Field Guide for Maintaining Rural Roadside Ditches




Protecting Lakes and Streams through Proper Ditch Maintenance

Funded by

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Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover

Field Guide for Maintaining Rural Roadside Ditches

Protecting Lakes and Streams through Proper Ditch Maintenance

By Fortin Consulting, Inc.; University of Minnesota Sea Grant Program;
and the Natural Resources Research Institute, University of Minnesota Duluth

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This field guide is dedicated to the professionals, contractors, local government employees, and state road crews who perform routine ditch maintenance throughout northeastern Minnesota.

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INTRODUCTION

The purpose of this Field Guide is to provide guidelines for maintaining upland roadside ditches in rural northeastern Minnesota in a way that reduces **sediment** and pollutant loads to waterways. Using the information will also help you prevent erosion and maintain good **water conveyance**. This guide offers practical advice and illustrations to hands-on maintenance workers, ditch maintenance contractors and local (township) road supervisors who maintain ditches. These pages contain technical guidance for routine work in the field when there is limited access to survey equipment and other sophisticated tools. The guide will also help you determine when maintenance is beyond routine and additional help and advice should be sought.

This Field Guide was written for the northeast region of Minnesota; however, it may be useful for other regions and other states. Northeastern Minnesota is often called **the Arrowhead**. Approximately 250,000-300,000 people live in the Arrowhead, which is also home to some of the state's most beautiful natural resources, including Voyageurs National Park, the Boundary Waters Canoe Area Wilderness, the Sawtooth Mountains and the Superior Hiking Trail. The Arrowhead's watersheds form the headwaters of Lake Superior, the largest freshwater lake in the world by surface area and the deepest and most pristine of the Laurentian Great Lakes. Lake Superior alone contains 10% of the fresh surface water on Earth and more than the four lower Great Lakes combined.

The soil, water and vegetation characteristics of the Arrowhead influence ditch maintenance. This region and nearby parts of western Wisconsin contain sand plains in flatter areas and heavy red clay or thin rocky soil in hillier ones. (Sometimes the flat areas are also thick with clay or are rocky). Each soil type and terrain possesses unique challenges for creating and maintaining ditches.

This field guide covers routine and some non-routine maintenance of upland ditches that carry stormwater **runoff** (Fig. 1).

This guide does not provide technical guidance for the design, reconstruction, or replacement of road or stream crossing **culverts**, **ditches** with constant flow, ditches that look like **streams** or **wetlands**, or the redesign of failing ditches (Fig. 1). This field guide is not written for engineers, nor is it a replacement for engineering or legal advice. Maintenance professionals should seek engineering advice whenever they are uncertain of a ditch maintenance activity and how it could affect the ditch system; they should seek legal advice whenever there is a question of jurisdiction or permitted work.

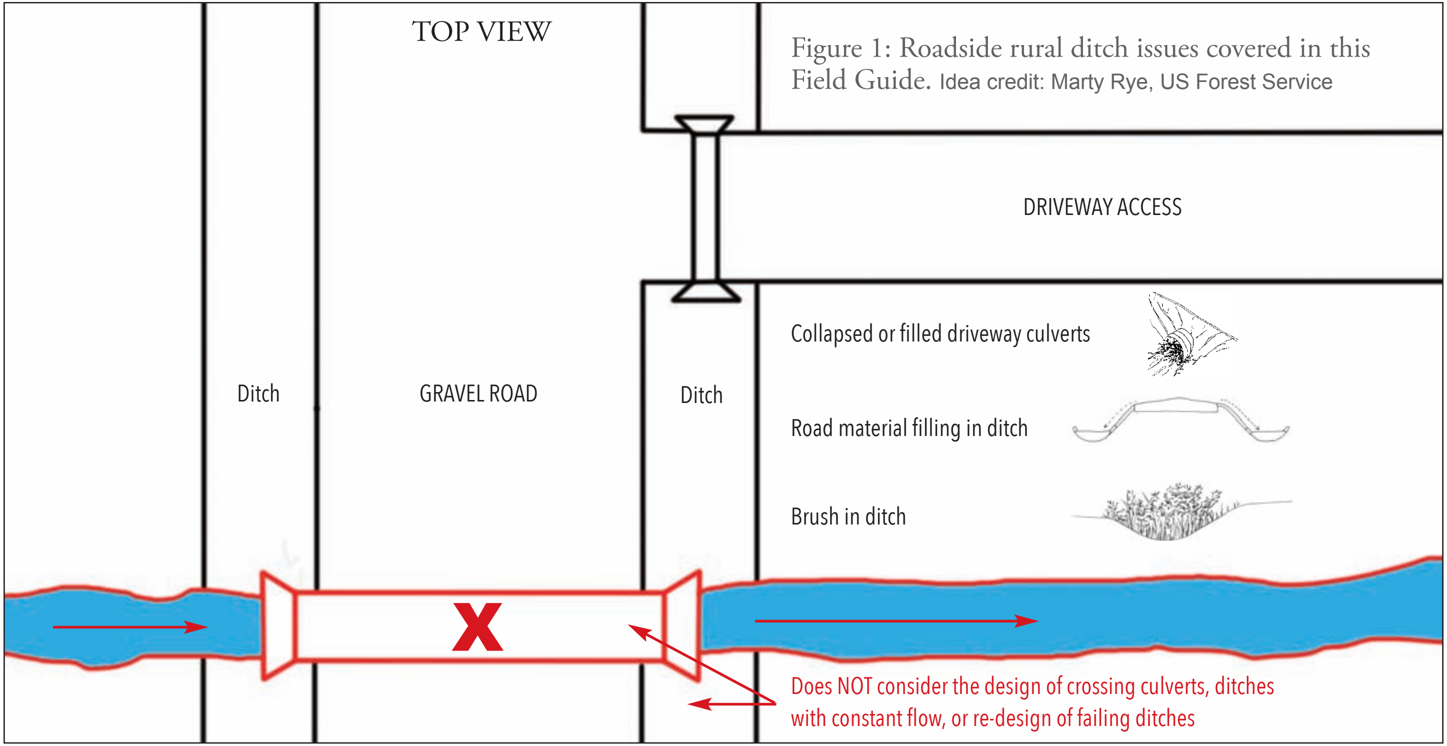


Figure 1: Roadside rural ditch issues covered in this Field Guide. Idea credit: Marty Rye, US Forest Service

This is not a road safety guide. The optimal ditch slopes for road safety are often not attainable with rural roadside ditches. This guide does not address high-volume and higher-traffic, paved-road ditch maintenance, although it is likely that many of the principles discussed here apply to other road systems.

Why Ditch Maintenance?

Road systems in the Arrowhead region of Minnesota are dominated by rural (ditched) sections. A large percentage of the roads are unpaved. Out of 3,004 miles of road maintained by St. Louis County, 1,546 miles are unpaved (St. Louis County, MN website), and Carlton County maintains 452 miles of unpaved roads out of 785 total miles (Carlton County, MN website).

Material from gravel roads, including sediment from winter sanding, moves from the roadbed to the ditches as a result of grading, traffic, rainfall runoff, snowmelt runoff, plowing, erosion, and potentially other activities.

Over time as a result of this movement, roadside ditches and culverts fill in with gravel and sediment. The periodic removal of this material is required to maintain the **hydraulic capacity** of the ditches and protect the roadway and travelling public.

Ditches are typically vegetated (Fig. 2). The resistance to flow and erosion can vary over time and space as **vegetation** grows and dies. The capacity of the ditches can be reduced by overgrown vegetation. Periodic mowing is often required to retain the hydraulic capacity of the ditches. **Invasive plant** species can spread along roads and dominate ditches when weed seeds mix into the soil/mud carried by vehicles. Invasive plants can also become established as a result of disturbance (sediments, erosion, ditch grading) and become a seed source for other areas.

Why Are Road Ditches Important?

Protecting the road: The main purpose of a roadside ditch is to protect the integrity of the road. Roads are designed to drain rain and snowmelt away from the road, toward the lower elevation of the roadside ditch. Once the water reaches the ditch, it can flow along the ditch and eventually away from the roadway, protecting the stability of the road **subgrade**.

Figure 2: Stable ditch

A ditch may respond to changes such as:

- Increased water flow
- Removed vegetation
- Blocked **channels**
- Increased sediment load

Figure 3: Unstable ditch

When its flow is blocked, water seeks a new course. It might carve a new path causing banks to erode or a channel to deepen. As the channel deepens and the banks become near vertical, the upper bank soils might **slough** to create a shallower slope (Fig. 3).

Protecting water quality: Ditches carry water directly to streams and lakes; the water is not treated or cleaned. Performing ditch maintenance that will protect both the roadways and the receiving waters is challenging.

Ditches often perform better than storm sewers when it comes to protecting water quality. In storm sewer systems, the water moves from the road into a pipe that leads directly to the receiving water. Ditches along rural roads are often vegetated (Fig. 2); the vegetation slows down the water, allowing a portion of it to **infiltrate** into the soil and allowing some of the debris and pollutants to settle out. **Fine sediments** and associated pollutants filter out as subsurface water moves through a mesh of plant roots. When plants take up water, they help to reduce the volume of runoff after a storm.

When ditches are unstable, or when the vegetation is disturbed during ditch maintenance, **erosion** is more likely (Fig. 3). Erosion can significantly impact water quality.

Turbidity (cloudiness or muddiness) impairs lakes and rivers in the Arrowhead; some are even on the state list of **impaired waters**. A common cause of turbidity is suspended (floating) sediment from erosion. Erosion can occur in the ditch itself and/or the ditch can convey turbid water caused by erosion in higher parts of the watershed. The Minnesota list of impaired waters can be found on the Minnesota Pollution Control Agency website.

IDENTIFYING DITCH PROBLEMS

To keep up with ditch maintenance, it might be helpful to create a ditch management plan that includes a ditch inventory and rating system. The rating system could be based on a combination of vehicle safety, potential for flooding, environmental impacts, customer complaints, etc., but ultimately the rating system should help to prioritize where maintenance time and money are best spent. Drive the routes and record ditch function as you develop a ditch maintenance schedule that keeps ahead of major problems. The best way to know if ditch systems are functioning properly is to observe and inspect them, especially during and immediately after rain or snowmelt events[1] when higher flows put more stress on them.[2]

Especially note these three conditions when rating ditches:

1) *Road appearance:* Potholes, degradation, cracking, rutting, road edge erosion/"breaking off", and suspicious wear and tear may indicate a ditch in need of maintenance. Roads also deteriorate because of undersized or clogged culverts or when the subgrade becomes saturated.[3]

2) *Ditch erosion or soil instability:* Look for un-vegetated banks, sediment deposits in the ditch, unstable or eroding slopes, **incision** (channel deepening) and **headcuts**. Is the **riprap** in place or has it been undercut or washed away? Check culvert ends for signs of scour.

3) *Water flow:* How frequently does the ditch vegetation need to be mowed or otherwise reduced to provide adequate flow rates? Pools of standing water in a ditch or water ponding between culverts over long periods indicate either a drainage problem or that the ditch may be a wetland or stream. Are blockages or flood problems diverting the flow? Are the culverts adequately sized to carry the flow? Inspect culverts for signs of corrosion, separated joints, sagging bottoms, blockage, piping, fill settling, and sediment buildup.[4]

[1] Local Roads Maintenance Workers' Manual, 2006. Iowa State University

[2] Lake Superior Streams Website

[3] Forest Road Construction and Maintenance. U.S. Forest Service

[4] Recommended Practices Manual: A Guidance for Maintenance and Service of Unpaved Roads, 2000. Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority

Indicate the roadside ditches and culverts you need to maintain on a map. Use this map as you drive the roads. As you record ditch conditions, link your field notes to a particular location on the map to jog your memory later. Take a **GPS** location at problem sites and those needing analysis. Photographs of problem areas will also be helpful as you try to remember each situation and explain it to others. Some smart phone Apps give latitude and longitude coordinates and tag photos with them.

DITCH MAINTENANCE CATEGORIES

This guide is divided into two maintenance sections: Routine and Non-routine.

Routine Maintenance: Work can generally be completed by maintenance staff in the field without major analysis or engineering. It includes work such as removing sediment that has filled in the ditch, replacing a damaged or corroded culvert of the same size and type under driveways or small roads, seeding a side slope, clearing brush, removing invasive species or noxious weeds, and mowing. Basic field measurements often precede routine maintenance (see App. A).

Non-routine Maintenance: Work requires professional analysis or engineering and possibly one or more permits. Non-routine maintenance often involves fixing headcuts, altering channel water carrying capacity, replacing culverts with different sizes or types, working in ditches that double as a stream or wetland, and combating major erosion.

Is the ditch just a ditch or is it also a public watercourse (stream or wetland)? Caution: If it is perennially wet, flows through a wetland or seems different than a typical upland dry ditch, state and federal permits and other requirements may apply. The DNR Public Waters Work Permit Program applies to those lakes, wetlands, and streams identified on DNR **Public Water Inventory** (PWI) maps. Proposed projects affecting the course, flow or cross-section of these water bodies may require a Public Waters Work Permit from the DNR and permits from the Army Corps of Engineers and other agencies. The PWI maps can be accessed through the Minnesota DNR website. See the Regulations section for more information.

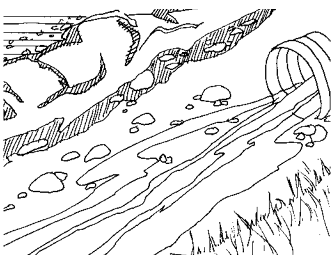
Use Table 1 below to identify common ditch problems and determine whether they are routine or non-routine. Non-routine maintenance requires additional analysis and/or engineering and/or permits. Engineering may be required for more serious problems or changes, and a civil engineer should be involved to determine the best solution.

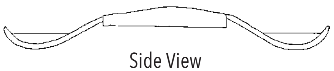
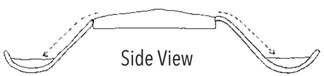
Maintenance vs. Redesign

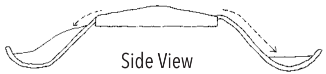
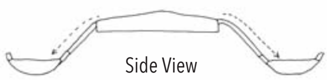
Ditch design is an essential step in protecting roads and waters. Many rural roadside ditches were merely excavated rather than designed, making them prone to problems. Changes in flow volume or velocity, or road traffic may necessitate redesigning a ditch. Proper design influences the type and frequency of maintenance work that is required to keep the ditch functional.

