Phosphorus Trade Crediting Calculations

National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit MN0040665

Proposed changes to this permit attachment shall follow the permit modification procedures outlined in the permit.

"High Delivery Zone" means the corridor of land along a stream, river or other watercourse that demonstrates high interaction of the soils with the watercourse. High Delivery Zones may include floodplains with a high flood return frequency, or land with convex slopes toward the watercourse that does not allow eroded materials to redeposit before overland flow enters the watercourse. The MPCA shall determine whether a proposed site is a High Delivery Zone or not.

The Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) shall be used to project the soil erosion rates from sheet, rill, and ephemeral gullies. The local Natural Resource Conservation Service (NRCS) and Soil and Water Conservation District (SWCD) staff shall determine the USLE and RUSLE coefficients for proposed trade sites in their respective local areas.

Credits under more than one Best Management Practice (BMP) for the same site shall not be allowed unless adequate justification is provided demonstrating that the cumulative credits are additive.

Trade crediting calculations are based on conservative professional estimates. The Permittee is required to achieve and maintain MPCA-approved credits in accordance with Chapter 12. These requirements are based upon a trading ratio of 2.6 which is determined as follows:

- 1.0 (Basic 1:1 Trading Ratio Requirements)
- +0.6 (Engineering safety factor reflecting potential site-to-site variations)
- +1.0 (Net reduction factor to achieve load reductions that improve water quality. This reduction factor is based on considerations including the MPCA water quality interim target for the Minnesota River Basin, the MPCA Total Maximum Daily Load limitation to address problems of low dissolved oxygen in the lower Minnesota River, and the MPCA Phosphorus Strategy.)
- =2.6 (Overall Trading Ratio)

1. Soil Erosion BMPs

Soil erosion BMPs are BMPs to reduce the impacts of sheet, nil, and ephemeral gully erosion; gully erosion; stream, river, and ditch bank erosion; and erosion at surface tile inlets. The following process shall be used to calculate the phosphorus credits from soil erosion BMPs.

Step 1: Calculate the reduction in soil erosion. The following methods of estimating the erosion rate apply, based on the erosion mechanism:

A. Sheet, Rill, and Ephemeral Gully Erosion: Calculate the site erosion rate before and after installing the BMP using the USLE or RUSLE. (The equation used shall be that currently used by the local NRCS and SWCD.) Express the results in tons/acre/year (SED_b and SED_a).

B. Streambank and Gully Erosion:

1. Using the existing contours, determine the volume of soil removed by gully erosion and/or streambank erosion (VOL).

2. Using the land operator as a reference, determine the amount of time in years it has taken to produce the gully and/or streambank erosion (VOL/YRs).

3. Using the Soil Density Values below, convert the volume per year determination to tons/year (SED_b). SED_a shall be equal to zero.

Soil Density Values

Soil Textural Class	**Dry Density (tons/ft^3)**
Sands, loamy sands	0.055
Sandy loam	0.0525
Fine sandy loam	0.05
Loams, sandy clay loams, sandy clay	0.045
Silt loam	0.0425
Silty clay loam, silty clay	0.04
Clay loam	0.0375
Clay	0.035
Organic	0.011

Step 2: Calculate the reduction in sediment delivered to the watercourse.

A. Sheet, Rill, and Ephemeral Gully Erosion: Using the Delivery Ratio Table below, enter the sheet and rill erosion category to calculate the delivery ratio for the site before and after implementation of BMP(s). Sediment reduction in tons equals the difference between these values times the acres that the practice is applied over. $SEDRT_b$ = Area * (SED_b*DR_b) and $SEDRT_a$ = Area * (SED_a*DR_a)

Delivery Ratio Table

Area	Surface Tile Inlets Absent			Surface Tile Inlets	
	High Delivery Zone	Non-high Delivery Zone less than ¼ mile from watercourse	Non-High Delivery Zone greater than ¼ mile from watercourse	Without a Standpipe	With a Standpipe
Gully Erosion Channelized to Watercourse	95%	95%	50%	NA	NA
Gully Erosion Non-Channelized to Watercourse	NA	15%	5%	20%	10%
Sheet, Rill Erosion	95% maximum	15%	5%	20%	10%
Streambank Erosion	95%	NA	NA	NA	NA

B. Streambank and Gully Erosion: Using the Delivery Ratio Table above, select the appropriate delivery ratio (DR_b). Multiply the soil erosion rate (SED_b in tons/year) by the delivery ratio to determine the amount of soil reaching the surface water. The results shall be in tons/year delivered. $SEDRDC = SED_b * DR_b$.

