Appendix M – Gully Erosion Quantification

Last Revised: March 2026

1.1 Introduction

Gully erosion of cropland has long been recognized as a challenge for agricultural producers, particularly where gullies disfigure the landscape and create impediments to equipment operation. Gullies form in fields where concentrated runoff dislodges and transports soil particles via the channel forming process. This process of erosion is sometimes seen as an extension of a watershed's drainage network and may occur naturally in some cases. Oftentimes, agricultural activities such as removal of native vegetation, tillage, and soil compaction will increase the risk factors that influence gully formation and erosion. Soil adhesion may be reduced via tillage, which decreases the threshold for dislodgement and transport when exposed to flowing water. Catchments with little vegetation or compacted soil may exhibit increased peak flows during rain events, causing greater erosive forces where flow concentrates. Site specific soil types, slopes, and management activities will influence the likelihood of gully formation and severity.

Flow that concentrates in gullies within fields has the potential to transport sediment, nutrients, and other pollutants into nearby surface waters. Preventing and correcting gully erosion on fields has been a major focus of conservation efforts, particularly in agricultural areas. A variety of measures may be prescribed to prevent, repair and/or stabilize concentrated flow and gully erosion areas. Grassed waterways are a common practice throughout Wisconsin, used to route concentrated flow through a vegetated, stabilized channel designed to handle storm flows. Terraces, farming on the contour, contour strips, and other measures to break up the field slope and overland flow have also been used to prevent gully erosion. More resource-intensive methods of gully stabilization involve surface hardening (rock rip rap) or check dams, which may or may not be compatible with annual cropping operations. The methods employed to address gully erosion should be prescribed by a trained agronomist, engineer, or conservation professional after considering the site-specific formation factors, as well as the planned future use of the land.

NRCS offers the following definitions of the two gully types:

Ephemeral Gully: Small erosion channels formed on crop fields as a result of concentrated flow of runoff water. These channels are routinely eliminated by tillage of the field but return following subsequent runoff events. Ephemeral gullies are small enough to be eliminated (temporarily) with the use of typical farm tillage equipment and they:

- Recur in the same area of concentrated flow each time they form
- Frequently form in well-defined depressions in natural drainage ways
- Are generally wider, deeper, and longer than the rills in the field

Gully Erosion: Permanent gullies are formed when channel development has progressed to the point where the gully is too wide and deep to be tilled across. These channels carry large amounts of water after rains and deposit eroded material at the foot of the gully. They disfigure the landscape and make the land unfit for growing crops. Gullies:

- May grow or enlarge from year to year by head cutting and lateral enlarging
- Most often occur in depressions or natural drainage ways
- May begin as ephemeral gullies that were left in the field untreated
- May, over time, become partially stabilized by grass, weeds or woody vegetation

Note: The term "classic gully" is sometimes used to describe permanent gullies.

Stabilization of active gully erosion may be used to generate pollutant credits, when specific criteria are met. Gullies must be shown to recur annually and deliver a pollutant load to perennial surface waters annually. Because credits are utilized by dischargers on an annual basis over a long period of time (five years or more), credit calculations must utilize the long-term annual average pollutant load for a given gully. Highly episodic gully erosion that does not deliver a pollutant load to perennial surface waters annually is not an appropriate pollutant source for generating pollutant credits. Historically eroded areas which are not actively eroding should not be used to generate pollutant credits. If gully erosion, prior to reaching surface waters, flows through a flat, depressional or vegetated area(s) within or downgradient of the field, a higher uncertainty factor must be applied to the gully pollutant load reduction estimate.

Is my gully eligible to generate credits?
The following are four common situations in which gullies do not qualify for WQT:

- The gully does not deliver sediment directly to surface waters.
- The gully was previously required to be stabilized under a prior contract or cost share agreement.
- The field on which the gully is located is subject to a WI NRCS 590 nutrient management plan.
- The pollutant load associated with gully erosion was not occurring on an annual basis.