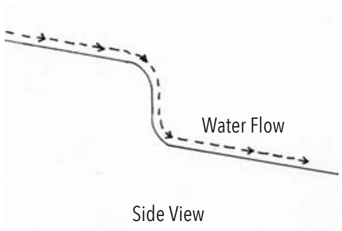
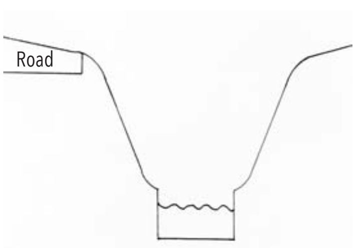
If the ditch was not designed properly or is not adequately carrying the stormwater runoff it receives, a redesign may be needed to reduce repeated maintenance issues. Redesign needs to take place within the framework of regulations that apply to the particular ditch.

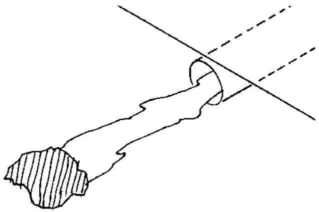
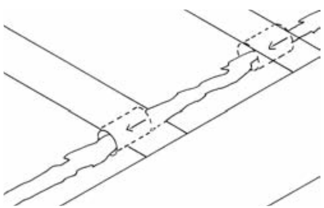
Table 1: Common Ditch Problems

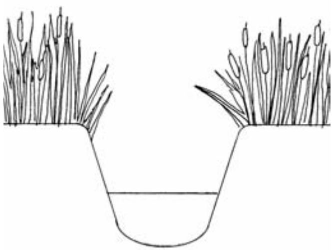
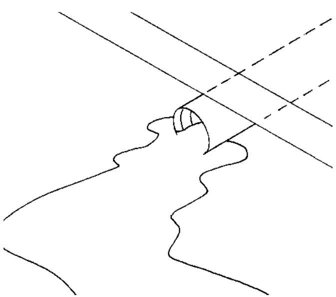
Problem/Sketch	Photo	Clues	Maintenance *Reference Pages*
No ditch			
		• Gully along shoulder • Lack of defined ditch channel • Road deterioration Also see Erosion Control *Pages 36-44*	Non-routine *Pages 49-56*

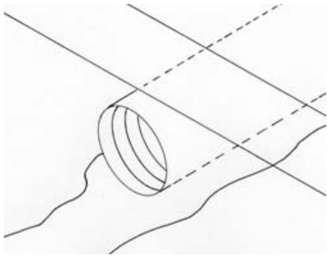
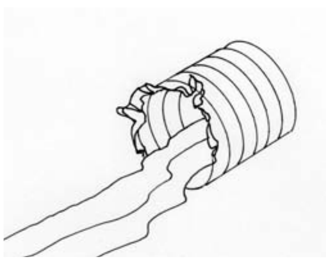
Problem/Sketch	Photo	Clues	Maintenance *Reference Pages*
Wet road for extended periods			
		• Road edges wet after rain • Possible standing water in ditch • Water not draining to ditch • High shoulder, water can't get to ditch • No ditch (see above) Also see Erosion Control *Page 36-44*	Routine (if removing washed -in dirt/gravel) *Page 27* Non-routine (if a new, deeper, or re-sloped ditch needed)
Gravel from road in ditch			
		• Gravel visible in ditch • Channel partially filled in	Routine *Page 27*

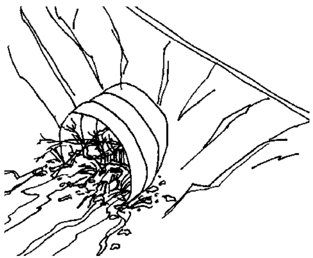
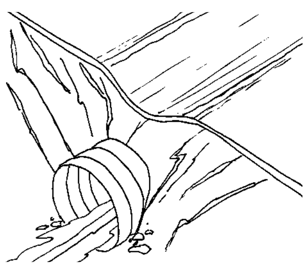
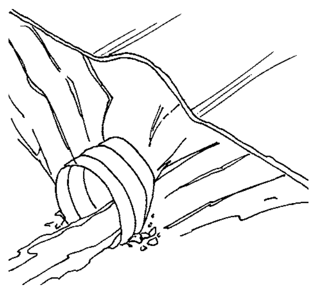
Problem/Sketch	Photo	Clues	Maintenance *Reference Pages*
Eroding side slope(s)/major bank undercutting and erosion			
		• Evidence of soil sloughing (May be more common on shady side of ditch)	Non-routine *Page 50* See also Erosion Control *Pages 36-44*
Minor bank erosion			
		• Small gullies (rills) on side slopes • Bank still has overall proper shape • Lack of vegetation	Routine *Pages 31-36* See also Erosion Control *Pages 36-44*

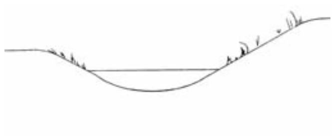
Problem/Sketch	**Photo**	**Clues**	**Maintenance** ***Reference Pages***
Headcut			
		• Eroded deep channel • Abrupt (vertical) drop in channel bottom • Sediment moved downstream • Perched culverts or tile outlets • Small waterfalls in ditch	Non-routine *Pages 54-55* See also Erosion Control *Pages 36-44*
Incision (channel deepening)			
 Cross Section		• Channel cut deeper • Steep side slopes	Non-routine *Pages 55-56* See also Erosion Control *Pages 36-44*

Problem/Sketch	**Photo**	**Clues**	**Maintenance *Reference Pages***
Standing water in upland ditch			
		• Stagnant water • Ditch not draining • Blockages in ditch • Not enough drop	Routine (if removing blockages) *Pages 28-29* Non-routine (if changing the slope of ditch system)
Permanently flowing ditch			
		• Ditch rarely, if ever, dries out • Flowing water	Non-routine This is likely a small stream rather than upland ditch and may be a public watercourse. Regulations apply. *Check pages 57-60*

Problem/Sketch	Photo	Clues	Maintenance *Reference Pages*
Ditch runs through wetland			
		• Area of cattails, sedges or other water-loving vegetation surrounds ditch (not just in the ditch bottom) • May be standing water	Non-routine This may be a wetland. Regulations apply. *Check pages 57-60*
Erosion at culvert outlet or inlet			
		• Culvert bottom not level with bottom of ditch • Bare eroded soils surrounding culvert • Scouring just downstream of culvert outlet • Scouring at culvert sides See also Erosion Control *Pages 36-44*	Routine (if repairs are minor and simple) *Pages 29-31* Non-routine (if there is major erosion around inlet/outlet) *Pages 50-52*

Problem/Sketch	Photo	Clues	Maintenance *Reference Pages*
Water flowing under or bypassing culvert			
		• Water is cutting and flowing under culvert • Large "gopher" hole on outlet side under culvert • Small "gopher" hole on inlet side under culvert	Routine (if involves a blocked culvert or the reinstallation of an existing culvert) *Pages 29-31* Non-routine (if there is major erosion around the culvert) *Pages 50-52*
Damaged culvert			
		• Crushed culvert ends • Corrosion • Other damage	Routine (if replacing with same size/type) *Pages 29-31* Non-routine (if replacing with different size/type) *Pages 50-52*

Problem/Sketch	**Photo**	**Clues**	**Maintenance *Reference Pages***
Culvert blocked			
		• Rock and gravel in culvert • Branches in culvert • Trash in culvert • Fallen trees in ditch • Dam or dam-building activity observed • Ponded water • Water flow changed around obstacles	Routine (if removing debris) *Pages 28-29* Non-routine (if this is a public watercourse) *Pages 57-60*
Frost heave			
		• Raised or settled area over culvert	Routine (if reinstalling same slope, size and type of culvert) *Pages 29-31* Non-routine (if changing culvert slope, size or type) *Pages 50-52*

Problem/Sketch	**Photo**	**Clues**	**Maintenance *Reference Pages***
Seeding failure/bare soils			
		• Soils visible • Erosion likely • May be more common on shady side of ditch	Routine; see Seeding *Pages 32-44*
Vegetation reducing flow			
		• Taller, dense vegetation (e.g. shrubs, cattails, willow) in ditch • Ponded areas upstream of vegetation	Routine; see Vegetation Management *Pages 44-47*

Problem/Sketch	Photo	Clues	Maintenance *Reference Pages*
Invasive species or noxious weeds in ditch or right-of-way			
		• Unwanted plants observed and spreading. Examples: • Purple loosestrife • Canada thistle • Buckthorn • Spotted knapweed	Routine; see Vegetation Management *Pages 44-47* See also Invasive and Noxious Weeds *Pages 80-83*
Rare or protected plants in ditch			
		Lady slipper species, for example	Non-routine *Page 45*

ROUTINE MAINTENANCE

Before excavating make sure underground utilities are marked. Appendix A contains important information about the shape and slope of ditch excavation. Take time to review it before excavating. If done right, routine ditch maintenance can fix common ditch problems while ensuring that high-performance ditches protect the road and waterways.

Correcting Sediment Buildup

The **longitudinal profile** of a ditch (the slope along the length of the bottom; see Figure 36 for an example) plays a major role in its stability. Over time certain reaches of a ditch can fill in, which alters the flow of the water. Ditches partially filled with sediment, rock or other debris should be cleaned out to regain the original ditch flow capacity. Careful excavation can correct this problem without significantly changing the longitudinal profile of the ditch. If slopes are changed significantly during excavation, a new cycle of sedimentation or erosion may occur in adjacent segments of the ditch. Use the best practices described below for seeding and erosion and **sediment control** during and following excavation to keep sediment from washing downstream. Limit excavation to removing accumulated sediment. In most cases, removing sediment without altering the original shape of the ditch would not require a permit.

Make sure to have underground utilities marked when doing any excavation work.

Changing the shape (depth and/or width) of the ditch is non-routine maintenance and may require permits; see the Regulations section for more information.

Disposing of Ditch Spoils

Call the local weed inspector or inspect ditches yourself for problem plants before excavating. When excavating, haul the excavated soil and vegetation (**spoils**) offsite to a local gravel pit or other designated disposal area as soon as possible. If possible, load them directly into the truck from the excavator. Spoils left onsite are likely to erode back into the ditch and wash downstream. Spoils should not be placed in wetlands or floodplains and special care must be taken if the site has invasive species or noxious weeds on it. Use sediment control structures around temporary spoil piles (see Erosion Control section).

Remove ditch spoils from the site as soon as possible.

Unblocking Blocked Culverts

Remove debris that blocks culverts to allow water to flow through them freely (Fig. 4). If soils are disturbed during this process, take time to stabilize them using the **erosion controls** discussed in this guide.

Figure 4: Debris blocking culvert

Battling Beavers

If beavers are creating dams in the ditch system, remove the dams as soon as possible and have a trapper remove the beavers. Beavers generally create dams in gently flowing water and extra sediment might settle near the dam. Sediments deposited in slower waters created by the dam can be easily eroded when the dam is removed. After removing a beaver dam, make sure the ditch bottom has an even grade so as not to create a headcut.

Dams indicate that the upland ditch may actually be a stream. (If conditions are right, beavers may create dams in upland ditches, too.) Woody debris may be removed without a permit, even in a public watercourse, as long as soil is not removed or added.

State, county, or local government employees, while on duty as a representative of that government, do not need a permit to remove beavers on land under their jurisdiction.

•*Minnesota Statute 97B.667 Removal of beaver dams and lodges by road authorities. When a drainage watercourse is impaired by a beaver dam and the water damages, or threatens to damage a public road, the road authority, as defined in section 160.02, subdivision 25, may remove the impairment and any associated beaver lodge within 300 feet of the road.*

Mitered culvert ends or **Clemson levelers** may be helpful where ongoing beaver problems exist. Clemson levelers work to prevent beavers from detecting flowing water in culverts, dams or water control structures. The Clemson leveler can impede fish migration and should not be used in situations where aquatic organisms need access to water on both sides of the culvert. See the Resources section for information on how to construct or purchase and use Clemson levelers as well as other alternatives for preventing beaver activity from plugging culverts.

Replacing Damaged Culverts: Same Size, Same Type

Damaged or corroded culverts may need to be replaced. Most of the time it is OK to replace a culvert without engineering analyses if you use the same material, size, length, **invert** elevations and conveyance capacity of the pipe. However, culverts must be installed correctly. Refer to the References section for resources on culvert installation. If you're replacing a culvert, make sure it is aligned to minimize future erosion problems. Culverts should be placed parallel with the ditch flow (Fig. 5). If water is directed through a culvert toward a bank, the bank will be more prone to erosion.

If the ditch is listed on the DNR Public Water Inventory maps or is in a designated floodplain, consult a Minnesota Department of Natural Resources area hydrologist prior to making a change.

Frost heaves may occur when moist soils freeze[5]. This creates a "speed bump" across the road or driveway over the culvert. Once the frost melts, settling might create a dip in the road or driveway. The culvert may need to be reinstalled or replaced if drainage is affected. Silt and silt-clay are the soils most susceptible to frost heaves. Clean mixes of sand and gravel are the least susceptible. Frost heaves may indicate the need to improve drainage in the area or replace frost-susceptible soils. Make sure the ditch and culverts are not blocked so that water drains away from the ditch-line culverts.

Controlling Minor Erosion at Culvert Ends

Ends of culverts are susceptible to erosion, especially if they are not protected by a headwall, apron or riprap. To repair the eroded area around the culvert in Figure 6, first try to determine what is causing it. In this case the culvert appears to be perched, causing an eddy to erode the nearby bank. To correct this problem, the culvert should be re-installed at the correct elevation. Fill in the eroded area. Seed the filled area and then cover it with an erosion control blanket. Adding aprons or riprap around the culvert would provide additional protection.

[5]Effects of Excess Subsurface Water. Local Highway Technical News, Vol. 17 No. 8, Feb. 2012. Cornell University.

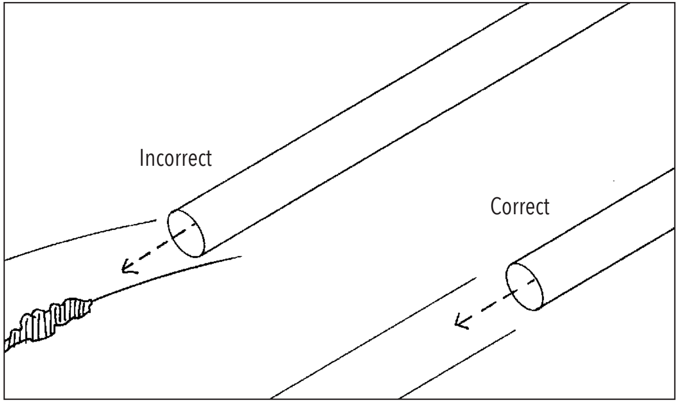


Figure 5: Culvert alignment for reduced erosion


Figure 6: Minor erosion around culvert

A Word About Culvert Inlets and Outlets: A straight cut (see Fig. 6), which can be easily clogged or damaged, is the least efficient way to begin and end a culvert. A mitered cut (Fig. 7) allows a culvert to handle 10% more water than a similar culvert with a straight end. Mitered culverts are also less likely to be plugged by beaver activity or debris[6]. For higher velocity ditches or steeper gradients, install flare ends, otherwise known as aprons (see Fig. 8 and 9). The apron acts as a funnel directing water through the culvert and protecting the outflow from erosion.