Step 3: Determine the phosphorus values associated with the sediment runoff.

A. Sheet, Rill, and Ephemeral Gully Erosion: To determine the annual phosphorus mass reduced, take the sediment tons per acre before and after (similar to step 2, without the area; $SEDRTP_b = SED_b * DR_b$ & $SEDRTP_a = SED_a * DR_a$) and enter the Phosphorus Enrichment Table. Phosphorus enrichment values represent the phosphorus attachment potential of different soil types combined with the settling characteristics of the different particles. The phosphorus attachment in the parent material is as presented in the table below for each soil type (e.g., 1.00 pound/ton for silt), however, as sands deposit out and clays continue on the move and the soil that remains on the move contains more P per ton of soil. This table is from the CREAMS algorithm for sediment-attached phosphorus and adjusts for phosphorus content of the parent material type. To determine the enrichment, take the phosphorus content results (phosphorus) for the "before value" and subtract the "after value" from the table. (P_b and P_a), $PRDC = P_b * Area - P_a. * Area$.

B. Streambank and Gully Erosion: Determine the phosphorus values associated with the sediment. Using the default values in the table below, calculate the amount of phosphorus delivered to the surface water (PDEL). PDEL = SEDRDC * PhosContent.

Soil Type	Sand	Silt	Clay	Peat
Phosphorus Content Factor	0.85 lb/ton	1.00 lb/ton	1.15 lb/ton	1.50 lb/ton

NOTE: The values used in Step 3 are conservative. At certain trade sites, soils may have enriched phosphorus content due to past application of fertilizers. Higher phosphorus levels may be justified through site-specific soil sampling. However, to account for uncertainties associated with the sampling process, site-specific values shall he multiplied by a safety factor of 75 percent to calculate the amount of phosphorus delivered, unless a site-specific soil sampling plan is approved in advance by the MPCA.

Phosphorus Enrichment Table

Sediment Delivery Rate (tons/ac/year)	Phosphorus Enrichment Value (lbs/acre)			
	Clay	Silt	Sand	Peat
0.01	0.05	0.04	0.03	0.06
0.02	0.08	0.07	0.06	0.10
0.03	0.11	0.10	0.08	0.15
0.04	0.14	0.12	0.10	0.18
0.05	0.17	0.15	0.12	0.22
0.06	0.19	0.17	0.14	0.25
0.07	0.22	0.19	0.16	0.29
0.08	0.24	0.21	0.18	0.32
0.09	0.27	0.23	0.20	0.35
0.1	0.29	0.25	0.22	0.38
0.2	0.51	0.44	0.38	0.66
0.3	0.70	0.61	0.52	0.92
0.4	0.88	0.77	0.65	1.15
0.5	1.1	0.9	0.8	1.4
0.6	1.2	1.1	0.9	1.6
0.7	1.4	1.2	1.0	1.8
0.8	1.5	1.3	1.1	2.0
0.9	1.7	1.5	1.2	2.2
1	1.8	1.6	1.4	2.4
2	3.2	2.8	2.4	4.2
3	4.4	3.9	3.3	5.8
4	5.6	4.8	4.1	7.3
5	6.7	5.8	4.9	8.7
6	7.7	6.7	5.7	10.1
7	8.7	7.6	6.4	11.4
8	9.7	8.4	7.2	12.7
9	10.7	9.3	7.9	13.9
10	11.6	10.1	8.6	15.1
11	12.5	10.9	9.3	16.3
12	13.4	11.7	9.9	17.5
13	14.3	12.4	10.6	18.7
14	15.2	13.2	11.2	19.8
15	16.0	14.0	11.9	20.9
16	16.9	14.7	12.5	22.0
17	17.7	15.4	13.1	23.1
18	18.6	16.1	13.7	24.2
19	19.4	16.9	14.3	25.3
20	20.2	17.6	14.9	26.3
21	21	18.3	15.5	27.4
22	21.8	19.0	16.1	28.4
23	22.6	19.6	16.7	29.5
24	23.4	20.3	17.3	30.5
25	24.1	21.0	17.8	31.5
26	24.9	21.7	18.4	32.5
27	25.7	22.3	19.0	33.5
28	26.4	23.0	19.5	34.5
29	27.2	23.6	20.1	35.5
30	27.9	24.3	20.7	36.4

