Waters (See Minn. Stat. 103E.227)

Although its objective is not drainage, this type of proceeding is mentioned here because it has the potential to impact an established public drainage system. The purpose of this proceeding is to conserve and make beneficial use of water within a given drainage system. However, unlike a drainage project the petition can be brought forward by outside agencies, organizations, and individuals as well as the drainage authority or benefited landowners. It corresponds to criteria number five of the environmental and land use considerations found in [Minn. Stat. § 103E.015](#). The impoundment, rerouting or diverting of drainage waters generally alters the normal functioning of the drainage system on which it is constructed and, therefore, the petitioners for this type of proceeding must obtain flowage easements or other rights-of-way from owners of land to be affected. However, the statutory recognition for this type of alternative function on a drainage system opens the door to some innovative projects. The inclusion of a water conservation facility within a public drainage project can lead to many alternative solutions to drainage problems.

B. Engineering Requirements

The engineer in response to a drainage project petition is responsible for recommending a practical drainage project (as defined in [Minn. Stat. § 103E.005](#) and listed in items 1-4 in **A. General**) design, to inform the drainage authority in the preliminary report on issues related to feasibility and present a fully defined constructible drainage project in the detailed survey report ordered by the drainage authority. **Section III** and **Section IV** in this chapter provide guidance to the engineer for conducting the required surveys and preparing the necessary reports. The following section identifies additional detailed recommendations related to engineering tasks for specific project types. It is recommended that the described engineering efforts be documented in both the engineer's preliminary survey report and the engineer's detailed survey report in accordance with present engineering practice.

1. Hydrologic and Hydraulic Analysis



The engineer is required to consider the flooding potential on the downstream of the drainage system as related to a proposed drainage project.

According to [Minn. Stat. § 103E.015, Subd. 1 \(4\)](#), the engineer is required to consider the flooding potential on and downstream of the drainage system as related to a proposed drainage project (i.e., for the 5-, 10-, 25-, and 50-year flood events). Standard engineering practice in Minnesota has generally favored a 2-year to 10-year return period for drainage ditch design.

Note: While it is not required by Chapter 103E, it is also important to understand the effects of a catastrophic flood event (e.g. the 100-year flood), particularly when a local government's floodplain ordinance comes into play. Therefore, it is recommended that the engineer's preliminary report contain an evaluation of the effects of the project for multiple flood events including those required for design, as outlined in [Minn. Stat. § 103E.015](#), and for catastrophic events.

2. Ditch/Channel Hydraulic Design

Once the engineer selects the design discharge, the channel dimensions, slope, and hydraulic properties are calculated by an appropriate method. For medium to large size projects, a design water surface profile should be developed from the project outlet to the upper end of the system. Commonly accepted hydraulic models for calculating water surface profiles include the U.S. Army Corps of

Engineers' HEC-RAS model, the Environmental Protection Agency's SWMM model and a variety of proprietary models based on the historic Soil Conservation Service's ² TR-20 Model.

Normal depth calculation results, for various flood events, and for all design reaches within the system, can be recorded in tabular form in the engineer's report(s). Velocities, flow depths, and soil types should be checked at all critical points in and along the course of the system to insure that erosion potential is within acceptable ranges, and that the maximum water surface profile does not adversely hamper the project's drainage function. Recommended design velocities may be found in Part 650 of the [NRCS National Engineering Field Handbook: Chapter 14 – Water Management \(Drainage\)](#).

3. Bridge/Culvert Hydraulic Analysis and Design

Centerline structures (bridges and culverts) are required at many points along a drainage system. The proper design discharge for these structures is a function of the type of crossing (county road, township road, private crossing, etc.), and the upstream or downstream damage potential (buildings, grain storage, etc.).

The engineer must select a design discharge which is most appropriate for the condition of a specific centerline structure's location. This generally involves a risk assessment of damage potential, balanced against structure costs. Commonly used design discharges are as follows:

Type of Road	Design Discharge
Field crossing	2-year to 5-year
Private driveway or road	5- to 10-year
Local or minor collector roads (e.g. city & township roads)	10- to 25-year
Major collector or minor arterial roads (e.g. County roads)	25- to 50-year
Major arterial roads (e.g. State or U.S. highways)	50- to 100-year

Note that 100-year or greater protection may be required when a road or highway is the primary/only access into a developed area and inundation would prevent safe access to properties. The [MnDOT Drainage Manual](#) provides additional guidance for appropriate design frequencies.³



An example of a new culvert placed in the field.