Common Problem: **Scouring at culvert outlet**. If erosion is occurring at the culvert outlet, additional protection is likely needed. Aprons, riprap and/or rock plunge pools may help. Scouring may also be a sign of an undersized culvert. See the Non-routine Maintenance section.

Common Problem: **Erosion around culvert outlet riprap**: The riprap may have been installed too high, diverting the water

[6]Wisconsin Transportation Bulletin No 15, revised September 2004. Page 5

around the riprap. Make sure the riprap is installed flush with the soils at the pipe invert. The riprap may not be wide enough, allowing the water to flank around the rock. The riprapped area width should be a minimum of twice the culvert diameter.

Figure 7: More efficient, mitered cut

Figure 8: Most efficient, apron inlet

Figure 9: Most efficient, apron outlet

What to do About Water Moving Alongside Culverts

If a culvert was not installed or backfilled properly, there may be air gaps (air pockets) or organic material left in the soil around the culvert. Water can form a path along these air pockets that eventually erodes away the finer soil. Over time, erosion can form larger conduits running parallel to the culvert or cause the soil to collapse along the culvert. Remedy this problem by removing the culvert and the substandard backfill, properly preparing the site, and re-installing the culvert with compacted backfill. Use of anti-seep collars/diaphragms can help prevent this problem.

Stabilizing Ditch Banks

Sediment enters ditch systems from two main sources: gravel from the road, and soil that erodes from the banks or bottom of ditches. Proper road maintenance can reduce the amount of gravel and dirt entering the ditch system (see Resources: gravel road maintenance). Tactics for stabilizing ditch banks are reviewed below and in Appendix A.

Soils: Some soils are more likely to erode than others. In general, soils containing a lot of silt and sand are the most erodible. Sand is gritty; silt is smooth; clay is sticky. Most soils are a combination of silt, sand, and clay. Clay helps bind soil particles together, making them less likely to erode. To get a rough idea about how erodible the soil type is, take a handful of moist soil and squeeze it into a ribbon. If it crumbles, it is mostly silt or sand and prone to erosion; if you can form a nice ribbon, it is mostly clay. Clay soils are less permeable and produce more runoff. They are also more difficult to stabilize with vegetation.

Timing: If possible, excavate when erosion potential is low, in drier periods after snowmelt and spring rains and during the growing season when vegetation can be quickly established. Stage your project so that exposed areas can be stabilized quickly, ideally within 24 hours. Look for ways to phase the cleanout so that vegetated strips in the downstream part of each ditch are left intact. The vegetation left in place will help stabilize the ditch and trap pollutants.[7] You may have to come back after the upstream area is stabilized to cleanout downstream areas.

Minimize Disturbance: Vegetation is the best protection against erosion. Minimize disturbance as much as possible. When excavating is necessary, try to remove only the deposited materials, leaving the more intact original soils in place.

Setting Seed

Shaping and Seedbed Preparation: One of the most important erosion prevention techniques is proper shaping and/or contouring. Round the bottom of the ditch and blend in the grading or excavating so it is relatively smooth. Sharp edges sometimes left after maintenance are prone to erosion and the large clods of soil left behind will make it difficult to install erosion control blankets tightly against the soil surface. Gently smooth out the graded areas to prepare the site for seed and blanket, but take care to not compact or glaze the banks during excavation or shaping. Once the proper shape is obtained, gently roughen or rake the soils on the slopes in a direction parallel to the ditch bottom (the long way) to allow spots for good seed/soil contact. Ideally excavator tracks will be angled to slow the flow of water into the ditch bottom, not usher it in. See Figure 10.

The most important step in successful seeding is good seedbed preparation. The soil should be graded smooth, but loose.

[7]Vegetated Stormwater Facility Maintenance Report WA-RD 495.1, Dec. 2000. Washington State Transportation Center.

Topsoil is necessary and may need to be added to allow the seeds to grow. Seeds will not germinate well in compacted or nutrient-poor soils. If you have poor soils on the site, consider incorporating soil salvaged from a weed-free project elsewhere to improve seeding success and promote deeper rooting. The sooner you can establish vegetation on the site, the quicker you will stabilize it.

Seed: Ditch maintenance is a year-round activity that does not always align with optimal times for seeding. To improve the chance of success, match the seed mix to the environment (wetland, woodland, grassland, sunny, shady). Seed can be broadcast or **hydroseeded**. Native seed mixes are initially more expensive but provide wildlife habitat and require less long-term care than non-native species. They also tend to have deeper and more extensive root systems that are better at stabilizing soil. Check the MnDOT seeding manual (see Resources section) or talk to your seed vendor for advice on native seed and establishing seeds. Native plantings require different care, especially when becoming established. Adding flowering plants, especially native plants, is one way to increase habitat for important pollinators like bees, which are exhibiting worrisome population declines. The seed mixes mentioned below (Table 2) include flowering plants although they are not the dominant type of plant.

Consider adding a cover crop that becomes established quickly. Try oats in spring and summer, and winter wheat in autumn. MnDOT seed mixes generally have a cover crop included.

When there are two different growing environments in the same ditch, such as shady slopes or wetter areas, consider using two seed mixes. If you don't want to seed them separately, mix the two together and seed the entire area with the mix. A local seed vendor may also offer appropriate mixes for your project. Make sure there are no weed seeds or seeds of invasive plants in the mixes.

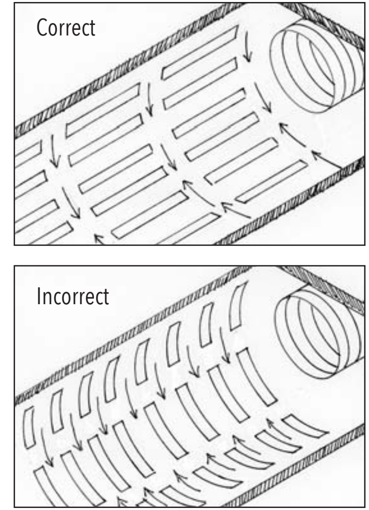


Figure 10: Ditch tracking

Use native seed mixes. They provide long-term stabilization and wildlife habitat.

Table 2: Seed Mixes and Rates for Ditch Maintenance Projects[8]

MnDOT Category	Name	Pure Live Seed Rate (lbs/acre)	Notes	Planting Season	
Cover Crop				Spring	Fall
21-112	Winter Wheat	100		NO	Aug. 1 – Oct. 1
21-111	Oats Cover Crop	100		May 1 – Aug. 1	NO
21-113	Field Pea / Oats	110	Soil building cover crop	May 1 – Aug. 1	NO
22-111	2-year Stabilization	30.5	1-2 year soil stabilization	April 1 – July 20	July 20 – Sept. 20
22-112	5-year Stabilization	40.00	1-2 year soil stabilization	April 1 – July 20	July 20 – Sept. 20
Non-Native Grassland					
25-131	Low Maintenance Turf	220	Salt, shade, drought tolerant turf	April 1 – June 1	July 20 – Sept. 20
25-141	Mesic (wet) General Roadside	59	General roadside and ditches; can be mowed	April 1 – June 1	July 20 – Sept. 20
25-142	Agricultural Roadside	45	Roadside areas cut for hay	April 1 – Sept. 1	NO
25-151	High Maintenance Turf	120	Conventional turf; requires more maintenance	April 1 – June 1	July 20 – Sept. 20
Stormwater (Native)					
33-361	Stormwater Northeast	35	Wetter areas, temporarily flooded areas and ditch bottoms	April 15 – July 20	Sept. 20 – Oct. 20
Woodland (Native)					
36-311	Woodland Edge Northeast	33.5	Partly shaded roadsides	April 15 – July 20	Sept. 20 – Oct. 20

[8] MnDOT Seeding Manual, 2014.

When to Seed: The season is generally from spring to early summer and from fall until the ground freezes. Dates recommended by local native seed suppliers may differ slightly from those listed and will vary depending on weather patterns. Once vegetation starts growing, periodic mowing will help control weeds. A link to the MnDOT seeding manual is included in the Resources section.

Dormant Seeding: Did you know that dormant seeding works better north of Trunk Highway 2 than anywhere in Minnesota?[9] If your maintenance project is completed in the fall, beyond the recommended seeding dates, try dormant seeding. Dormant seeding should occur after the seed is likely to germinate and before the snow falls. The seed will sprout and grow the next year. After seeding, blanket the area. Try to avoid excavating after the ground freezes, but if faced with frozen-ground conditions, use nails and washers rather than staples to anchor the blanket. Dormant seeding is often not as effective as planting within the designated season, so plan to monitor your site and reseed if necessary.

Fertilizer: A soil test is recommended to help you determine whether or not you need to fertilize, and to select the proper type of fertilizer. Without a soil test, use a 22-5-10 fertilizer with a slow release nitrogen source at a rate of 100 lbs/acre.[10] Fertilizer may not be needed with native seed plantings if the soil test confirms high **phosphorus** levels and the soil is prepared properly with a layer of topsoil, or topsoil with a compost mix.[11]

Fertilizer will improve the success of plantings but must be used cautiously in a ditch situation. Try to fertilize when a relatively dry period is forecasted to prevent the fertilizer from being washed downstream and polluting streams and lakes. For the same reason, do not fertilize in a ditch where water is flowing. Take time to calibrate the fertilizer spreader and do not over-fertilize. Make sure to mix the fertilizer into the soil.

Slow-release nitrogen is harder to find and more expensive but it nourishes the plants longer and protects the water from excess nutrients. Use the highest percentage of slow-release nitrogen you can find. Slow-release nitrogen may be labeled “water insoluble nitrogen” or “coated nitrogen.”

[9,10] Personal communication, Dwayne Stenlund, MnDOT, April 28, 2014

[11] Personal communication, Doug Mensing, Applied Ecological Services, April 26, 2014

Common Problem: Failed seeding. If the seeding fails, the ditch will be prone to erosion and will need to be reseeded. Broadcast new seed over the existing blanket or mulch. There are usually enough openings to achieve adequate seed/soil contact. Another option is to mix enough mulch into the seed to act as a tracer and blow it into the blanket (injection seeding).

Preventing Erosion After Seeding
After seeding, the soils and seed need temporary protection until vegetation is established. There are many options but the techniques that show the most promise in controlling ditch erosion are wood fiber blankets, hydromulch with a **tackifier**, and polyacrylamide **flocculent** products. The purchase cost from least expensive to most expensive is: straw mulch, straw blanket, wood fiber blanket, coir blanket, turf reinforcement mat. The purchase cost should be only part of the economic decision; picking the product that will give you the best lasting results is the most cost-effective solution (Table 3).

If You Must, Mulch
When it comes to protecting ditch projects, mulch is not as effective as erosion control blankets (Table 3, App. B). Bagged mulches, such as soil stabilization granules (made of recycled newsprint and wood shavings), are handy for small areas and are activated by water. The mulch should be free of noxious weeds and placed at a rate of about 1.5 tons per acre (about one 74 lb bale per 800 square feet). Aim to cover the soil by about 70% or more.

Straw mulch is inexpensive but is likely to be washed or blown away. Straw mulch must be anchored to be effective. If you can't anchor it, don't use it. Anchoring is difficult in narrow areas and on steep slopes. Disk anchoring or roller punching are not likely to be used in narrow right of ways and on clay or rocky soils.

- **Netting** – Netting can be applied over mulch or straw and anchored with staples. Jute is a natural biodegradable fiber that can replace plastic netting (Fig. 11). Jute netting over straw mulch is comparable in price to plastic netting, and has been used successfully in ditches (Table 4). Jute netting is often available in narrow width rolls and lasts up to 2 years. Seeding can happen before or after installation.

- **Tackifiers** – A specialized hydraulic soil stabilizer or tackifier is sprayed over the mulch. This may be the most practical option for ditches in the Arrowhead region of Minnesota. Hydraulic soil stabilizers are used in combination with seeding and are mixed with water and sprayed in place. They include hydromulch, hydromulch blends and Bonded Fiber Matrix (BFM). They form a layer of mulch over the soil and work well to hold the seed and soil in place (Fig. 12).

Table 3. Seed Protection Recommendations for Ditches[12]

Protection Type	Side Slope Horizontal:Vertical	Notes
Mulch	3:1 or flatter	Must be anchored in place; hydromulch with a tackifier is best.
Straw erosion control blanket, netting on 1 or 2 sides	3:1 to 2:1	Most common temporary stabilization method for ditch bottoms. For blanketed areas next to DNR protected waters and certain other streams, use a natural netting and stitching. 2-sided netting recommended for slopes longer than 50 ft.
Wood fiber blanket, netting on 1 or 2 sides	3:1 or steeper	2-sided netting recommended for moderate slopes (between 3:1 and 2:1) longer than 50 ft or slopes steeper than 2:1
Turf reinforcement mats	2:1 to 1:1	Permanent surface stabilization. Synthetic (polypropylene) fibers. For higher velocity flows or areas prone to erosion.

Other methods of securing mulch include:

- **Hand punching** – If the soils allow, a square-blade spade or shovel can be used to embed the straw at least 4 inches into the ground about every 12 inches. The punched straw should stand perpendicular to the slope.

Tough situations call for TRMs
For highly erosive situations, turf reinforcement mats (TRMs) may be used. TRMs are permanent rolled erosion control products made of non-degradable synthetic fibers (Table 3).

[12]Erosion and Sediment Control Design Guidance, MnDOT 2010. MnDOT Turf Establishment Recommendations for Projects in District 1, June 15, 2012. MnDOT Standard Specifications Regarding Erosion Control.

Best to Blanket

Erosion control blankets work well and should be used as often as is affordable. They should always be used in these critical situations:

- Ditch side slopes steeper than 3:1
- Erosive ditch bottoms (especially V-shaped)
- Ditches that drain directly to a lake or river

Erosion control blankets are made of wood fiber, straw, jute, coir (coconut) or a combination of these, typically with either 1 or 2 layers of plastic or jute netting which holds the material together (App. B lists the different types of blankets and their characteristics). You may wish to avoid using blankets with plastic netting, which takes several years to degrade. Be aware that all netting can damage mowers and entangle wildlife, even snakes. Wood fiber is probably the best blanket for use in ditches. A wood fiber blanket should last 15 months to 3 years depending on the specific product. The plastic netting within it is photodegradable but still a potential hazard to wildlife, mowers, and people who walk through the area. A netfree blanket, which is stitched together with a biodegradable thread, is a better option for flatter areas that will be mowed or to prevent potential wildlife entrapment.

