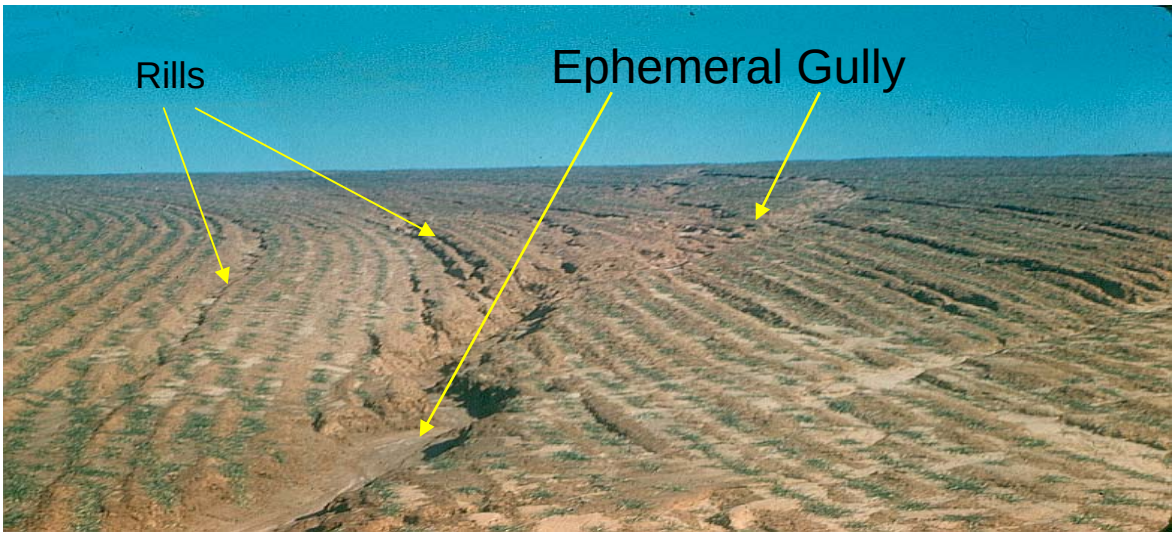
ESTIMATING SOIL LOSS FROM GULLY EROSION
- EPHEMERAL AND CLASSIC -

Definitions

Ephemeral Gully - Ephemeral gullies are shallow channels in cropland created when runoff removes soil that has been loosened by tillage operations. They are found on cropland where rills converge into a single watercourse or defined channel. This usually results from the junction of rills that form a dendritic (branching or tree-like) pattern of channels. An ephemeral gully typically erodes only to the tilled depth. Ephemeral gullies are rarely more than 1 foot deep, and generally have nearly vertical sides in the bottom of the eroding portion of the channel **(see Figures 1, 2 and 3).** If untreated, the ephemeral gully may develop into a classic gully over time. Ephemeral gullies can be crossed with farm equipment and may be obliterated or masked with tillage operations. Although tillage removes the visible erosion, it also moves loosened soil back into the bottom of the channel for the next rainfall event. This soil is loose and readily available to be transported by runoff from the next rain event. In general, an ephemeral cropland gully is larger than a rill and smaller than a classic gully. Total soil loss from the field includes the loss predicted by RUSLE2 as well as the loss from the accelerated erosion in the ephemeral gully area.

Characteristics of Ephemeral Cropland Gullies

1. They usually occur in the upper reaches of the drainage network on crop fields.
2. They are usually dendritic, but may have other patterns caused by row alignment or other characteristics of field operations.
3. Over time they frequently form well defined depressions on the crop field.
4. They recur in the same area of the field each time they form rather than randomly at different places on a slope.
5. They can be crossed with tillage equipment and are partially or totally erased by tillage operations. The filling results in soil deterioration over a larger area than the gully itself.
6. They are generally wider, deeper, and longer than rills on crop fields.
7. They can occur in depressions in which rows or tillage marks lead.
8. They can occur in terraced fields where overtopping of terraces occurs or where piping occurs below the terrace embankment.
9. They can occur in the bottom of gradient terraces.