The engineer must also check to see that the proposed structure will adequately pass the proposed drainage system's design flow without adversely affecting the drainage system's performance. Other hydraulic design items of concern are maximum culvert velocity (erosion and scour potential) and headwater - tailwater conditions (stage increase).

There are many methods and publications available for the hydraulic analysis of bridges and culverts. The *MnDOT Drainage Manual* is the foremost publication in the State of Minnesota for the hydraulic design of bridges and culverts. The Federal Highway Administration also has two publications which may be consulted for bridge and culvert analysis: "[Hydraulic Design Series No. 7](#)" (Ref. 11), for bridges, and "[Hydraulic Design Series No. 5](#)," for culverts. Many hydraulic design programs are capable of completing acceptable bridge and culvert hydraulic design calculations. It is critical for the design engineer to understand the limitations of each model prior to beginning the design. At a minimum, the modeling or evaluation methods should consider the effects of the downstream water surface (i.e. tailwater), the inlet capacity, and hydraulic losses through the structure. Bridge and culvert hydraulic design results should be documented in tabular form in the engineer's report(s). See **Appendix 10** for a suggested format for such a table.

4. Erosion Control for Drainage Water Entry to a Public Ditch

There are multiple ways that drainage water enters into a public drainage ditch: tile outlets, ditch outlets, drainageway outlets, side inlets, and sheet flow. The engineer will need to consider erosion and sedimentation control measures for each type of entry (see **Chapter 5**).

Each entry location will have unique characteristics such as conveyance type, size of tributary watershed, elevation of contact with the ditch, potential for erosion of or by the drainage water conveyance, and the velocity of the flow.

Side inlets are any concentrated drainage water entry from the field to the public ditch. When the side inlet is a drainageway formed by nature or by the landowner in existing soil, it can be a significant source of sediment. The sediment can come from the field via overland flow, from headcutting of the drainageway, and from erosion of the drainageway. Side inlet controls are used when there is an excessive drop in elevation from the field or natural ground level to the ditch bottom. Drainage Law allows for incremental implementation of side inlet controls ([Minn. Stat. § 103E.021, Subd 6.](#)), "to control erosion

and sedimentation, improve water quality, or maintain the efficiency of the drainage system". They are most often owned and maintained by the system. The NRCS provides a design standard for side inlet controls in their *Field Office Technical Guide* ([Grade Stabilization Structure, Code 410](#)).

Note: It is recommended, but not required that the engineer when possible use an alternative side inlet control design that provides water detention for trapping sediment and incremental reduction of ditch flood peaks and is constructed on the edge of the field.

Side inlet controls are also used in conjunction with flap gates (flood gates) to prevent backflow from the ditch system onto adjacent property when water level stages in the ditch are higher than the adjacent natural topography. The decision to use flap gates is based on a water surface profile and backflow history. Ditch inlets are sometimes shown on the preliminary plan and profile drawings even though side inlet control locations are usually field sited during construction.