Wood fiber blankets work better than straw because, when wetted, they swell and the barbed fibers bind together to stay in place more effectively (Fig. 13). The wood fibers also absorb water, helping seeds to germinate. Straw tends to float and doesn't absorb water or bind to the ditch or its slopes. Straw blankets generally last less than 12 months. Once the netting degrades, the straw is not anchored and can blow off site. Wood fiber blanket costs more, but typically works better for ditch maintenance projects.

Figure 11: Jute blanket

Figure 12: Soil adhering to BFM

Figure 13a and b: Wood fiber blankets. Credit: Lawn and Driveway Service, Inc.

Table 4. Types of Netting and Their Characteristics

Netting Types	Material	Biodegradability*	Price*
Polypropylene	Polypropylene plastic net with bonded joints	◊	$
Jute	Jute yarn woven into an open mesh	◊◊	$
Coir	100% coconut woven material	◊◊◊	$$

*Biodegradability: ◊ = Least Biodegradable; Price: $ = Least Expensive

Installing Erosion Control Blankets

The site should be graded evenly and seeded before installing an erosion control blanket. Depending on the width of the ditch, you may be able to cover the entire surface with one blanket. It is difficult to roll the blanket out within the ditch. Instead, roll it out on the shoulder of the road and drag it into place.

Confused about what side to put against the ground? Place the blanket roll on the ground so that the blanket comes off the bottom. This lays the proper side down.

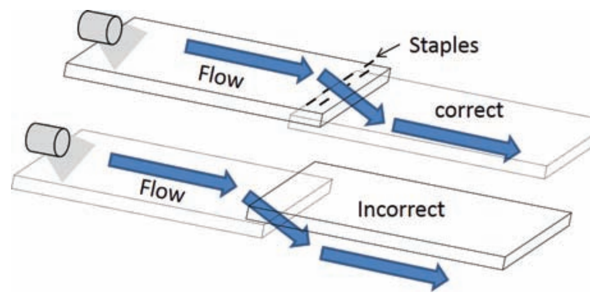
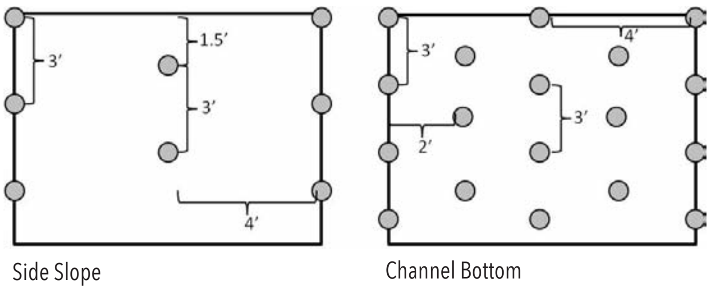


Figure 14: How to "shingle" and staple blanket layers in ditch bottom (12 inch overlap).

Drag the erosion control blankets into place so that they are parallel to the direction of flow within the ditch (e.g., the long way). When laying them out, remember to overlap the blankets by about 12 inches as if you were shingling a roof. Start at the bottom of the ditch. Figure 14 shows how to lay the blankets correctly. Try to avoid placing overlapping side seams in the bottom of the ditch, but if such seams are needed, overlap the blankets by about 12 inches so that they do not separate. Make sure you have good soil contact with the blanket.

Staple the blankets every 1.5 feet at the overlap and add a second row of staples staggered to the first. If the blanket is not overlapped and stapled, water may flow under the blanket and erode the soils. Overlap the blankets along the length of the ditch side slopes, too.

Staple blankets using 6 to 8 inch sod staples. Follow the manufacturer's recommendations for stapling pattern. The blanket should be stapled approximately every 3 to 5 feet along the length, and staggered every 18 to 24 inches along the width in a diamond pattern (Fig. 15). Staple spacing is sometimes indicated with dots on the blankets. For the blankets on the ditch bottom, staples are installed at about twice the density as on the slope.



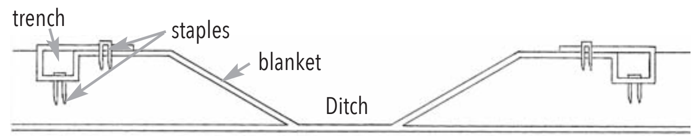


Figure 15: Example staple patterns

Figure 16: Trenching and stapling. Blanket is trenched and stapled at the top of the slope

It is important to dig a small trench (approximately 6 inches deep) along the full length of each side of the ditch, and bury and staple the blanket within these trenches (Fig. 16). Otherwise, water will flow under the blanket and erode the soils. Make sure staples are placed in critical areas including overlaps, at the anticipated water line, and at the toe of the slopes.

If you are not covering the entire side of a slope, place the blanket at least one foot higher up on the slopes than the **normal high water level**. Again, lay blanket sections as if laying roofing shingles (Fig. 17). Side seams need 4 to 6 inches of overlap and plenty of staples on the overlapping areas.

Common Problem: Undercutting. If the water is going under the blanket, it may have been installed without trenching the upper ends, or be improperly shingled and stapled. When such undercutting is occurring, the area should be reshaped and blanket re-installed properly. If it was installed properly the first time, the slope or velocity may be too much for the method used and the site may require a different type of blanket or erosion control method such as riprap.

Avoid placing seams in ditch bottom

Additional protection can come from adding check slots to prevent water from flowing under the blanket. This can be done by digging a small trench (likely the size of the bucket you are using), placing the blanket over the channel and down in the trench, and covering the blanket with rock so it is flush with the channel bottom. A less effective but easier method is to add lines of double stapling along the blanket in the areas prone to undercutting.

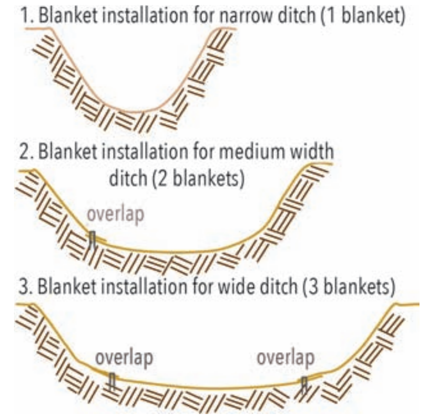


Figure 17: How to install single and multiple ditch blankets. Four to six inch overlap on side seams.

Other Ideas to Keep Things in Place

Polyacrylamide flocculants (PAMs) are easy to use and effective. PAMs can be broadcast in granular form with a fertilizer spreader, or they can be sprayed or blown along with seed. The granular form must be wetted to be activated. You can do this with a water truck or wait for a gentle rain. A hard rain will ruin your work by washing the flocculent away unless it has already been activated by water. Flocculants make the soil particles bind into larger clumps that are less likely to move (Fig. 18). PAMs can be used with mulch to improve its effectiveness. Bagged mixtures (PAM and mulch) are available and easily applied. PAMs should be used with **check dams** to retain soil and flocculent.

Figure 18: PAM flocculant on soil

Some additives and forms of PAM can be toxic to aquatic life. Check with the manufacture to make sure you have an anionic/non-toxic form of PAM. See the Resources section for more information on PAMs.

Riprap. Sometimes it is not possible to establish vegetation in ditches. Examples include cases in which there is rocky substrate, high velocity flow conditions or heavy shade. In such instances, **riprap** can be used to protect vulnerable areas in ditch systems such as culvert **outlets**, steep slopes or high velocity flow areas. Culvert outlets (especially to streams, often called "outfalls") are especially prone to erosion. See the Non-routine Maintenance section; check with an engineer if you are planning to armor the ditches with rock.

Root Rap. Rock can be vegetated using a technique known as root rap. Rock is mixed with or covered with soil and then seeded. This provides for a more vegetated approach for areas requiring the additional protection provided by rocks.

Installing Check Dams

Check dams will slow water velocity and trap sediment to prevent it from washing away (Fig. 19 and 20). Trapped sediment should be removed periodically. Check dams can be permanent or temporary. Temporary check dams may be removed when vegetation is established and the ditch is stable. Be aware that check dams can create unsafe conditions for mowing, snowmobiling, ATV traffic or other uses of the ditch system.

Install check dams so that the bottom of the outer edges is higher than the top of the center of the dam. In other words, extend the ends up the ditch sides to prevent water from flanking around the dam (Fig. 21). The dam should curve (smile) toward the oncoming flow of water.

Common Problem: **Flanking**. If water is flowing around the check dams, they likely need to be extended up the slope further (see Fig. 21). Add additional biolog or rock so the check dam extends above the high water level, forcing water over the check dam rather than around it. When more than one length of bioroll is required, they should be overlapped rather than butted.

Check dams should be spaced so that the bottom elevation of the upstream ditch check is level with the top center elevation of the downstream ditch check (Fig. 22).

Figure 19: Biolog check dam

Extend check dams so that water won't flow around them.

Figure 20: Rock check dam

There are a variety of materials used in check dams:

- Biorolls - Straw or wood fiber logs or rolls of material inside netting can be used as temporary ditch checks. These are appropriate for light duty use in flatter ditch grades. Biorolls are anchored with wood stakes driven through the back half of the bioroll at about a 45-degree angle with the top of the stake pointing upstream and spaced one foot apart (Fig. 23).
- Geotextile triangular dikes - Small triangular dikes made from geotextile can be purchased for use as temporary check dams and may be reused.

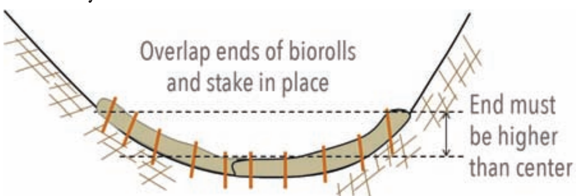


Figure 21: Proper check dam installation

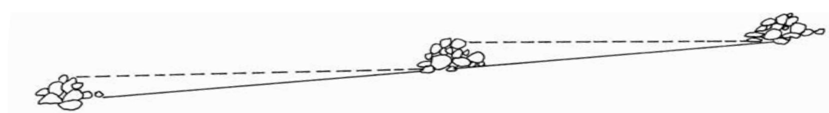


Figure 22: Proper spacing of check dams to control running water's energy.

- Compost logs – These logs will trap sediment under low flow conditions.
- Rock riprap - Permanent installation for larger problem areas; should be properly designed by an engineer.

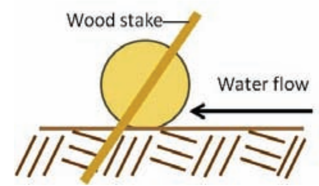


Figure 23: Proper staking of bioroll

Managing Vegetation

A stable ditch ideally has dense vegetation that doesn't interrupt the water flowing through it. Vegetation provides habitat for wildlife, stabilizes soils, and increases the rate and quantity of water infiltration.

Many roadside ditches are shaded, a condition that is not conducive to growing certain grasses. In these situations planting shrubs on the side slopes may prevent erosion on steeper slopes. Native shade-tolerant mixes should be considered for shady sites. See the Seeding section for more information.

Brushing is a common ditch maintenance practice. Remove woody vegetation when it impedes the flow of water in the ditch. Woody vegetation on the **back slope** may not need to be removed and helps prevent bank erosion. Leave the plant roots intact since they hold soil in place and limit pollutants from entering lakes and rivers. Established roots promote infiltration and moisture uptake. Remove cut branches or other vegetative debris after brushing to reduce the chances of clogging culverts and spreading invasive plants.

If you use herbicides to control shrubs and bushes, spot-treat individual plants rather than treating the entire area. Spot-spray weeds as needed to control invasive plants; blanket applications of herbicides are often unnecessary. Spray annuals before they produce seed. Spray perennials in the fall as the plant is directing energy into its root system.

To protect nesting birds and other small wildlife, Minnesota Statute 160.232 places limitations on when to mow roadside ditches. The top edge, up to eight feet from the road or shoulder, may be mowed at any time. Do not mow ditch bottoms and back slopes until after July 31. If mowing after September 1, MNDNR recommends not mowing lower than 10 inches to provide cover for next year's early nesters and winter cover for wildlife. Safety considerations

To Protect Wildlife:

Before July 31, don't mow ditches.

After September 1, mow at least 10 inches high.

allow mowing at other times, but only at a height greater than 12 inches. This limitation does not apply when establishing permanent vegetation. This statute does not apply to property owners.

MNDNR's "roadsides for wildlife" program promotes basic steps to protect wildlife and increase habitat through ditch maintenance practices (Fig. 24).

Figure 24: Roadsides for wildlife sign

Working with Protected Plants, Invasive Species, and Noxious Weeds

While working on ditches, you will likely find a variety of state or federally protected plants, invasive species, and noxious weeds. Here's what to do in each situation.

Protected Plants are classified as Endangered, Threatened, Special Concern, or Rare species. Several species of lady's slippers, for example, are protected in Minnesota, and these may appear in roadside ditches. The MNDNR and the United States Fish and Wildlife Service websites provide lists of protected species in Minnesota. Work around protected plants during ditch maintenance. Document the locations of protected species in the ditches you maintain so they are not damaged during future work.

Invasive Plants cause or are likely to cause economic or environmental harm, or are considered harmful to human health. They are not native to the local ecosystem. Invasive plants often out-compete native plants and threaten the survival of wildlife that depend on native plant communities. If you are not familiar with these plants, contact a weed inspector to look over the area before digging.

Invasive plants can be easily spread along ditch corridors by ditch maintenance activities. Areas of disturbed soil are especially vulnerable to invasive plants, which can spread through root cuttings in spoil piles or contaminated equipment and clothing. Spoil piles with invasive species in them can be bagged, buried, burned or placed on hard surfaces and covered while awaiting proper disposal.

The least expensive way to control invasive plants is to avoid introducing them to new areas and to eradicate new populations before they spread. Keeping the populations under control can save money in the long run and make maintenance work easier.

Noxious Weeds: As of 2014, the Minnesota Department of Agriculture (MDA) listed 19 species as prohibited noxious weeds (11 are on the eradicate list). The MDA oversees the management of these aggressively invasive plants in Minnesota. See Appendix C and the MDA website for a list of these species and for more information.