1.2 Pollutant Load Calculation Methods

The direct-volume method of soil loss calculation can be used for most gullies. This method has been adopted and broadly utilized by NRCS, county LCD offices, and others. The calculation approach and assumptions differ depending on the type of gully at hand. A spreadsheet has been developed by Wisconsin NRCS to aid in calculating erosion via the direct volumetric approach. The spreadsheet may be downloaded at the following link: Wisconsin NRCS Soil Loss Calculator (https://dnr.wisconsin.gov/sites/default/files/topic/Wastewater/Erosion_Calculator_7-2017.xlsx)

The pollutant load associated with a gully can be calculated by estimating the annual average mass of soil loss that occurs via gully erosion within the field and accounting for, prior to reaching a perennial surface water, sediment deposition within flat, depressional or vegetated areas within or downgradient of the field. After soil samples are taken, phosphorus analysis results can be applied to the mass of annual soil delivery to calculate an annual phosphorus load. These methods do not directly predict a future pollutant load, but rather estimate a baseline of past years' pollutant loading. In most cases, it can be assumed that future erosion would be similar to past erosion if an intervention does not occur. In cases of large ongoing/permanent gullies, or gullies not located on a cropped field, alternate quantification methods may be needed.

1.3 Ephemeral Gully

The key assumption behind the ephemeral gully calculations is that the entire volume of the observed gully is eroded from the field on an annual (or more frequent) basis. For this to occur, tillage must eliminate and fill in the gully depression with new soil. Gullies that do not receive an annual "filling-in" via tillage are more likely to be considered permanent gullies.

$$\frac{\text{Ephemeral Gully Length} \times \text{Average Width} \times \text{Average Depth}}{2000} \times \text{Soil Weight}\left(\frac{lbs}{cu.ft}\right) \times \text{Occurrences Per Year}$$
$$= \text{Estimated Soil Loss (Tons Per Year)}$$

1.4 Permanent Gully

Because permanent gullies increase in size each year (they are not eliminated with tillage), the total volume of the gully is divided by the number of years it took the gully to form. The annual average rate of soil loss is assumed to be divided equally across each of the years and is assumed to continue occurring absent intervention. For very large gullies, this method may overestimate future years' soil loss due to the natural grade stabilization process where upper parts of the slope, not acted upon by concentrated flow, no longer erode at the same rate as in the past. Very large gullies may require alternative quantification methods.

$$\frac{\text{Permanent Gully Length} \times \text{Average Width} \times \text{Average Depth} \times \text{Soil Weight}\left(\frac{lbs}{cu.ft}\right)}{2000} \div \text{Formation Years}$$
$$= \text{Estimated Soil Loss (Tons Per Year)}$$

1.5 Soil Sampling to Estimate Phosphorus Loss

Before work is done to correct the gully, collect soil samples from the actively eroding gully side slopes and channel bottom. A single composite soil sample for each gully is recommended. Subsamples should be positioned to capture the range of different soil types and textures within the gully. Mark subsample points on a field-scale map to include in the WQT plan. Samples should be transported to an accredited lab in accordance with the lab's quality assurance protocols and analyzed for total phosphorus.

$$\frac{Estimated\ Soil\ Loss\ (tons\ per\ year) \times Total\ Phosphorus\ (\%/100)}{2000} = Phosphorus\ Loss\ (pounds\ per\ year)$$

1.6 Quantification

TABLE M1: NRCS EPHEMERAL GULLY EROSION WORKBOOK (DATA INPUT FIELDS HIGHLIGHTED IN YELLOW)

NRCS Ephemeral Gully Erosion Estimator

Farmer / Cooperator Name: ______ Evaluated By: ______

Tract Number: ______ Evaluation Date: ______

Field Number	Ephemeral Gully (EG)	Gully Length (Feet)	Gully Average Width (Feet)	Gully Average Depth (Inches)	Volume (FT^3) Eroded Estimate	Soil Texture	Pounds of Soil per FT^3 Estimate	Number of Similar EGs In Field	Soil Loss (Tons per Occurrence) Estimate	Number of Occurrences per Year Estimate	Total EG Soil Loss per Year Estimate
	1										
	2										
	3										
						Total Estimated Ephemeral Gully Soil Loss Per Year (Tons/yr):					