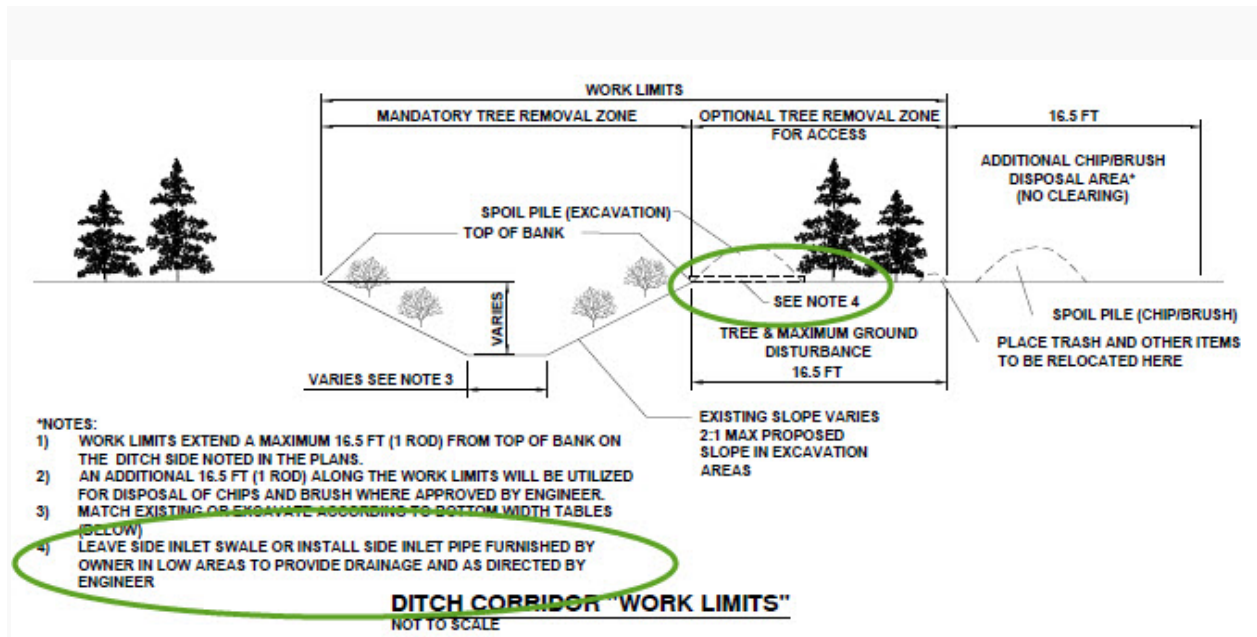
Note: It is recommended but not required that a tabulation of side inlet control pipe quantities should be included in the engineer's report(s) as part of the itemized cost estimate.

When surface water from larger watersheds are tributary to a ditch, it may be necessary to use a rock weir and/or a rock chute design. A rock chute design spreadsheet can be found in **Appendix 11**.

5. Miscellaneous Structures

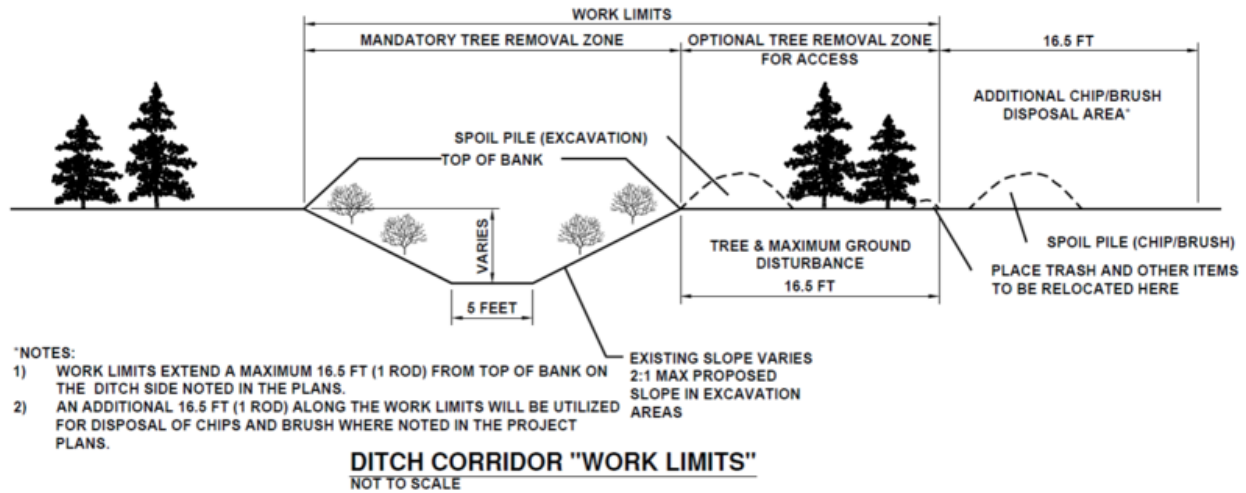
Specific project requirements may dictate the use of special purpose structures for erosion control (e.g. drop structures and riprap), sediment control (e.g. sediment basins and BMPs) and flood control (e.g. water level control structures and detention basins). Hydraulic design of these structures is of a specialized nature, and their design and/or requirement is not specifically addressed within [Minn. Stat. § 103E](#). Therefore, the design of these structures is not discussed in detail within this manual.