Take note of where noxious weeds are present in your ditches and use appropriate measures to manage them. Minnesota State Statutes, Sections 18.75 to 18.91, and Minnesota Rules, Chapter 1505, require public road authorities to control noxious weeds on public land such as roadside ditches. Several counties in the Arrowhead region require the control of additional noxious weeds. Contact the county agricultural inspector for a list of these plants and advice on how to control them.

Best Management Practices to Control Invasive Plants and Noxious Weeds

Learn how a plant spreads and you can better control it. Reed canary grass spreads by rhizomes as well as seed. Mowing will not control it, and spoils from excavation will spread it. Canada thistle spreads by seed. Mowing prior to the seeding stage could greatly reduce its spread.

- Document the location of significant infestations.
- Schedule maintenance to control infestations at the times most likely to be effective.
- Minimize soil disturbance. Disturbing soils will allow invasive plants to invade. If you use mulch, make sure it is weed-free.
- Try to schedule soil disturbance work when seeds or plant propagules are least likely to be viable and spread.
- Plan it out. Work in weed-free areas first, then in areas with invasive plants.
- Stage your equipment in areas free of problem plants.
- Thoroughly clean all tools, machinery, equipment, shoes and clothing before leaving worksites and disposal sites.
- Make areas with invasive plants priority areas so that they are mowed before going to seed. Highest priority should be given to ditches adjacent to sensitive areas where it is important not to spread invasive plants. Note that mowing will not

kill purple loosestrife, Japanese knotweed, reed canary grass or giant reed grass. These plants are able to sprout from stems and root fragments.

- When using herbicides, follow the label directions for where they can be used, types of plants controlled, concentration to use, application rate, application method, and frequency of use, as well as safety precautions and environmental hazards. Do not apply in water unless using an herbicide labeled for aquatic use.
- Spot treat with herbicide. Avoid blanket treatments.
- Be patient when using herbicide. Wait the recommended time interval for the herbicide to work before continuing maintenance in the treated areas.
- Dispose of soils contaminated with weed species by spreading them out and stabilizing them on site, or by hauling them to a contained area.
- Cover plant material or contaminated soils during transport. Note: Transport of infested materials may require a permit from the county weed inspector.
- Monitor work areas for several years for new invasive species infestations.

Inspecting and Recording Your Work
Always inspect your work sites and take time to record your findings. If you replaced a culvert or re-graded a ditch, check it after several storms and again the following year.

If your work created a headcut or other problems, or you have an area that keeps eroding, consult an engineer for solutions to the problem.

Cleaning up the Site
When a ditch project is finished, clean up the job site. It shows the public that you and your organization take pride in your work and the community. Leaving debris can also undermine ditch maintenance efforts and lead to other problems.

Silt fencing is often over-used and frequently left on the landscape beyond its usefulness (Fig. 25). It should be installed along the slope contours to act as a temporary sediment trap during construction. The longer it is left in place, the more difficult it is to remove. When silt fencing is left, it continues to impede wildlife movement (on some construction sites, silt fencing is used as an intentional barrier for snakes, turtles, and migratory animals) and it is ugly. If ditch maintenance is going to be contracted out, consider withholding the final payment until the silt fence has been removed. Remove silt fence once permanent vegetation is established and the site is stable.

Spoil piles, tree trimming debris or other unattractive reminders of ditch maintenance should be cleared. Keep the work area neat with a new sign, a properly blanketed ditch, spoils removed, and/or riprap in its proper place.

Figure 25: Remove silt fence when vegetation is established

NON-ROUTINE MAINTENANCE

Use the information provided to help identify when maintenance goes beyond routine and requires additional analysis, engineering and/or permits.

Perennially Flowing Ditches, Streams and Wetlands
If the ditch contains water that flows most of the time, it may be considered a stream and its maintenance is not covered in this guide. Additional permitting and analysis are needed to maintain or alter these waterways/ditches. If the ditch flows through larger wet areas with plants such as cattails and willows, there are likely wetlands involved. The Wetland Conservation Act requirements and other regulations may apply. Not all wetlands are obvious. For example, there are wooded areas with cedar and black ash that may be wetlands. For any wet areas or areas considered public waters, consult with others such as engineers, MNDNR, and your local Soil and Water Conservation District.

When to Involve an Engineer
Each ditch segment and culvert is a part of a system; altering any part will affect other sections.
Consult with an engineer if you want to:

- Create a new ditch
- Change the size of the culvert
- Change the size of the original ditch
- Change the shape of the original ditch
- Change the slope(s) for the culvert or the ditch
- Change culvert inverts
- Change the drainage pattern (lateral ditches, turn-outs)
- Work in ditches with perennial flow

- Find a long-term fit for a recurring problem
- Replace culverts for streams crossing under roads or ditches crossing under large roads

If conditions change in the watershed resulting in increased water volume, the ditch design may need to be evaluated.

Figure 26: Side slope erosion (sloughing)

Major Side Slope Erosion

Sloughing or undercutting that creates vertical or near vertical banks (Fig. 26) requires reshaping of the slopes. A permit(s) is often required for this work. The ditch **hydraulic conveyance capacity** will be altered as the width of the ditch is widened to create flatter side slopes. The rest of the ditch system might be affected; consulting an engineer in this situation will help prevent future problems.

Excavation that Changes Ditch Shape

REMINDER: Altering the ditch shape should only be undertaken if it is truly necessary for proper water conveyance or road protection. If the course, flow, cross-section, hydraulic capacity, or purpose of the ditch is being changed from its original shape and purpose, a permit(s) is needed (see Regulations section).

Before excavating, refer to Ditch Conditions in Appendix A.

A ditch's stability depends on its longitudinal profile as well as the profile of its cross-section. When excavating to correct problems, don't change a ditch's slopes lest you create a new cycle of erosion.

The cross-section of a ditch also determines its hydraulic conveyance (capacity). Modifying the cross-section of a ditch would generally require engineering analysis, but there is a method for increasing capacity while maintaining the stability of the ditch banks: keep the width-to-depth ratio the same during and after the excavation (Fig. 27). Thus, if ditch capacity must be changed (and permits will likely be needed for this), keeping the width-to-depth ratio the same will reduce the risk of causing other problems in the ditch system.

In most cases, restoring capacity requires deepening the ditch bottom. If a ditch bottom were excavated without altering the top width, the resulting ditch banks would have steeper side slopes, and a higher potential for failing (Fig. 27). Avoid this pitfall by maintaining the ratio of the width of the ditch top to ditch depth before and after the excavation. Measure this ratio at a few locations along the ditch segment that will be excavated (Fig. 27); use an average ratio through the ditch segment. Although you are maintaining the ditch's shape, enlarging it in this manner will change its hydraulic capacity and will likely require a permit. Widening the ditch proportional to the depth of the excavation may not be possible in all cases and could affect the roadway. In this case, consult an engineer for assistance.

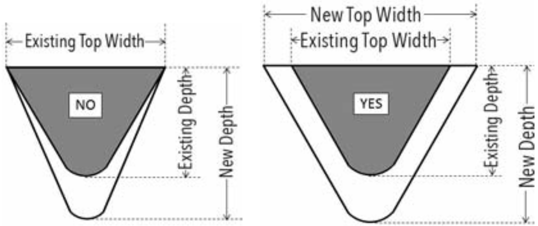


Figure 27: Maintain the original width-to-depth ratio when excavating

EXAMPLE:

If a ditch section had a width of 6' and a depth of 3', then the w/d ratio would be 6/3 or 2.

When the ditch is excavated, keep this ratio the same. Thus, if the ditch is made 1 foot deeper, it should also be made 2 feet wider to keep the same relationship (8/4 or 2).

Replacing a Stream-crossing Culvert

If a culvert is in a ditch with perennial flow or flow during much of the year, it is likely a stream-crossing culvert rather than a runoff management culvert. Replacing stream-crossing culverts requires permits and possibly considerations for fish passage; this guide does not cover replacing them.

Replacing Damaged Culverts: Different Size or Type

If replacing a culvert involves a change in diameter, invert elevations or material, it is not considered routine maintenance. A culvert should not be replaced with a culvert made out of different material or a culvert of a different size due to differences in friction and capacity, which can create more erosion and ditch maintenance issues. Different materials have different roughness and roughness affects conveyance. For example, high-density polyethylene (HDPE) pipes have very low friction compared to corrugated metal (either aluminum or steel) pipes (CMP). Concrete pipes have friction factors somewhere between HDPE and CMP.

The acidic soils found in parts of the Arrowhead region are damaging to culverts. Some culvert materials are better at tolerating acidic conditions. Peat soils, some clay soils and soils with high organic content are more likely to be corrosive, especially with high moisture levels. Check with your

County or SWCD for maps showing soil types. See a comparison of culvert types and qualities in Table 5.

When to Change Culvert Size

Ideally, ditch culverts should be replaced with the same size culverts and installed at the same uphill and downhill invert elevations. Any change in culvert size and invert elevations might cause a new cycle of erosion and/or **deposition** in the ditch system.

WARNING

One of the major causes of headcutting and ditch incision (deepening of the ditch bottom) is change of the culvert invert (inside bottom elevation) and the ditch slope (profile) during culvert replacements.

Problems such as flooding uphill of the culvert, water overtopping a driveway, erosion around the uphill end of a ditch culvert (**inlet**), and/or scouring at the pipe outlet or inlet indicate that a larger culvert may be needed.

A ditch culvert can be replaced with a larger size if engineering guidelines are followed and permits are obtained. If the existing culvert is already perched (outlet is elevated above the ditch bottom) or undersized, it is possible that the culvert may have already affected the local ditch slope, width and elevation. In such cases, it is necessary to measure the longitudinal profile of the ditch in unaffected sections uphill and downhill of the damaged section in order to predict the intended or original ditch slope and elevation at the culvert site. Consult an engineer.

Installing Riprap

Riprap is recommended for areas with:

- High velocity flows
- Steep gradients
- A drop in elevation from the culvert (perched culvert)
- A culvert outlet that is close to the ditch bank
- Erosion problems

Key points for riprap installation:

- **Install flush with ditch bottom at inlet**
- **Install to create plunge pool at culvert outlet for high flow systems**
- **Flow and velocity at outlet determine riprap size**
- **Length of riprap should be at least 4-5x the culvert diameter**
- **Width should be approximately 2x the culvert diameter**
- **Depth of riprap = 2x largest piece of riprap**
- **Use geotextile or granular filter under riprap**
- **Check with engineer for culverts over 36 in. diameter**

Sources: Stenlund, D. Personal communication (Jan 2014); Maine DEP, 2003.

Table 5: Comparison of Common Culvert Materials

	Galvanized Steel - corrugated	Aluminized Steel - corrugated	Aluminum Alloy - corrugated	Plastic (HDPE)	Concrete
Cost (material, transportation, installation)	$	$	$$	$$	$$$
Lifespan* (years)	20 - 30	75 +	25 - 30	25 - 50	50 - 100
Shorter lifespan when always wet (ex. wetlands)	X				
Ideal pH range	5.5 – 8.5	5.0 – 9.0	4.5 – 9.0	All	5.0 – 9.0
Bog Compatible (pH: 3 – 5)			X	X	
Fen Compatible (pH: 5 – 8)	>5.5	X	X	X	X
Swamp Compatible (pH: 7 – 8)	X	X	X	X	X
Light weight	X	X	X	X	
Easy to install	X	X	X	X	
Readily available	X			Not in larger sizes	Not in all areas
Smooth surface (good for heavy water flow)				X	X
Resistant to abrasion and corrosion		X	X	X	X
Easily punctured during backfill			X	Use granular backfill and handle carefully	
Salt resistant		X	X	X	
Notes		Susceptible to corrosion if coating is compromised	Minimum of 1 ft cover and proper backfill methods. Do not use for centerline culvert		

* Can vary widely depending on many factors such as acidity of soil, abrasive conditions, and instillation practices

Riprap may be needed at both ends of a culvert. It will prevent erosion around the pipes and scouring at the pipe outlet. For many driveway culverts, riprap is not needed if vegetation is holding the soil in place. Riprap is more costly than vegetation, but in an area prone to erosion that requires more frequent repair, riprap can be cost-effective. Geotextile fabric or a layer of gravel placed under the riprap prevents soils from being scoured out beneath the riprap.

The culvert diameter and velocity of flow should dictate the appropriate rock size. The rock should not change the elevation of the ditch and should match the invert elevation. Generally, culvert sizes of 24 inches or larger require type 3 riprap (median diameter 9 inches, maximum 15 inches). For smaller culverts, type 2 riprap (median diameter 6 inches, maximum 12 inches) is adequate but type 3 is better. See Figures 28 and 29.

To dissipate the energy of the flow at the culvert outlet, the riprap should be shaped into a plunge pool constructed so that water flows out of the apron onto the top of the rock and then down into a holding pool. If the rock is placed too high, the rock will either be pushed away from the apron due to the force of the water or major erosion will result from water running under or around the rock.

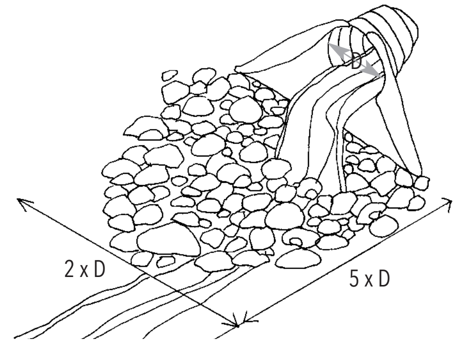


Figure 28: Sizing of riprap installation based on culvert diameter (D)

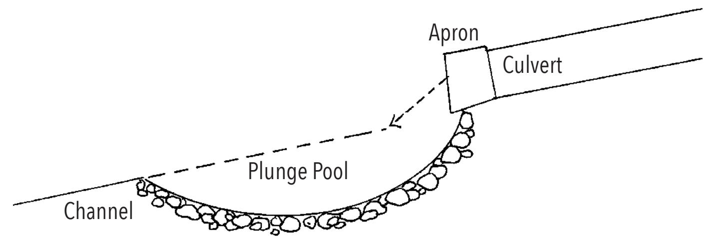


Figure 29: Side view of plunge pool riprap installation

Heading Off Headcuts

A **headcut** in a ditch is an abrupt drop in the ditch bottom caused by erosion as the ditch adjusts to a natural or human-induced disturbance (Fig. 30). Most waterfalls (i.e. Niagara Falls) are large-scale examples of a headcut.

Headcuts are formed because gravity is working to flatten ditch slopes to create a more stable condition. There are three main causes of headcuts (Fig. 31):

1. Changes in the invert of a culvert downstream
2. Changes in hydrology (higher flows/velocity)
3. Disturbances of the ditch's longitudinal slope

If the headcut is older, it may be a ¼ mile or more long.