2. Cattle Exclusion

Cattle exclusion means fencing and an alternative water supply that provides a separation distance protecting the waters of the state and their shorelands.

The following process shall be used to calculate the phosphorus credits from cattle exclusion.

Step 1: Determine the number of head and size of animals. The maximum grazing density for cattle that can be supported without supplemental feeding is one animal per acre (head/ac) over a 5-month grazing season for steers. Other cattle pasture operations shall determine the land's capacity and document the assumptions. The animal count shall be determined by the typical weight categories given in the Midwest Plan Service's Livestock Waste Facilities Handbook (MWPS-18). Keep separate counts for each animal category presented (HEAD).

Step 2: Determine the manure load generated by the herd. The MWPS-18 lists standard production rates for phosphorus (MP):

MP = HEAD * MWPS-18 P
MTP = Phosphorus from all the animal categories presented

Step 3: Determine the field layout before and after cattle exclusion has been implemented. The pasture area shall be divided into a High Delivery Zone and a non-High Delivery Zone. For large pastures, the non-High Delivery Zone shall be divided based on the delivery ratio as shown below:

Area	High Delivery Zone	Non-High Delivery Zone less ¼ mile from watercourse	Non-High Delivery Zone greater than ¼ mile from watercourse
Delivery Ratio	100%	40%	20%

Step 4: Determine the amount of phosphorus delivered in each portion of the pasture before and after implementation of the BMP. Deposition of manure in pasture areas shall be directly proportional to the amount of time spent by the animals in each area. The following time distribution shall be used for cattle having unrestricted access in the riparian zone:

Month	**Time in High Delivery Zone**
May	25%
June	25%
July 0-15	25%
July 15-30	36%
August	36%
September	25%
Average	**28%**

The alternative water supply shall be located in the pasture, as specified in the operation and maintenance plans, to minimize the time the cattle are next to the exclusion fencing.

Time not spent in the High Delivery Zone shall be spread equally throughout the upland pasture area in the following distribution: The ratio of the total field size to the portion less than ¼ mile or greater than a ¼ mile the watercourse. The amount of phosphorus deposited in each portion of the pasture shall be calculated based on the ratio of the field size to the portion of land less than or equal to ¼ mile and greater than or ¼ mile. For example, if 20 percent of the field exceeds ¼ mile then 20 percent of the manure shall be allocated the 20 percent delivery ratio after the cattle exclusion is implemented. Example time distributions (TD) are shown below (in this example zero percent of the field is located more than ¼ mile from the watercourse):

Example Time Distributions

Pasture Area Cattle Management	**Before Cattle Exclusion**	**After Cattle Exclusion**
High Delivery Zone	28%	0%
Non-High Delivery Zone less than ¼ mile from watercourse	72%	100%

Step 5: Determine amount of phosphorus delivered

The amount of phosphorus delivered shall be calculated from the amount deposited in each pasture area multiplied by that area's delivery ratio, and shall be adjusted according to:

- Herd Size: If a substantial portion of the pasture would fall under a conservation easement, the herd size shall be reduced in the calculations to reflect the decreased carrying capacity after the implementation of cattle exclusion.