TABLE M2: NRCS PERMANENT GULLY EROSION WORKBOOK (DATA INPUT FIELDS HIGHLIGHTED IN YELLOW)

NRCS Classic Gully Erosion Estimator											
Farmer / Cooperator Name:								Evaluated By:			
Tract Number:								Evaluation Date:			
Field Number	Gully	Total Active Gully Length (Feet) *	Gully Average Top Width (Feet)	Gully Average Bottom Width (Feet)	Gully Average Depth (Feet)	Estimated Total Volume (FT^3) Eroded	Gully Formation: Estimated Number of Years	Soil Texture	Approximate Pounds of Soil per FT^3	Estimated Total Gully Soil Loss (Tons)	Estimated Gully Soil Loss Per Year (Tons/yr)
	1										
	2										
	3										
			Total Estimated Annual Gully Soil Loss (Tons/yr):								

Data Input Field Notes

Field Number / Gully Number: Each gully should be given a unique ID number that can be tied to other supporting documentation (photos, maps) in the water quality trading plan.

Total Active Gully Length: Define the length of actively eroding gully based on in-field measurements. Length should not extend beyond the portion of the gully that is actively eroding. If gully length varies from year to year, a long-term average length value should be used.

Gully Average Width: Determine the average width of the gully via multiple measurements spaced evenly down the length of the gully. For permanent gullies, measurements should be taken at the top of the actively eroding area and at the base.

Gully Average Depth: Gully depth is the measured vertical distance from the bottom of the actively eroding channel to the adjacent soil surface that is not actively eroding. Multiple depth measurements should be taken and averaged.

Soil Texture: Soil texture may be obtained from SSURGO soil maps or by analysis of soil samples.

Number of Similar EGs in Field: This should not be used for water quality trading pollutant load estimates (leave field blank). Measurements from each gully are needed to substantiate the pollutant load reduction.

Number of Occurrences Per Year Estimate: In most cases, this number will be set equal to one. In cases where in-field measurements document formation multiple times per year, the value may be higher than one. This number should not be set higher than the annual average number of tillage events.

Gully Formation Estimated Number of Years: For permanent gullies, the total volume of gully sediment eroded is assumed to be distributed across the number of formation years. This value should be defined based on local site history or aerial photo interpretation.

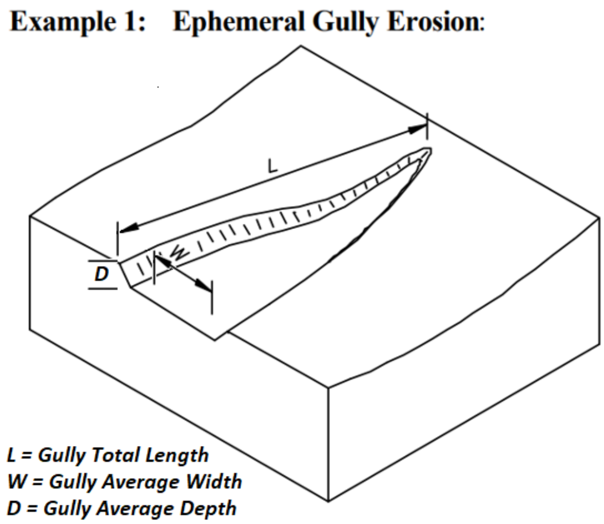

FIGURE M1: EPHEMERAL GULLY EROSION DIMENSIONS DIAGRAM, ADAPTED FROM HTTPS://EFOTG.SC.EGOV.USDA.GOV/REFERENCES/PUBLIC/MO/GULLY-EPHEMERAL_EROSION.PDF