Classic Gully – Classic gullies are channels or miniature valleys cut into the landscape by concentrated runoff, but through which water commonly flows only during and immediately after rainfall events. A classic gully may be either branching or linear (long, narrow, and of uniform width) with a width and depth that prevents normal tillage or equipment crossing.

Characteristics of Classic Gullies

1. They may grow or enlarge from year to year by head cutting and lateral widening.
2. They may also occur in depressions and natural drainageways.
3. They may start as an ephemeral gully.
4. They may become partially stabilized by grass, weeds, or woody vegetation.

Procedures for Estimating Erosion

Ephemeral Gully Erosion

It is important to note that ephemeral gully calculations are made on a field by field basis and that the erosion above the point where rills converge is accounted for in the RUSLE2 calculations. Refer to **Tables 1, 2, 3, and 4** for estimated erosion rates associated with different depth, width, and length combinations. Erosion rates in the tables are in tons and are rounded to the nearest whole number. For ephemeral gully dimensions (width, depth or length) that exceed the increments shown in these tables, combine the erosion rates from two or more columns that equate to the actual size. Interpolation of erosion rates between tables may be used when needed. **Ephemeral gully erosion will be assumed to be zero on fields with adequate and properly functioning terrace systems.**

The erosion rates in Tables 1, 2, 3, and 4 are based on the formula below. The soil erosion values in the tables must be multiplied by the number of tillage operations occurring in the months of April, May, June, September, and October to obtain an estimate of the soil loss in tons per year. If no tillage occurs in these months then

multiply the soil loss value by one (1). The formula below can be used to estimate ephemeral gully soil loss in lieu of using the tables:

$$\frac{L \times W \times D}{12} = V$$

Where: **L** = the total length in feet;
W = the average width in feet;
D = the average depth measured in inches; and
V = the displaced volume in cubic feet.

To convert this calculated volume into a weight of soil lost, use the following formula:

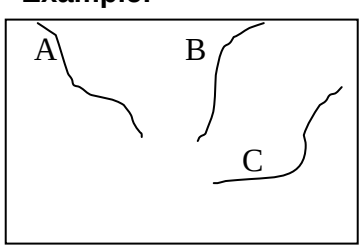
(V x 90 / 2000) x N x T = E

Where: **V** = the volume in cubic feet calculated above;
90 = the average weight of soil in pounds per cubic foot;
2000= the weight in pounds per ton;
N = the number of similar ephemeral gullies;
T = the number of tillage operations done in the months of April, May, June, September and October;
E = the current soil loss in tons per year.

The Ephemeral and Classic Gully Worksheet is available for use to calculate erosion.

NOTE: Ephemeral gully erosion occurs between seasonal tillage operations. **The number of years that the gully has been active will always be equal to 1 for an ephemeral gully.** On intensively tilled cropland, ephemeral gullies may form after rainfall events following tillage operations in any given year. The formula above calculates the erosion that occurred since the most recent tillage operation. Therefore, the amount of soil loss calculated using the above formula or the values found in the tables will be multiplied by one (1) or by the number of tillage operations occurring in the months of April, May, June, September and October. Tillage operations include implements that provide full width tillage across the field and refill ephemeral gullies with soil after their use. Such implements include but are not limited too disks, chisels, sweeps, moldboard plows, field cultivators, and harrows.

Example:



Ephemeral Gully A = 100' long, 1' wide, 4" deep, 2 tillage operations: 100 x 1 x 4 / 12 = 33.3 cu ft
33.3 x 90 / 2000 x 2 = **3 tons/yr**

Ephemeral Gully B = 200' long, 2' wide, 2" deep, 2 tillage operations: 200 x 2 x 2 / 12 = 66.6 cu ft
66.6 x 90 / 2000 x 2 = **6 tons/yr**

Ephemeral Gully C = 150' long, 1.5' wide, 3" deep, 2 tillage operations: 150 x 1.5 x 3 / 12 = 56.25 cu ft
56.25 x 90 / 2000 x 2 = **5.06 tons/yr**