The source of the problem is likely to be downstream of the affected area. Headcuts work their way upstream from a channel change or issue until they hit an immoveable object such as rock. Simply filling in the eroded section is not the solution and the problem will likely reappear. Headcut repair is one of the more difficult problems to solve. Installing grade control structures may help resolve the problem. Analysis and engineering are needed to determine the most effective solution.

Figure 30: Headcut migrating upstream

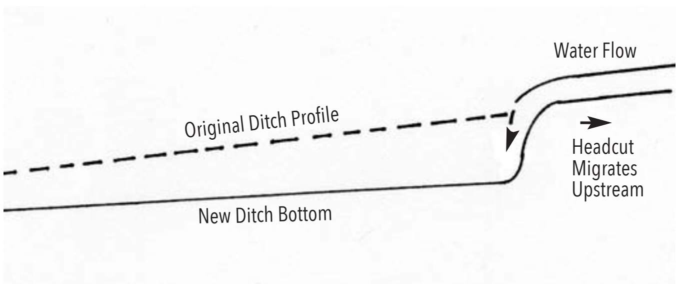


Figure 31: The cause of a headcut can be upstream or downstream of the problem

Check on Channel Incisions

Channel **incision** occurs when flowing water cuts downward into the bottom of the ditch and lowers its elevation. The main cause of incision is the imbalance of sediment load and the sediment carrying capacity of the ditch, and one of the most common contributors is an increase in the amount of runoff.

What starts as channel incision could quickly progress to a headcut or a widening channel. Channel incision is one of the first indicators of pending major problems in a ditch system.

Channel incision can be caused by:

- Decreased resistance to erosion of the ditch bottom (e.g. removal of vegetation and/or plant roots that hold soil together)
- Increased erosional forces in the ditch (e.g. steeper gradient, greater concentration of flow, more frequent high flow events, or a dramatic reduction in sediment load)

Channel incision and the lowering of the ditch bed might destabilize the upstream and downstream segments of the ditch. If another ditch is merging with the incised ditch, the confluence of the main and the lateral ditch could have a grade difference causing additional headcutting in the lateral ditch.

REGULATIONS AFFECTING DITCH MAINTENANCE

Legal questions can arise when considering ditch maintenance and/or repair. Be proactive and request assistance from your local Soil and Water Conservation District (SWCD) or the appropriate authority before beginning. If you are not sure if your project is considered routine maintenance, check with your county SWCD staff. They can help you determine what permits may be required.

Potential need for permits when doing ditch maintenance

Answer the following questions to help you determine if a permit(s) is required.

1. Is this a roadside upland ditch?

A. The ditch dries out between rainstorms and does not have running water much or all of the time; AND

B. The ditch does not look like a wetland or run through a wetland (Note: wetlands are not always obvious, see "wetland" in the Definitions section).

If either is false, it is NOT an upland road ditch and permits are likely to be required.

If BOTH A and B are true, it is likely an upland ditch, but even then may require a "National Pollutant Discharge Elimination System/State Disposal System" (NPDES/SDS) Construction Stormwater Permit and/or other permits if:

1. Non-routine maintenance: The ditch is being expanded by more than an acre, deepened, or redesigned to hold more flow or drain more area.
2. Routine maintenance: The ditch work disturbs 5 acres or more. (It is easy to go over the 5-acre limit, especially if maintaining the ditches on both sides of a roadway. If you have a 10 foot wide ditch on both sides of the road, just over 2 miles of work would disturb 5 acres and require a permit).

Do not dig in streams or any area you suspect might be a stream or wetland, even if they run alongside the road and serve as a ditch. Permits are likely required.

Apply for these permits through the MPCA under their Construction Stormwater Section. (Your local SWCD can help). Refer to the MPCA's Drainage Ditch Guidance document for more information on NPDES/SDS permit requirements.

A public or private ditch clean out project can qualify as **routine maintenance** and not require an NPDES/SDS Construction Stormwater Permit if you determine that ALL of the following apply:

- The project will disturb less than five acres of land; AND
- Clean-out of a ditch will return the affected area to the original line and grade, hydraulic capacity, and original purpose of the ditch; AND
- Maintenance of the ditch is in compliance with state and federal wetland regulations, including the MN Wetland Conservation Act and Section 404 of the Clean Water Act, as applicable (NOTE: this will be true if it is an upland ditch); AND
- Appropriate best management practices (BMPs) are used to prevent erosion and control sediment and associated contaminants that would violate water quality standards downstream during maintenance and re-stabilization of the drainage ditch.

2. Does the ditch discharge to a special or impaired water?

There are many special or impaired waters in the Arrowhead region. NPDES/SDS permits for construction sites with a discharge point that flows towards, and is within one mile (aerial radius measurement) of specially protected and impaired waters, require additional controls, conditions or an individual permit. If your project requires an NPDES/SDS Construction Stormwater Permit, use MPCA's Special and Impaired Waters Search to identify whether the lake or stream to which your ditch drains is listed as a special or impaired water. The online mapping tool also lists the additional requirements, such as BMPs. If the ditch falls within the radius of one of these waters and the work requires an NPDES/SDS permit, contact your local SWCD for additional permit instructions.

3. Does the ditch look like a wetland (e.g., cattails, etc.), run through a wetland, or often hold water even during dry periods between rainstorms?

Working in “wet” ditches is much more likely to require a permit of some kind, although many maintenance activities qualify for exemptions. In addition to the NPDES permit listed above, work in a wet ditch may require a permit because of the Wetland Conservation Act, Section 404 of the Clean Water Act, or because of DNR Protected Waters.

The Wetland Conservation Act (WCA) allows control of noxious weeds within wetlands if the control activity does not drain, fill or excavate the protected area. This leaves open the possibility of spraying to control invasive plants in a ditch associated with a wetland. A DNR aquatic vegetation management permit would be required if the ditch is designated (all or in part) as a public water.

For assistance determining whether or not you need permits, contact your county SWCD. Their staff is familiar with federal and state requirements.

For all maintenance work, be aware of MN Rule 7050.0210 Subp. 2. General Standards for **Waters of the State**. Nuisance conditions prohibited:

> *No sewage, industrial waste, or other wastes shall be discharged from either point or nonpoint sources into any waters of the state so as to cause any nuisance conditions, such as the presence of significant amounts of floating solids, scum, visible oil film, excessive suspended solids, material discoloration, obnoxious odors, gas ebullition, deleterious sludge deposits, undesirable slimes or fungus growths, aquatic habitat degradation, excessive growths of aquatic plants, or other offensive or harmful effects.*

(Potential nuisance pollutant problem from ditch work: suspended solids are often clay particles in the water due to erosion; this can result from poorly-managed ditch maintenance projects.)

Other Permits and Considerations
Be aware that there are additional permits that may be needed if you are working in a non-upland ditch (stream or wetland). The MNDNR Public Waters Work Permit Program applies to those lakes, wetlands, and streams identified on DNR Public Water Inventory (PWI) maps. Some streams and wetlands may not be obvious; they may be dry during the summer. Proposed projects affecting the course, flow, or cross-section of these water bodies may require a Public Waters Work Permit from the DNR and permits from other agencies.

Consult the PWI map before doing any excavation or work that alters ditch dimensions to verify if the ditch is a Public Water. Contact your local SWCD or the MNDNR for assistance. Work in "Waters of the U.S." (which includes some wetlands) may require a permit from the U.S. Army Corps of Engineers if it is not routine maintenance.

Remember that ditch maintenance work is not allowed to impact private property unless proper easements are obtained. Road ditches and culverts are mostly located within easements. Care should be taken when mowing or doing other ditch work when the width of the right-of-way is in question. The roadway should not be assumed to have a 33-foot right-of-way from the centerline. The right-of-way is either defined by an easement or a road order, or it is the width that has been maintained for the past six consecutive years. Whatever the legal situation, it is still important to communicate with property owners about the work that is being planned. Water should not be diverted onto private property from either the road itself or the ditch.

If the ditch maintenance qualifies for exemptions, take the time to document how you determined this in case the decisions are questioned. Even if a permit is not needed, you must and should follow BMPs to protect water resources.

MAINTENANCE CHECKLISTS

The following checklists will help you prepare for maintenance activities and/or remind you of steps that you might have overlooked. Add to these lists and customize them to your operation.

Table 6. Pre-maintenance Checklist

Plan ditch maintenance projects and identify potential permits needed. Acquire the following information prior to starting so you will have fewer surprises during the project. If any of your answers are "I don't know," you are not ready to proceed with the project.

Project name/description

Reason for maintenance

Project date

√	Consider	Reason	Yes/No/I don't know	Notes
	Utilities located?	Required by law, safety, excavation restrictions		
	Hazards	People, animals, water, rock...		
	Ditch or public water?	Restrictions apply		
	Right-of-way width?			
	Altering private property?	Vegetation, driveway, culverts		
	Landowner contacts?	Permission needed beyond right-of-way		
	Permits needed?			
	MPCA NPDES Permit	Disturb over 5 acres, 1 acre if changing from original shape		
	Additional requirements	Drains into special or impaired water		
	WCA	Wetland area		
	DNR Permit	Ditch is a stream on PWI list; Wetland area; Unusual right of way?		
	Other notifications?	City, county, state, school …		
	Road problems?	Wet, washboard, eroding shoulder		
	Protected plants?			
	Invasive plants?	Contact weed inspector for help		
	Inv. species control plan?			
	Existing culvert sizes and types?			
	Original ditch design?	Slope, horizontal/vertical (H/V) ratio?		
	Aerial photos?			
	Work zone plan?	Traffic control required?		
	Storage area for spoils?			
	Safety design standards?	Ensure safe conditions		

Table 7. Ditch Maintenance Packing Checklist

Tools and supplies commonly used for ditch maintenance. Use this list to help you pack.					
Project name/description					
Project date					
Pack √	**Supplies**	**Use**	**Type**	**Amount**	**Notes**
	Cover crop seed	Temporary vegetation			
	Perennial seed mix	Permanent vegetation			
	Fertilizer, if needed	22-5-10 w/slow release N or get soil test			
	Top soil				
	Erosion control blanket	Cover soils			
	Scissors/knife	Cut blanket			
	Weed-free mulch	Cover soils			
	Staples/stakes	Attach blanket, install bio logs, bales			
	Hammers	Staking, stapling			
	Shovel	Trench in entire edge of blanket			
	Tape measure	For H/V ratio on side slopes			
	Survey tools	Hand level			
	Culverts	Replacement			
	Culvert aprons				
	Culvert tools	Attaching culvert pieces and aprons, cutting culverts			
	Riprap	Ends of culvert			
	Biologs or rock	Ditch checks			
	Tarp	To cover load			
	Work zone signs	Safety			
	Tools to clean equipment	If invasive plants			
	Brushing tools	Clear brush			

Table 8. Excavation Checklist for Ditch Maintenance

Use this checklist prior to leaving the excavation site.			
Project name/description			
Project date			
√	Activity	Reason	Notes
	Removed spoils	Prevent from entering ditch	
	Tarped load	Prevent spills	
	Ditch bottom and slopes are rounded	No vertical slopes or sharp edges	
	Front slope flatter than back slope	Safety	
	Same H/V ratio as original ditch design	Same carrying capacity of water	
	Culvert inverts the same as pre-maintenance	Reduce chance of head cut	
	Riprap at culvert ends	Erosion control	
	Excavated to original depth	Will match with culvert inverts	
	Slopes graded smooth, not compacted	Good seedbed preparation	
	Seeded, and seed has good soil contact	Establish vegetation for erosion control	
	Ditch blanketed or mulched	Erosion control	
	Blanket trenched at top of slope and stapled tightly	Water flows over top and doesn’t erode soils under blanket	
	Blanket shingled in direction of water flow	Prevent water from flowing under blanket and eroding soils	
	No objects at toe of slope	Driving hazard	
	Reported problems	If needed	
	Cleaned equipment	If invasive plant concern	
	Picked up tools/supplies		
	Prepare reminder note to remove silt fence if used	Proper cleanup, remove potential hazard to wildlife	

Table 9: Mowing, Trimming and Cleaning Ditches Checklist

Project name/description			
Project date			
√	**Activity**	**Reason**	**Notes**
	Checked for mowing hazards	Riprap, sink holes, wires, plastic netting	
	Not nesting season	Ok to mow the top edge up to 8 feet from the road at any time. The rest can only be mowed Aug. 1 - Aug. 31. After Sept. 1, mow > 10 inches.	
	Mowed vegetation	When impeding water flow	
	Bailed/raked grasses	Plugs culverts/enters lakes	
	Brushed	When impeding flow	
	Removed brush	Plugs culverts, slows flow, aesthetics	
	Cleaned equipment before leaving site	If invasive plants	
	Removed debris in ditch	Prevent blockages	
	Debris disposed of properly	Prevent spread of invasives, site clean-up	
	Reported other problems	Violation of right of way, damaged culvert, erosion…	
	Removed debris blocking culverts	Prevent blockages	
	Other		

CONTACTS

Permits and Agencies

Aitkin County Highway Dept. .... (218) 927-3741

Carlton County Highway Dept. .... (218) 384-9150

Cook County Highway Dept. .... (218) 387-3014

Itasca County Highway Dept. .... (218) 327-2853

Koochiching County Highway Dept. .... (218) 283-1186

Lake County Highway Dept. .... (218) 834-8380

St. Louis County Public Works Dept. .... (218) 625-3830

Board of Water & Soil Resources (BWSR) Duluth Office .... (218) 723-4752

Minnesota Department of Natural Resources (MNDNR) area hydrologists

Minnesota Department of Transportation (MnDOT) (651) 296-3000

Minnesota Pollution Control Agency (MPCA) Duluth Office (218) 723-4460

Soil and Water Conservation District (SWCD) offices in the Arrowhead:

- Aitkin County SWCD .... (218) 927-6565
- Carlton County SWCD .... (218) 384-3891
- Cook County SWCD .... (218) 387-3647
- Itasca County SWCD .... (218) 326-0017
- Koochiching County SWCD .... (218) 283-1174
- Lake County SWCD .... (218) 834-8372
- North St. Louis County SWCD .... (218) 749-2000
- South St. Louis County SWCD .... (218) 723-4867

Minnesota Erosion Control Association .... (320) 685-5444

Erosion Control Technology Council .... (651) 554-1895

Erosion Control and Seeding Supplies

ASDCO .... (218) 628-1027
4631 Mike Colalillo Drive, Duluth, MN 55807

American Peat Technology, LLC .... (218) 927-1888
36203 350th Ave, Aitkin, MN 56431

Brock White Company .... (218) 628-2231
4231 W 1st St, Duluth, MN 55807

Prairie Restorations, Inc. (Boreal Natives) .... (218) 729-7001
3943 Munger Shaw Road, Cloquet, MN 55720-9254

RLP Services, LLC .... (218) 262-1717
2115 E 31st Street, Hibbing, MN 55746

Sunshine Gardens Nursery & Landscaping Inc. .... (218) 947-3154
1286 Shadywood Shores Drive, Pine River, MN 56474

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Carlton County Website, Transportation Department.