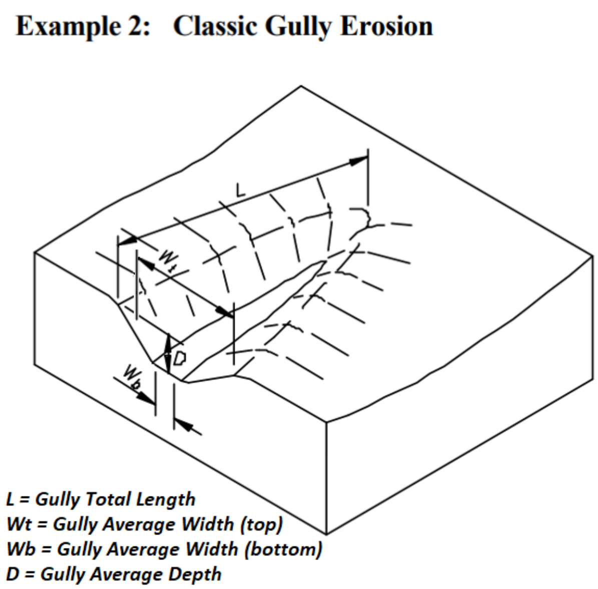

FIGURE M2: CLASSIC (PERMANENT) GULLY EROSION DIMENSIONS DIAGRAM, ADAPTED FROM HTTPS://EFOTG.SC.EGOV.USDA.GOV/REFERENCES/PUBLIC/MO/GULLY-EPHEMERAL_EROSION.PDF

1.7 Gully Documentation in WQT Plans:

To support the pollutant load quantification, water quality trading plans that propose credit generation via gully stabilization should provide the following documentation that supports calculation inputs:

- A map should show the location of each gully on the field and define the length of each gully. The map should also define where soil samples were taken.

- If soil texture is not defined via sample analysis, a soils map is needed to specify soil type.
- Photographs of each gully should enable a WQT plan reviewer to evaluate gully parameters and active erosion status. Including an object, such as level rod of defined length, for scale in photos is recommended. Multiple photos taken at different points throughout the length of gully are recommended.
- A topographic map and photograph(s) showing the gully flow path and termination point within a perennial surface water. Concentrated flow must fully deliver soil particles to perennial water for the full annual erosion estimate to be considered representative of the surface water pollution load. Gullies that deposit sediment prior to entering surface waters, via flow into flat, depressional or vegetated areas, may not be appropriate for trading. In some cases, gullies with partial sediment deposition that can discharge into perennial surface waters, may be used to trade with an additional point (+1) added to the uncertainty factor.
- The field's management history (tillage, cropping practices, etc.) should be described. This can help make the distinction between ephemeral and permanent gullies.
- The WQT plan should describe the process by which gully measurements were obtained. Gully dimensions used in the quantification should be based on a long-term annual average rather than a single year's observation. Gully measurements, flow path, and discharge point to surface waters should corroborate with maps and photos provided in the WQT plan. Two categories of default uncertainty factors are used in the trade ratio, depending on amount of data used to generate annual average values for the quantification.
    - Gullies with baseline data supporting measurements taken in at least two of the proceeding ten years are assigned an uncertainty factor of 2.
    - Gullies with baseline data supporting measurements taken in less than two years of the proceeding ten years are assigned an uncertainty factor of 3.
      Note: Baseline data can include aerial photographs, historic ground-level photos, or measurements taken afield.

1.8 Stabilization Techniques

Across Wisconsin's agricultural landscape, grassed waterways are the most common management practice employed to address gully erosion. WI NRCS technical standard 412 provides criteria, considerations, and standard operation and maintenance protocols for grassed waterways. The WQT plan and WQT agreement should ensure that activities conform to WI NRCS technical standard 412.

Regardless of stabilization method, water quality trading plans should commit to maintaining the site free of erosion during each year that credits are generated. Credits cannot be generated until the site is stabilized by vegetation establishment or other means. Should erosion recur, corrective measures need to be taken. Future pollutant loads in excess of WQT plan calculations can be considered a permit violation.