Total ephemeral erosion for the field: 3 + 6 + 5.06 = 14.06 tons/yr

Figure 1 – Rills Converge to Create an Ephemeral Gully

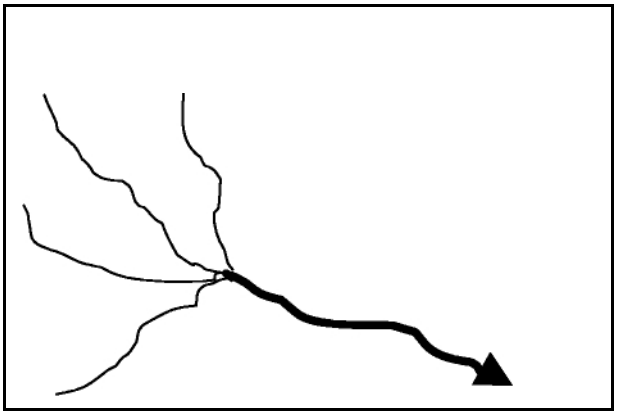


Figure 2 – Wide Shallow Ephemeral Gully

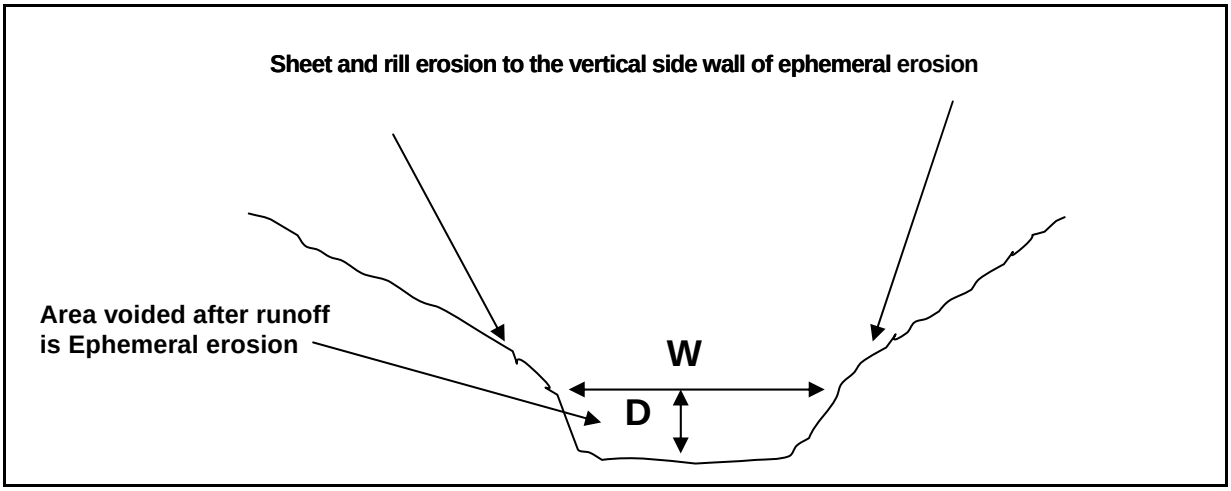
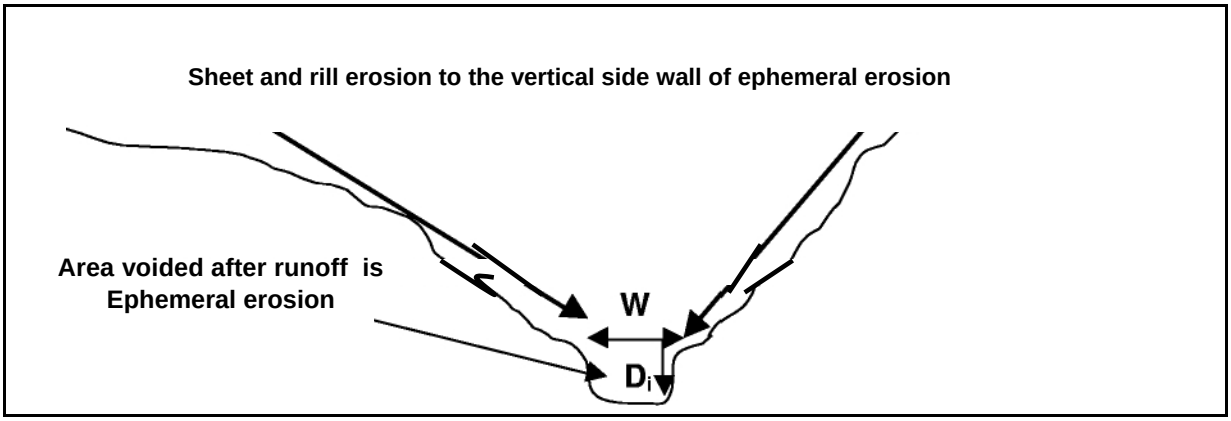