6. Channel Geometry



This figure shows a side inlet in detail.

Channel dimensions are generally a function of hydraulic design requirements. However, side slopes for the trapezoidal shaped ditch can be dictated by other factors. Soil slope stability considerations may dictate flatter side slopes to prevent sloughing. An acceptable design side slope, which is consistent with soil stability, can be determined by a geotechnical analysis of soil boring samples taken along the ditch alignment.



This figure shows a typical cross section in detail.

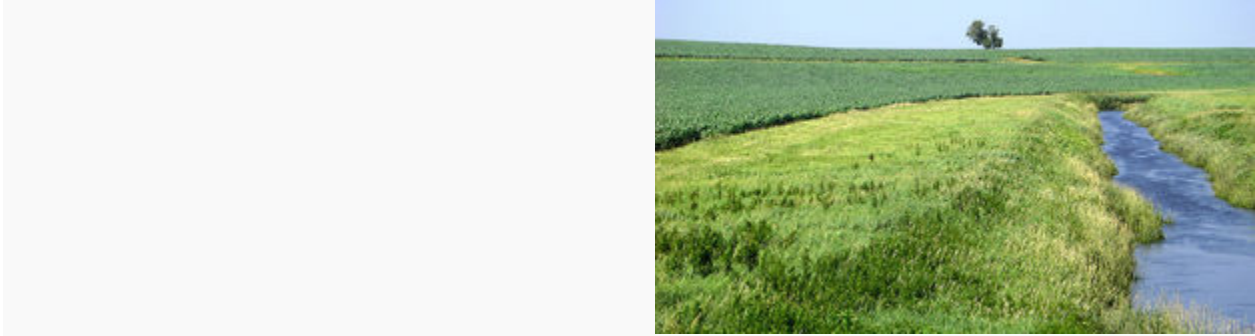
However, the engineer can base the design of the side slope on past experience in the area with acceptable risk. This is a commonly accepted practice in Minnesota. Slope stability can also be enhanced by spreading the ditch excavation spoil in a thin layer along the ditch bank or by leaving a berm.

Other factors affecting the design ditch side slope include:

- The amount of right-of-way necessary (economic);
- Ease of maintenance for tractors and mowers;
- Minimization of snow blockage (early spring opening);
- Vehicle recovery zone safety; and
- Regional practices

7. Vegetated Ditch Buffer Strips

The drainage code requires in [Minn. Stat. § 103E.021, Subd. 1](#), that, 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 permanent strips of perennial vegetation must be a minimum of one rod (16.5 feet) in width measured from the top edge of the constructed channel, or to the crown of the leveled spoil bank (whichever is greater).



Since some Repair proceedings require viewers to assess benefits and damages, repairs completed under those circumstances must provide for the grass buffer strip per Minn. Stat. 103E. Photo courtesy of BWSR.