- Filter Strips: Filter strip credit may be allowed for management areas where flow characteristics and vegetation are such that filtering out of solids is enhanced. The minimum width of the easement for application of a filter strip function is 25 feet for stem grass vegetation and 50 feet for woody vegetation Filter strips are assumed to remove 30 percent of particulate pollutants and 0 percent of soluble pollutants. The relative distribution of soluble/particulate fractions shall be 50 percent/50 percent for manure-based phosphorus.

$LPDR_B = MTP * THZ * DR + MTP * TG1/4 * DR + MTP * TL1/4 *$

$LPDR_A = MTP * TG1/4 * DR + MTP * TL1/4 * DR$

DR = Delivery Ratios as determined by table on Delivery ratios

THZ = time assumed to be in High Delivery Zone (28% of the time)

TG1/4 = time determined to be spent in pasture more distant than ¼ mile

TL1/4 = time determined to be spent in pasture closure than a ¼ mile

Filter Strip Crediting

$$FilterLE = LPDR_B - LPDR_A - (LPDR_A * TE * Solidf)$$

TE = equals a treatment efficiency of 30% removal of particulate matter.

Solidf = equals the assumption of 50% of manure being in solid versus soluble.

3. Rotational Grazing with Cattle Exclusion

The operation and maintenance plans for rotational grazing shall include a description of the enhanced forage species for the pastures, including the vegetation criteria to determine over-grazed pastures from properly rotated pastures.

Rotational grazing with cattle exclusion shall be credited similar to Cattle Exclusion except for the time spent in distant pastures and reductions in the delivery ratio attributed to manure rates being closer to agronomic rates. More credit may be obtained if rotational grazing documents more time spent in the pastures farther than ¼ mile from the watercourse. Acceptable documentation includes establishing a rotational grazing plan and recording the rotational movement in that operation, and an annual "T" transect of the forage grasses present. The "T" transect shall consist of determining the vegetation species found every along two 100-foot lines perpendicular to each other in each field paddock. If the paddock shaping has dimension(s) of less than 100 feet then the count may be reduced to every six inches along a 50-foot length. The vegetation ratios shall meet the enhanced forage vegetation criteria include din the project operation and maintenance plan. Over-intensive grazing shall identify which grass species dominate the "T" transect, for example, a pasture that is dominated by Kentucky bluegrass or base soils.

Steps 1-2. Follow Cattle Exclusion Steps 1-2.

Step 3. Determine the field layout before and after called exclusion with rotational grazing has been implemented. The pasture area shall be divided into a High Delivery Zone and a non-High Delivery Zone. For large pastures, the non-High Delivery Zone shall be divided based on the delivery ratio as shown below:

Area	High Delivery Zone	Non-High Delivery Zone less than ¼ mile from watercourse	Non-High Delivery Zone greater than ¼ mile from watercourse
Delivery Ratio	100%	20%	10%

Step 4. Follow Cattle Exclusion Step 4. Example time distributions (TD) are shown below:

<u>Example Time Distributions</u>

Pasture Area Cattle Management	Before Cattle Exclusion	After Cattle Exclusion
High Delivery Zone	28%	0%
Non-High Delivery Zone less than ¼ mile from watercourse	36%	50%
Non-High Delivery Zone greater than ¼ mile from watercourse	36%	50%

Step 5. Follow Cattle Exclusion Step 5.

4. Critical Area Set Aside

Critical area set aside means changing the principal land use to reduce high erosion levels.

The following process shall be used to calculate the phosphorus credits from critical area set aside.

Set asides may be credited for this permit only if it is verified that the land being credited is not eligible for the Minnesota River Watershed Conservation Reserve Enhancement Program (CREP), and the land is not within the Beaver Creek Watershed. (CREP-eligible land within the Beaver Creek Watershed only may be proposed for critical area set aside trade credits.) The permit credit may be used to extend the CREP corridor on land adjacent to the watercourse. If the CREP program sets aside a site stream corridor but does not set aside the whole site, critical area set aside phosphorus credits under this permit may be available for the non-corridor portion of that site.