Castro, J. Feb. 2003. Geomorphologic Impacts of Culvert Replacement and Removal: Avoiding Channel Incision. US Fish and Wildlife Service.

Depth of Footings – Foundations. 2012. Builder's Engineer.

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Effects of Excess Subsurface Water, Feb. 2012. Local Highway Technical News 17 (8). Cornell University.

Forest Road Construction and Maintenance, undated. USDA Forest Service. Local Roads Maintenance Workers' Manual, 2006. Chapter 5: Drainage, Ditches, and Culverts. Iowa State University, Institute for Transportation.

MnDOT Standard Specifications Regarding Erosion Control

MnDOT Erosion and Sediment Control Design Guidance, 2010.

Recommended Practices Manual: A Guideline for Maintenance and Service of Unpaved Roads, 2000. Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority.

Roadside Ditches (Best management practices to reduce floods, droughts and water pollution), 2010. Cornell University.

St. Louis County Website, Transportation Department.

Stenlund, Dwayne. MnDOT, personal communication (Jan 2014).

Vegetated Stormwater Facility Maintenance Report WA-RD 495.1, Dec 2000. Washington State Transportation Center.

Weston, D. P., R. D. Lentz, M. D. Cahn, R. S. Ogle, A. K. Rothert, and M. J. Lydy. 2009. Toxicity of Anionic Polyacrylamide Formulations when Used for Erosion Control in Agriculture. J. Environ. Qual. 38:238–247.

RESOURCES

Beavers

Living with Wildlife – Beavers, MNDNR

Working with Beavers. Gerich, N., USDA Forest Service.

The Clemson Beaver Pond Leveler, MNDNR.

Culverts

Culverts – Proper Use and Installation, Wisconsin Transportation Bulletin.

Aquatic Organism Passage, USDA Forest Service.

Lake Superior Watershed Ditch and Culvert Design Workshop - March 6-7, 2013..

Drainage Manual. Chapter 5 Culverts. Minnesota Department of Transportation. 2000.

Culvert Design, Installation and Maintenance Workshop. Minnesota Local Technical Assistance Program.

Soils Maps - check with your county for maps showing locations of acid, peat and clay soils which may be more corrosive to some culvert materials.

Erosion Control and Seeding

Erosion control material installation instructions and drawings, Erosion Control Technology Council.

A Review of the Western Lake Superior Basin Erosion-Sediment Control Project; the Red Clay Research and Demonstration Project, J. Jereczek, et. al.

Standard Specifications Regarding Erosion Control, MnDOT.

Seeding Manual 2014 Edition, MnDOT.

Turf Establishment Recommendations for Projects in District 1, MnDOT, 2012.

Polyacrylamide (PAM), Michigan Department of Environmental Quality.

Understanding our Streams, Resource Sheet 1. Streambank Erosion and Restoration. MNDNR 2010.

Straw Mulching Fact Sheet, Washington Conservation District.

General

EPA guidance on ditch maintenance.

NCHRP Project 25-25(04) Environmental Stewardship Practices, Procedures, and Policies for Highway Construction and Management. Chapter 10: Roadside management and maintenance beyond vegetation.

Gravel Road Maintenance

Minnesota Local Technical Assistance Program (LTAP), Center for Transportation Studies, (612) 626-1077
511 Washington Ave SE, Minneapolis, MN 55455

Erosion Control Handbook for Local Roads

Protected Plants

A Field Guide to Identification of Minnesota Aquatic Plants, 2007. Blickenderfer, Mary. University of Minnesota Extension.

Minnesota Department of Natural Resources, Roadsides for Wildlife Program

Minnesota Department of Natural Resources, Minnesota's Endangered, Threatened, and Special Concern Species

U.S. Fish and Wildlife Service: Minnesota Endangered Species

Invasive Plants and Noxious Weeds

See Appendix C

Water

Minnesota Pollution Control Agency (MPCA) Special and Impaired Waters Search.

MPCA NPDES Construction Stormwater Permit Program.

Drainage Ditch Projects: Guidance Regarding NPDES/SDS Construction. Stormwater Permit Requirements. February 2009.

Public Waters Inventory, MNDNR.

Lake Superior Streams. Natural Resources Research Institute, UMD.

DEFINITIONS

The Arrowhead: A region in northeastern Minnesota consisting of Carlton, Cook, Lake and Saint Louis counties (sometimes Aitkin, Itasca and Koochiching counties are included). The name comes from the shape formed by the counties. Depending on how it is defined, the Arrowhead ranges from 10,635 square miles to 18,222 square miles.

Back slope (outslope): Slope from the bottom of the ditch to the interior of the property, away from the road.

Channel: The bed or deeper portion of a waterway, such as a ditch.

Channel freeboard: The higher portions of a ditch that are not normally subjected to flowing water.

Check dam: A small dam, temporary or permanent, built across a ditch. It slows the speed of the water, reducing erosion and allowing sediment to settle behind the dam.

Clemson levelers: Culvert extension device used to deter beaver activity by making it difficult for beavers to detect currents flowing through a culvert.

Culvert: A pipe crossing under a road or embankment.

Deposition: The settling out of sediment and material carried in water.

Ditch: A manmade trough in the ground for carrying stormwater runoff away from roads, fields or constructed facilities. Typically they run adjacent to a road or parking lot and are not channelized streams.

Erosion: The process of dislodging soil by action of water or wind.

Erosion control: Prevention of soil loss, principally from water action. There are a variety of methods used to control erosion.

Erosion control blankets: Products used to prevent the movement of soil off the site. Erosion control blankets are either biodegradable (straw, coconut, wood fiber, jute) or synthetic (TRMs).

Fine sediment: Sand, silt, and clay particles. These are the particles that build up in ditches. Clay particles create turbidity in water.

Flocculant: An additive that causes soils to clump. They are useful to keep soil from moving off a site, or to create heavier clumps that settle out of water.

Front slope (inslope or foreslope): Slope of the ditch angling toward the road.

GPS: Global Positioning System. GPS receivers use satellite information to determine latitude and longitude.

Headcut: An abrupt drop in the elevation of the channel bottom.

Hydraulic capacity or conveyance: Water carrying capacity of a channel.

Hydroseeding: Also known as hydromulching; a planting process which utilizes a slurry of seed and mulch to cover an area.

Impaired waters: Streams or lakes not meeting state or federal pollutant standards and officially designated as impaired.

Incision: Downward erosion (deepening) of the channel bed.

Infiltrate: The movement of water downward into the soil toward groundwater.

Inlet: Where water enters a culvert, ditch or waterway.

Invasive plant: Aggressive undesirable plant. (Often not a native plant).

Invert: The elevation of the inside bottom of the culvert.

Longitudinal profile: Elevations along the length of the ditch.

Normal high water level: The high water levels that occur in a typical spring.

Outlet: Where water leaves a culvert, ditch or other waterway.

Phosphorus: A nutrient found in plants, leaves, grass clippings, many fertilizers and soils; when added to a lake or wetland it will promote algae and plant growth.

Public Water Inventory: A map and list of Minnesota waters that are considered public waters.

Riprap: Rock used for stabilizing soils.

Runoff: The water that flows off of a site after a rainfall or snowmelt.

Sediment: Mineral material that is in suspension, is being transported, or has been moved from its site of origin.

Sediment control: A practice or device designed to trap eroded soil so that it does not wash off and cause pollution of water bodies downstream.

Sloughing: Cutting away of the banks.

Spoils: Material excavated from ditches.

Stream: A channel that is usually flowing but can be dry. It may or may not be in its natural course, and can be parallel or perpendicular to the road.

Subgrade: The native material underneath a constructed road.

Tackifier: A substance added to increase stickiness.

Toe: Location at the bottom of a slope where the slope changes from vertical to horizontal.

TRM: Turf Reinforcement Mat. Permanent erosion control blankets made of non-degradable synthetic fibers.

Turbidity: Cloudiness or muddiness of the water mostly due to suspended sediment (often clay) or organic matter.

Vegetation: Living plants of any type, rooted in the soil.

Water conveyance capacity: See Hydraulic capacity.

Waters of the State: Surface or underground waters, except surface waters that are not confined but are spread and diffused over the land. Waters of the state includes boundary and inland waters.

Wetland: Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil. Wetlands do not always have open water and may contain primarily woody vegetation (such as willows, black ash, and cedar). They may dry out on occasion. Wet or dry, the wetland plants are very good indicators of a wetland.

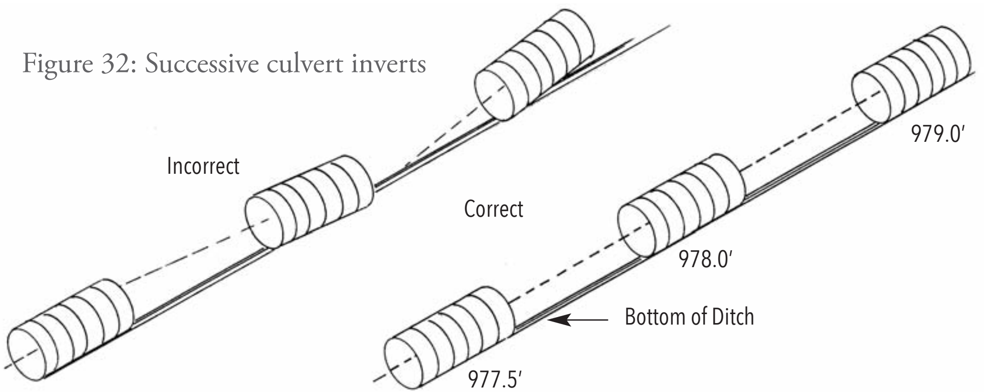
APPENDIX A
DITCH BASICS

Routine ditch maintenance should not change the original shape of the ditch.

Clues for Determining the Original Bottom

1. **Inverts** of successive culverts. The invert (elevation of the inside bottom) of the culverts will trend downward in the flow direction (Fig. 32), usually with the same slope.

Figure 32: Successive culvert inverts



2. Historic aerial photos and documentation (including initial design documents and historical maintenance documents, if available).
3. Soil cores taken with a soil probe or shovel to determine soil (original soils vs. deposited/organic material).
4. Stretches of ditch that are not clogged with sediment and look natural.
5. Bottom of the ditch should be a minimum of one foot below the subgrade of the road in order to provide proper drainage.
6. **Channel freeboard** should be at least one to one and a half feet below the edge of the shoulder (Fig. 33).

Ditch Shape

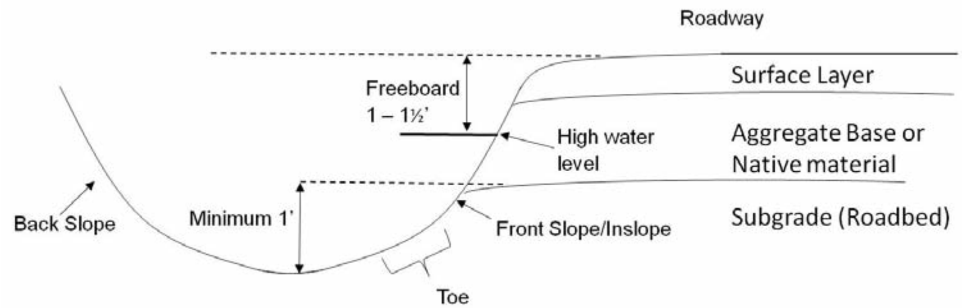


Figure 33: A ditch profile and some basic features

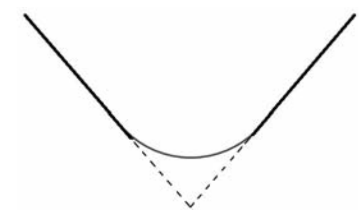


Figure 34: Rounded-bottom, V-shaped ditch

The shape of the ditch and slope of its sides will determine its long-term stability. Hydraulically, the most efficient cross section for ditches is parabolic. However, the most practical shape for rural roadside ditches in most locations is the rounded-bottom, V-shaped profile (Fig. 34 and 35). The rounded-bottom, V-shaped ditch often has different **front slopes** and **back slopes**.

You can come close forming the ideal ditch shape with typical ditch maintenance equipment. Working along the ditch with a backhoe with the boom perpendicular to the ditch, an operator can use the bucket of the backhoe to scoop out a rounded chunk of dirt from the bottom. He or she can also produce almost smooth side slopes.

Ideally, the front slope should be the same or flatter than the back slope. Safety standards often dictate minimum slopes. A more gradual front slope improves driving safety. If the front slope is steep, guardrails may be needed. There should be no fixed object (signs, poles, etc.) near the **toe** of the front slope.

Side slopes should not be vertical, as in a U-shape (Fig. 36). Ditches with this profile are not stable, and will show significant erosion and **sloughing**.

Due to right-of-way challenges, the back slope might have to be steeper than ideal. If the back slope area is rocky or space is limited, then the back slopes may need to be close to vertical (Fig. 37). Steep back slope designs should be examined by an engineer for slope stability.

Figure 37 shows a sloughing **vertical slope**. Most ditches along low-traffic rural roads are unfortunately shaped in a way that is prone to higher rates of erosion. In addition to the erosion potential, U-shaped cross sections also have less flow capacity compared to similar-sized ditches with a round-bottom V-shape or with a trapezoidal cross section (Fig. 38).

Figure 35: Example of a stable ditch shape

Figure 36: Example of a ditch you don't want to dig- a U-shaped ditch with vertical sides

How Flat Should Side Slopes Be?

When establishing a rounded V-shaped bottom, the side slopes should be as flat as possible. Flatter side slopes are more stable, are safer, and will generally result in fewer maintenance problems. If you can easily walk up or mow the slope, it is probably a stable design. With limited road right-of-way, flatter slopes are often impractical for rural roads. Consult and follow road authority design standards for safety.