Figure 3 – Narrow Deep Ephemeral Gully



ESTIMATED TONS OF EPHEMERAL GULLY EROSION*

TABLE 1 - DEPTH OF EROSION EQUALS ***2 INCHES***

W (ft) / L (ft)	1	2	3	4	5	6	7	8	9	10
25	**	**	1	1	1	1	1	2	2	2
50	**	1	1	2	2	2	3	3	3	4
75	1	1	2	2	3	3	4	5	5	6
100	1	2	2	3	4	5	5	6	7	8
125	1	2	3	4	5	6	7	8	8	9
150	1	2	3	5	6	7	8	9	10	11
175	1	3	4	5	7	8	9	11	12	13
200	2	3	5	6	8	9	11	12	14	15
225	2	3	5	7	8	10	12	14	15	17
250	2	4	6	8	9	11	13	15	17	19
275	2	4	6	8	10	12	14	17	19	21
300	2	5	7	9	11	14	16	18	20	23

TABLE 2 - DEPTH OF EROSION EQUALS ***4 INCHES***

W (ft) / L (ft)	1	2	3	4	5	6	7	8	9	10
25	**	1	1	2	2	2	3	3	3	4
50	1	2	2	3	4	5	5	6	7	8
75	1	2	3	5	6	7	8	9	10	11
100	2	3	5	6	8	9	11	12	14	15
125	2	4	6	8	9	11	13	15	17	19
150	2	5	7	9	11	14	16	18	20	23
175	3	5	8	11	13	16	18	21	24	26
200	3	6	9	12	15	18	21	24	27	30
225	3	7	10	14	17	20	24	27	30	34
250	4	8	11	15	19	23	26	30	34	38
275	4	8	12	17	21	25	29	33	37	41
300	5	9	14	18	23	27	32	36	41	45

* Soil loss values are derived from ephemeral gully erosion formulas. To obtain total estimated soil loss from ephemeral gullies, values in tables must be multiplied by one or the number of tillage operations occurring in April, May, June, September, and October. Values in tables are rounded up to the next whole number.

**Insignificant amounts (less than 0.5 ton).

ESTIMATED TONS OF EPHEMERAL EROSION*

TABLE 3 - DEPTH OF EROSION EQUALS ***6 INCHES***

L (ft) \ W (ft)	1	2	3	4	5	6	7	8	9	10
25	1	1	2	2	3	3	4	5	5	6
50	1	2	3	5	6	7	8	9	10	11
75	2	3	5	7	8	10	12	14	15	17
100	2	5	7	9	11	14	16	18	20	23
125	3	6	8	11	14	17	20	23	25	28
150	3	7	10	14	17	20	24	27	30	34
175	4	8	12	16	20	24	28	32	35	39
200	5	9	14	18	23	27	32	36	41	45
225	5	10	15	20	25	30	35	41	46	51
250	6	11	17	23	28	34	39	45	51	56
275	6	12	19	25	31	37	43	50	56	62
300	7	14	20	27	34	41	47	54	61	68

TABLE 4 - DEPTH OF EROSION EQUALS ***8 INCHES***

L (ft) \ W (ft)	1	2	3	4	5	6	7	8	9	10
25	1	2	2	3	4	5	5	6	7	8
50	2	3	5	6	8	9	11	12	14	15
75	2	5	7	9	11	14	16	18	20	23
100	3	6	9	12	15	18	21	24	27	30
125	4	8	11	15	19	23	26	30	34	38
150	5	9	14	18	23	27	32	36	41	45
175	5	11	16	21	26	32	37	42	47	53
200	6	12	18	24	30	36	42	48	54	60
225	7	14	20	27	34	41	47	54	61	68
250	8	15	23	30	38	45	53	60	68	75
275	8	17	25	33	41	50	58	66	74	83
300	9	18	27	36	45	54	63	72	81	90

* Soil loss values are derived from ephemeral gully erosion formulas. To obtain total estimated soil loss from ephemeral gullies, values in tables must be multiplied by one or the number of tillage operations occurring in April, May, June, September, and October. Values in tables are rounded up to the next whole number.