River Flood-Scoured Areas

Step 1: Determine portion of field subject to scour excavation. This information may be obtained by direct observation of field conditions, or through physical records including maps and photographs. The erosion volumes shall be calculated by averaging the previous events in a documented manner (AREA, VOL). The volume of the soil is determined by multiplying the area by the depth of scour over that area if evenly eroded or, if irregular in shape, determining that volume voided as described in Soil Erosion BMPs.

Step 2: Determine the period of time the scouring occurred. This may be determined from topographic map records, or as determined and justified by a professional engineer (TIME).

Step 3: Using the soil density values under Soil Erosion BMPs calculate the weight of the soil eroded by multiplying the dry density and the volume (tons/acre). SED = VOL * Density.

Step 4: Determine the erosion rate VER = SED/TIME (tons/acre/yr).

Step 5: Follow Soil Erosion BMPs Step 3B, assuming a 95 percent delivery ratio.
SEDP = VER * DR PhosContent (lbs of P/yr).

Bluffs

The calculations for bluff critical area set asides shall follow the soil erosion calculations under the Soil Erosion BMPs that most closely apply to the type of erosion at the site. In addition, the special practices needed to maintain soil stability during set aside installation and throughout the project trade duration shall be detailed. The design shall consider protecting the site against upland contributing flows form the surface and groundwater sources, and providing stability at the toe of the bluff.

Restored Wetlands

The calculations for restored wetlands critical area set-asides shall follow the sheet, rill, and ephemeral gully erosion calculations under the Soil Erosion BMPs. In addition, it shall be demonstrated that restored wetland contributing areas shall remain hydraulically unconnected with the watershed to which it previously drained. If a restored wetland contributing area remains hydraulically connected with the watershed to which it previously drained, it is not eligible for Critical Area Set Aside credits, but may be eligible for Constructed Wetlands Treatment Systems credits.

5. Constructed Wetland Treatment Systems

Constructed wetland treatment systems shall be designed, constructed, operated and maintained as follows:

1. Water contact recreation and consumptive fishing shall be discouraged in the wastewater treatment system.

2. The wetland shape shall be simple to encourage good water circulation. The length shall be three to five times the width for maximum detention efficiency and the inlets and outlets shall be widely spaced to minimize short-circulation. Lower length to width ratios shall be allowed if justified based on the design flows and/or energy of the unchannelized water in the wetland.

3. The inlet and outlet areas shall be protected from scour erosion.

4. Minimum and maximum depths of the wetland shall be considered. The depth shall not be such that anoxic layers readily develop. The bounce of the wetland shall not vary sufficiently to impair aquatic emergent vegetation in the wetland.

5. Maximum flows to be treated shall be designed for by providing adequate detention times and emergency spillway or flow bypasses. The design shall address the capture and long-term storage of the sediment and phosphorus.

6. The water level bounce and vegetation shall be controlled such that at least seventy percent of the permanent pool remains vegetated with emergent varieties.

The following equation shall be used to calculate the phosphorus credits form constructed wetland system:

$$\ln[C_O/C_i] = - k/q$$

where:

C_O = outlet mean annual phosphorus concentration in mg/L

C_i = inlet mean annual phosphorus concentration in mg/L

k = first order rate constant set at 12.1 meters depth per year (23.7 meters depth per year may be used instead when intensive and continuing monitoring and assessment is provided for a site-specific treatment efficiency; a monitoring and assessment project shall be a minimum of three years long but no longer than six years; upon completion of the assessment the site the long term average treatment efficiency shall be used)

q = loading rate in meters of depth per year

Sediment trapping phosphorus reduction credits shall be based on the difference in flow-weighted mean annual water concentration of total phosphorus of the inlet and the outlet. Other forms of estimating the inlet concentrations other than monitoring will be reviewed upon submittal to the MPCA. The volume treated shall be determined by the design flows based on the average year's cycle as determined by flow data (if available) at the location. Wetland intensive and continuing monitoring and assessment shall be targeted at assessing the performance of wetland treatment sites in Minnesota. This monitoring and assessment may be provided by another partner or non-trade participant.