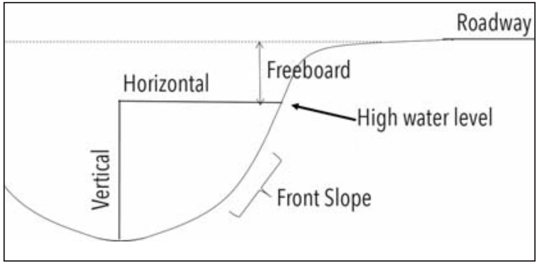

Figure 37: Ditch with vertical back slope sloughing due to instability


Figure 38: Rounded-bottom ditch incising toward a V shape after heavy rainstorm

How To Measure Side Slopes

Using survey equipment is the most reliable way to measure side slopes. If you are in the field without such tools, calculate the angle of the side slopes by taking horizontal and vertical measurements (Fig. 39 and 40). There are also tools such as a "smart level" and even applications on smart phones that allow you to measure slope angles.

To calculate the angle of a slope, you need to know: 1) the distance from the middle of the ditch bottom to the side of the ditch (this is the horizontal measure, or H), and 2) the distance from the bottom of the ditch upwards to a height that is equal to the **normal high water level** (this is the vertical measure, or V). Normal high water level is the high water level observed in a typical spring. Look for signs of high water flow in the ditch. If you can't identify an approximate normal high water elevation, just take the horizontal measurement at about ¾ of the ditch height or where there is a change in slope (Fig. 39).



The vertical measure (V) is the height from the bottom of the ditch to the elevation of normal high water flows. The horizontal measure (H) is the distance from the middle of the ditch to the bank at the height of normal high flow.

Figure 39: Measuring the H:V ratio for the front slope

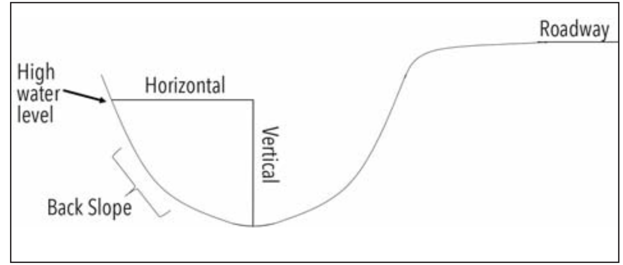


Figure 40: Measuring H:V ratio for back slope

Figure 41: Ditch slope assessment tool

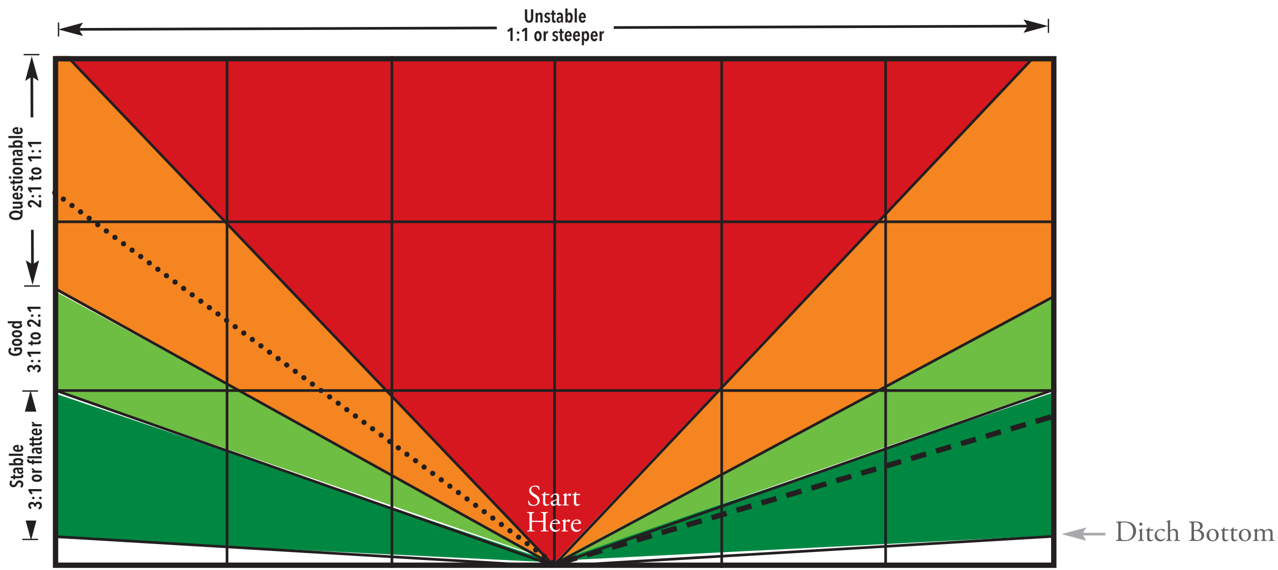


Figure 42: Ditch front slope example

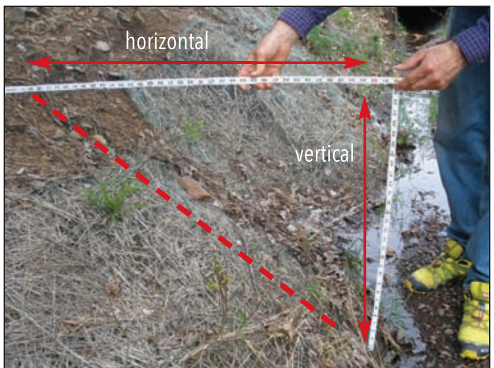


Figure 43: Ditch back slope example

Looking at the H:V ratio, is the slope stable when compared to the Ditch Slope Assessment Tool (Fig. 41)? The Ditch Slope Assessment Tool will help you interpret the stability of a ditch slope relative to its horizontal (H) and vertical (V) measurements. Measurement units can be whatever you want them to be: feet, yards, an arm's length, etc.

Convert your H and V measurements to the simplest ratio possible; for example, 45:15 reduces to 3:1. Start at the bottom center of the Slope Assessment Tool (Fig. 41), move across and count out the number of squares that represent the horizontal units. Then move up the number of squares representing the vertical units. When you connect your starting point bottom center to the top corner of the number of squares that reflect the V measurement, you will produce an angled line showing that ditch's side slope.

To evaluate a ditch, look at both slopes and perhaps measure them at different points if their shape varies greatly over the ditch's course. In the ditch in Figure 42, the front slope (dashed line) turned out to be flatter than 3:1, which is stable.

In this example, the horizontal (width) measurement was 45 inches and the vertical (depth) was 15 inches. This provides a 45:15 ratio, which simplifies to 3:1 (black dashed line in Figure 41).

In this same ditch, the back slope (dashed line on Figure 43) was found to have a H:V ratio of 1.5:1 (black dotted line in Figure 41). The horizontal distance was 42 inches and the vertical was 30 inches. Such a slope falls into the questionable range of stability and is likely to develop erosion problems. You can see in the photo that small erosion channels have already formed.

By measuring the slopes and comparing them to the stability ranges on the Ditch Slope Assessment Tool, you can predict the stability of the ditch system. To increase the chances of successfully restoring the ditch to a stable profile, work to find ways to establish flatter side slopes. Flattening the side slopes without changing the original bottom elevation for maintenance purposes is generally allowable through various exemptions.

APPENDIX B
APPLICATION AND CHARACTERISTICS OF EROSION CONTROL BLANKETS

Use/Slope	Material	Service Life	Bio-degradability*	Wildlife Friendly*	Price*	Specifications*
Flat, mowed areas (less than 3:1)	Wood Cellulose	6-8 wks	◊◊◊◊◊	◊◊◊◊◊	$	1S, NT, RD
Flat, mowed areas (less than 3:1)	Wood Fiber	6-8 wks	◊◊◊◊◊	◊◊◊◊◊	$	RD, 0S
Flat areas (less than 3:1), shoulder drain outlets, roadway shoulders	Straw or Wood Fiber	1-3 mo	◊◊◊◊◊	◊◊◊◊◊	$$	RD, 1S
Side slopes from 3:1 to 2:1 and less than 50 ft long; ditch bottoms with up to 2% grade	Straw or Wood Fiber	6-9 mo	◊◊◊	◊◊◊◊	$$	1S
Side slopes from 3:1 to 2:1 and greater than 50 ft long; ditch bottoms with up to 3% grade	Straw or Wood Fiber	6-9 mo	◊◊◊	◊◊◊◊	$$	2S
Side slopes 2:1 & steeper; ditch bottoms with up to 4% grade	70% Straw-30% Coconut or Wood Fiber	24-36 mo	◊◊	◊◊◊	$$$	Straw-Coco – 2S Wood – HV, 2S
Ditch bottoms with up to 5% grade	70% Coconut-30% Straw	24-36 mo	◊◊	◊◊	$$$$$	2S
Ditch bottoms with up to 6% grade	70% Straw-30% Coconut or Wood Fiber	> 36 mo	◊	◊	$$$	3S
Ditch bottoms with up to 7% grade	Coconut or Wood Fiber	> 36 mo	◊	◊	$$$$	3S

* **Biodegradability:** ◊ = Slow; **Wildlife Friendly:** ◊ = Less Friendly; **Price:** $ = Least Expensive **Specification codes: 0S** – No Net, Stitch Only; **1S** – 1 Side Netting; **2S** – 2 Side Netting; **3S** – More than 2 nets (3-D Matrix) **RD** – Rapidly Degradable net & stitch; **HV** – High Velocity; **NT** – No thread/stitching

Relative prices based on on-line review of product costs and do not include installation costs. Using the wrong product, or applying it incorrectly, may result in failure and require re-application. Source: http://www.dot.state.mn.us/environment/erosion/specs.html

APPENDIX C: NOXIOUS AND INVASIVE WEEDS

Public road authorities are responsible for the eradication or control of these noxious weeds within roadside ditches:

Eradicate List – must be eradicated by killing the above and below ground parts of the plant.

1. Yellow Star Thistle, *Centaurea solstitialis* L.
2. Grecian Foxglove, *Digitalis lanata* Ehrh.
3. Oriental Bittersweet, *Celastrus orbiculatus* Thunb.
4. Japanese Hops, *Humulus japonicus* Siebold & Zucc.
5. Dalmatian Toadflax, *Linaria dalmatica* (L.) Mill.
6. Common Teasel, *Dipsacus fullonum* L.
7. Cutleaf Teasel, *Dipsacus laciniatus* L.
8. Giant Hogweed, *Heracleum mantegazzianum* Sommier & Levier
9. Brown Knapweed, *Centaurea jacea* L.
10. Meadow Knapweed, *Centaurea x moncktonii* C.E. Britton
11. Black Swallow-wort, *Cynanchum louiseae* Kartesz & Gandhi

Control List – must be controlled by preventing the maturation and spread of propagating parts.

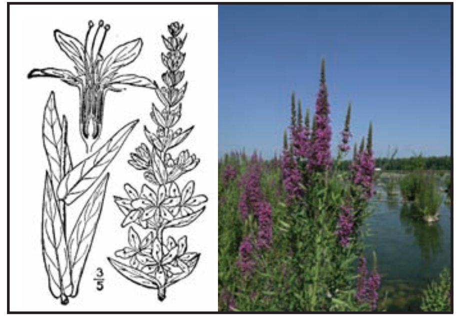
1. Leafy Spurge, *Euphorbia esula* L.
2. Canada Thistle, *Cirsium arvense* (L.) Scop.
3. Plumeless Thistle, *Carduus acanthoides* L.
4. Purple Loosestrife, *Lythrum salicaria* L., *L. virgatum* L.
5. Wild Parsnip, *Pastinaca sativa* L. (Except for non-wild cultivated varieties)
6. Common Tansy, *Tanacetum vulgare* L.
7. Spotted Knapweed, *Centaurea stoebe* L. ssp. *micranthos* (Gugler) Hayek
8. Narrowleaf Bittercress, *Cardamine impatiens* L.

Spotted knapweed, *Centourea stoebe*

2-3' tall; 1-20 wiry, branched stems. Leaves alternate, grayish, and divided into lance-shaped lobes. Flowers are thistle-like pink to purple flowers sitting at the tips of stems.

Sketch: USDA

Photo: Licensed under a Creative Commons Attribution-Noncommercial 3.0 United States License. Leslie J. Mehrhoff, University of Connecticut, Bugwood.org



Purple loosestrife, *Lythrum salicaria*

3-6' tall; multiple square stems. Leaves are opposite and downy with smooth edges. Flowers clusters form spikes with many individual pink/purple 5-6 petal flowers.

Sketch: USDA

Photo: US Fish and Wildlife Service

Common tansy, *Tanacetum vulgare*

3' tall. A single erect stem that branches at the top to form a flat-topped cluster of bright yellow button-like flowers. Leaves are alternate, irregularly lobed, and very aromatic.

Sketch: USDA

Photo: Licensed under a Creative Commons Attribution-Noncommercial 3.0 United States License. Steve Dewey, Utah State University, Bugwood.org.

Reed canary grass, *Phalaris arundinacea*

2-6' tall; sprouts early in spring. Erect hairless stems. Leaf blades are 1/3" wide, gradually tapering, up to 10" long, with obvious ligule. Flowers are densely clusterd single florets, green to purple changing to beige.

Sketch: USDA

Photo: Licensed under a Creative Commons Attribution-Noncommercial 3.0 United States License. Jamie Nielsen, University of Alaska Fairbanks, Cooperative Extension Service, Bugwood.org

Canada thistle, *Cirsium arvense*

2-5' tall; slender grooved stems that branch at the top. Leaves are alternate, oblong, tapering, deeply divided, with prickly margins. Small purple flowers on top of the upper branched stems.

Sketch: USDA

Photo: Licensed under a Creative Commons Attribution-Noncommercial 3.0 United States License. Steve Dewey, Utah State University, Bugwood.org.

Grecian foxglove, *Digitalis lanata*

2-5' tall; single to multiple coarse erect stems; leaves are alternate along stem. Elongated flower cluster, conspicuous cream colored, tubular flowers, with purplish-brown veins.

Sketch: Alice Kenny

Photo: Johan N (Own work) GFDL (http://www.gnu.org/copyleft/fdl.html), via Wikimedia Commons

For more information, see:

Minnesota Department of Agriculture (MDA), (651) 201-6000

Noxious and Invasive Weed Program

Minnesota Noxious Weeds

County Agricultural Inspectors - contact for county-designated noxious weeds

Minnesota Department of Natural Resources, (651) 296-6157

Invasive Plants

Minnesota and Federal Prohibited and Noxious Plants List

Preventing the Spread of Invasive Plants: Best Management Practices for Transportation and Utility Corridors, January 2012. Cal-IPC Publication.

BMPs for Roadside Invasives, 2008. Perron, Christine. New Hampshire Department of Transportation

Weeds! May 2013. Sironen, Mary Ann. Duluth Township Newsletter.

SLOPE ASSESSMENT TOOL

Photocopy onto acetate or transparent media for use in the field.