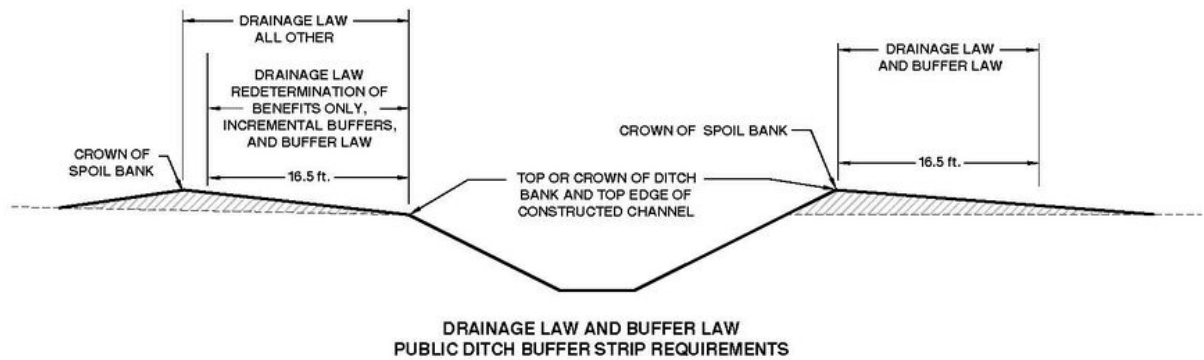
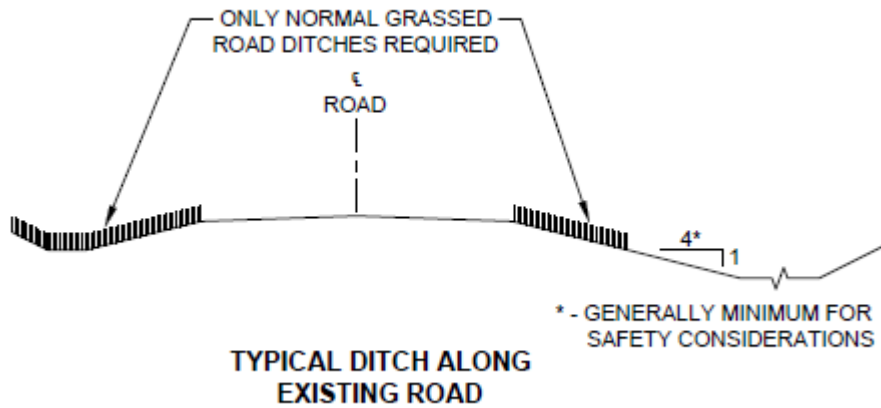
The above requirement applies whenever viewers are appointed for new ditch construction or modifications to existing drainage systems. Since some Repair proceedings require viewers to assess benefits and damages, repairs completed under those circumstances must provide for the grass buffer strip.

*Note: [Minn. Stat. § 103F.48 Subd. 3](#) requires the establishment of a 16.5-foot-wide buffer along any Chapter 103E ditch prior to November 1, 2018. Therefore, it is recommended that buffers be established in conjunction with any public drainage system project per the compliance required under this statute. More information regarding the applicability of this statute in relation to [Minn. Stat. § 103F.48](#) is found in **Appendix 12**.*

The figure below illustrates the grass buffer strip requirement described in Drainage Law. The top and middle portions of this figure represent a typical open field public ditch commonly found along property lines or some other location. The top portion of Figure 3-3 illustrates that more than 16½ feet of grassed strip is mandated because the grass buffer strip must go to 16½ feet from the top of the ditch bank, or **to the crown of spoil bank**, whichever is the greater of the two. In the middle example, the top of bank to crown of spoil is less than the minimum of 16½ feet; the grass buffer strip must therefore extend beyond the crown of spoil to get the required 16½ foot width.

When a road is located adjacent to an open ditch, the situation becomes less clear, as shown in the bottom illustration of the figure. The buffer for the field side of the ditch follows as stated above. However, on the roadway side it may be infeasible to establish a full buffer (or any buffer at all) at the top of the ditch bank due to the proximity of the roadway. In such situations, we must consider the intent of the grassed buffer strip provision, which is to minimize wind-blown topsoil from entering the ditch, prevent agricultural encroachment, and to minimize washing soil into the ditch. Because the roadway by its very nature serves these purposes, and since it would be infeasible to establish the buffer under these circumstances, no grassed strip need be required along the roadway side of the open ditch.

Chapter 5 provides additional information on the design of the buffer strip, including type of vegetation and prevention of erosion prior to establishment.



FOOTNOTES

² Subsequent to the development of the TR-20 model, the Soil Conservation Service was reestablished as the "Natural Resource Conservation Service" (NRCS). The historic TR-20 is no longer supported by the NRCS. However, the SCS method of unit hydrograph generation and the TR-20 routing methodology are still utilized by many proprietary hydrology and hydraulics models.

³ The *Mn/DOT Drainage Manual* specifies design criteria which are required for state-aid funded projects and roadways. These design criteria are not required for most public drainage system construction but serve as a good starting point for establishing design criteria on a drainage project.