For wetland treatment sites using the 23.7-meter depth rate constant, a multiplier of 1.3 times the credit shall be applied to remove site-variability safety factor. (This multiplier reflects the use of known data instead of estimates.) $(C_O\text{-}C_i)$*(volume in million gallons/year)*8.34 = pounds reduced.

6. Alternative Surface Tile Inlets

Surface tile inlets are a length of pipe, slotted or not, which connects the surface water ponding in depressions directly to the subsurface tile. Alternative surface tile inlets means changing past, traditional surface tile inlets by using hickenbottom risers, rock filters, and/or buffered areas.

The following process shall be used to calculate the phosphorus credits form alternative surface tile inlets.

Step 1. Determine the area in the subwatershed feeding the surface tile inlet. (A=AREA).

Step 2. Determine the RUSLE/USLE erosion rate for that portion of the site in this subwatershed. (ER=Erosion Rate).

Step3. Determine the sediment treatment efficiency of the pre-existing surface tile inlet. The tile inlet shall have been installed before 1998. The following factors shall be considered in determining the treatment efficiency.

- Slope of field at inlet
- Type of inlet at site

<u>Surface Inlet Delivery Ratio =SIDR</u>

Tile Inlet Method of Delivery	No Standpipe	With a Standpipe
Delivery Ratio	20%	10%

Step 4. Determine the prior sediment delivery mass. $SedDR_b$ = ER * A * SIDR.

Step 5. Determine the after sediment delivery mass. $SedDR_a$ = ER * A * SIDR *TE.

TE = Surface Tile Inlet Alternative Treatment Efficiencies

Method	Treatment Efficiency
Buffered	35%
Rock Filter, Hickenbottom Riser	50%

Step 6. Determine the phosphorus content of the soil by using the $SedDR_b$ and $SedDR_a$ values to enter the Phosphorus Enrichment Table under the Soil Erosion BMPs. $PSIDR_b$, $PSIDR_a$.

Step 7. Determine the phosphorus reduction by subtracting $PSIDR_a$ from $PSIDR_b$.

Step 8. Determine the phosphorus credit estimate for the site: $PCREST = PSIDR_b - PSIDR_a$.

7. Cover Cropping

Cover cropping means using small grain crops planted in the spacing between row crops, or using small grain crops planted after the harvest of the cash crop such as peas, to increase the residue cover for soil protection against erosion. The establishment criteria for the cover crop for each cash crop shall be provided according to Chapter 12.

The following process shall be used to calculate the phosphorus credits from cover cropping.

Step 1: Calculate the site erosion rate before and after installing the BMP using the USLE or RUSLE. (The equation used shall be that currently used by the local NRCS and SWCD.) Express the results in tons/acre/year (SED_b and SED_a). The cropping management factor "C" will be the only change in the calculation for before and after BMP calculations. The "C" factor shall be calculated by the local NRCS and/or SWCD or, in the case of sugar beet acreage, by those familiar with those calculations for that crop, such as the NRCS office in St. Peter, MN.

Step 2: Using the Delivery Ratio Table below, enter the sheet and rill erosion category to calculate the delivery ratio for the site before and after implementation of BMP(s). Sediment reduction in tons equals the difference between these values times the acres that the practice is applied over.
$SEDR_b = SED_b * SEDR_a = SED_a * DR$.

Delivery Ratio Table

Area	Less than ¼ mile from watercourse	Greater than a ¼ mile from watercourse	Surface Tile Inlets without a Standpipe	Surface Tile Inlets with a Standpipe
Sheet, Rill Erosion	15%	5%	20%	10%

Step 3: To determine the annual phosphorus mass reduced, take the sediment tons per acre before, $SEDR_a$, and after, $SEDR_b$, and enter the Phosphorus Enrichment Table under Soil Erosion BMPs (P_b and P_a). Phosphorus enrichment values represent the phosphorus attachment potential of different soil types combined with the settling characteristics of the different particles. To determine the enrichment, take the phosphorus content results (phosphorus) for the "before value" and subtract the "after value" from the table. (P_b and P_a), PRDC = P_b * Area - P_a * Area.