**Insignificant amounts (less than 0.5 ton).

Classic Gully Erosion

Erosion from classic gullies will be estimated using the headcut formula and/or the sidewall formula. The amount of erosion derived from each formula will be added together to determine the total estimated erosion for the gully in tons per year. Branches of gullies will be calculated individually and added together to determine the total soil loss for the gully system **(see examples below).**

Variables for gully erosion calculations:

T = top width in feet
B = bottom width in feet
D = depth in feet
L = length in feet
E = *soil unit weight in lbs per cubic foot
H = headcut advancement, feet per year
S = average annual rate of sloughing or recession, feet per year
N = number of sides sloughing

*The average unit weight of 90 pounds per cubic foot soils can be used in the absence of site specific data.

Headcut example – 30 ft top, 6 ft bottom, 6 ft deep, headcut advancing at 5 ft /year

$$\frac{(T+B) \times D \times H \times E}{2 \times 2000} = \frac{(30+6) \times 6 \times 5 \times 90}{2 \times 2000} = 24.3 \text{ tons/yr}$$

Sidewall example - 2 sides sloughing, 8 feet high, 1560 feet long, sloughing at a rate of 0.25 ft/yr.

$$\frac{N \times D \times L \times S \times E}{2000} = \frac{2 \times 8 \times 1560 \times 0.25 \times 90}{2000} = 280.8 \text{ tons/yr}$$

The attached Ephemeral and Classic Gully Worksheets are provided to document erosion calculations. These worksheets are available in electronic fillable forms on eFOTG.

Ephemeral Gully Worksheet

Cooperator Name: _____ **Field Office:** _____ **Plan No:** _____ **Date:** _____

Location: _____ **Field No:** _____

Volume Formula

$$\frac{L \times W \times D}{12} = V$$

Where:
L = the total length in ft.
W = the average width in ft.
D = the average depth in inches

V = the volume of soil in cu.ft. per year

Conversion Formula

$$\frac{(V \times 90) \times N \times T}{2000} = E$$

Where:
V = the volume of soil in cu.ft.
90 = the average weight in pounds per cu.ft.
2000 = the weight in pounds per ton
N = the number of ephemeral gullies
T = The number of tillage operations done in the months of April, May, June, September, and October
E = the total soil loss in tons per year

Field or Gully No.	L (ft)		W (ft)		D (in)		Volume (cu.ft.)	Number of Ephemeral Gullies		Number of Tillage Operations	Soil Loss Tons/year
Control + c clears Worksheet										Total:	

Classic Gully Worksheet
Headcut and Sidewall Method

Cooperator Name: _____ **Field Office:** _____ **Plan No:** _____ **Date:** _____

Location: _____ **Field No:** _____

Headcut Calculation

$$\frac{(T+B) \times D \times H \times E}{2 \times 2000} = \text{Tons/yr}$$

Where: **T** = average top width in ft. **D** = depth in ft. **H** = headcut advancement in ft/yr **N** = number of sides sloughing
B = average bottom width in ft **E**= soil unit weight in lbs/cu.ft. **S** = annual rate of sloughing ft/yr **L** = Length in ft.

Field or Gully No.	T (ft)		B (ft)		D (ft)		H (ft/yr)		E (lbs/cu.ft.)		Soil Loss Tons/Year
										Total:	

Sidewall Calculation

$$\frac{N \times D \times L \times S \times E}{2000} = \text{Tons/yr}$$

Field or Gully No.	N (No)		D (ft)		L (ft)		S (ft/yr)		E (lbs/cu.ft.)		Soil Loss Tons/Year
										Total:	
Control+d clears worksheet									Headcut + Sidewall Soil Loss		