TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE STATE OF COLORADO NATURAL RESOURCES CONSERVATION SERVICE

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To: All Offices

From: James L. Sharkoff
State Conservation Agronomist

Colorado Phosphorus Index Risk Assessment, Version 5

The Colorado Phosphorus Index (COPI), Version 5, is a risk assessment tool developed cooperatively with Colorado State University (CSU) in accordance with the Natural Resources Conservation Service (NRCS), Nutrient Management Policy, GM-190-402, January 2012; National Instruction for Nutrient Policy Implementation, NI-190-302, January 2012; and National Handbook of Conservation Practices Nutrient Management Standard 590, January 2012.

The COPI is a planning tool that considers the qualitative risk of P loss off-site. The purpose for the tool is to determine if it is appropriate to apply organic nutrients based on crop N requirements or crop P requirements, or if the risk of P loss off-site is too great to apply organic nutrients.

COPI Version 5 includes the following revisions.

Wind erosion is an additional risk factor for irrigated and non-irrigated sites.

Table 1a, Index Surface Runoff, includes saturated hydraulic conductivity classes rather than permeability classes, based on information available electronically from the NRCS Web Soil Survey application.

BMP/Mitigation credits for Contour Buffer Strips, Filter Strips, Furrow Diking, Terraces and Residue and Tillage Management are included in RUSLE2 and WEPS erosion prediction estimates, rather than separate index credits.

NRCS Nutrient Management 590 planning criteria requires a field-by-field phosphorus-index risk assessment of the potential for phosphorus movement off-site in any of the following situations.

1. The Preliminary Phosphorus Risk Screening Tool directs the user to complete a Phosphorus Index Risk Assessment for the field
2. The planned phosphorus application rate exceeds CSU recommendations for the planned crop
3. The field is located within a phosphorus-impaired watershed (contributes to a 303d-listed water body)

Colorado Phosphorus Index Risk Assessment, Version 5

James L. Sharkoff [1], Jessica G. Davis [2] and Troy A. Bauder [3]

The Colorado Phosphorus Index (COPI) is a tool for planners, producers and consultants to develop management alternatives to minimize the potential for phosphorus movement off-site, from agricultural fields. The COPI will not quantify the amount of phosphorus transported off-site. Rather, it ranks the relative potential for phosphorus transport to determine if it is appropriate to apply organic nutrients based on crop N requirements or crop P requirements, or if the risk of P loss off-site is too great to apply organic nutrients.

The COPI is patterned after the phosphorus index proposed by Lemunyon and Gilbert (1993) and is modified for use in Colorado. Modifications were made based on the equivalent of 38 site years of irrigation tailwater phosphorus concentration data collected in the Arkansas, South Platte and Uncompahgre River Basins of Colorado during the 1998 and 1999 growing seasons.

Use the Preliminary Phosphorus Risk Screening Tool below to determine if you need to complete a phosphorus risk assessment for an individual field. If the field does not require a risk assessment based on the screening tool, document the screening tool results in the nutrient management plan.

Preliminary Phosphorus Risk Screening Tool

Do the planned nutrient applications for this field include manure, compost, biosolids or other organic amendments?

No → A COPI Risk Assessment is not required for this field.

Yes ↓

Is soil test P greater than 10 ppm AB-DTPA; 20 ppm Olsen ($NaHCO_3$); 30 ppm Bray P1, or; 40 ppm Mehlich 3?

No → A COPI Risk Assessment is not required for this field. The organic P application rate may exceed the crop P requirement if the application does not exceed the N requirement for the next crop.

Yes ↓

Does irrigation tailwater or stormwater runoff from the site drain directly to a continuous or intermittent stream, irrigation ditch, creek, river, lake, reservoir, pond, wetland or riparian area?

No → A COPI Risk Assessment is not required for this field. The organic P application rate may exceed the crop P requirement if the application does not exceed the N requirement for the next crop.

Yes ↓

Complete a COPI Risk Assessment for this field.

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[1] State Conservation Agronomist, USDA, Natural Resources Conservation Service, Denver, CO

[2] Professor and Extension Soil Specialist, Department of Soil & Crop Sciences, Colorado State University, Fort Collins, CO

[3] Research Scientist, Extension Water Resources Specialist, Department of Soil & Crop Sciences, Colorado State University, Fort Collins, CO

Procedures for Making an Assessment

The Colorado Phosphorus Index consists of four site and management risk factors that can affect the potential for movement of phosphorus off-site. In order to complete an assessment, rate the relative risk associated with each of the four factors. The rating scale ranges from Low (1), to Medium (2), to High (3), to Very High (4).

The rating process requires a field-specific knowledge of individual soils, slope percentages, soil physical properties, predicted soil erosion estimates, soil-test phosphorus concentration, crop rotation and planned phosphorus application amounts, sources, methods and timing. After rating each risk factor, add the values together and compare the sum with the Risk Interpretations Table to determine the relative potential for phosphorus movement off-site. Additionally, planning and application of certain Best Management Practices and mitigation activities can decrease the relative risk of phosphorus movement off-site.

Colorado Phosphorus Index Risk Factors

Factor 1. P Transport

Phosphorus can move off-site as soluble and or sediment P by irrigation runoff and rill and interrill erosion, and as sediment P by wind erosion. Evaluate two P transport risk factors for each field or site based on the following requirements for irrigated and non-irrigated fields. The higher of the two risk factors is the P Transport Risk Factor for the field.

Irrigated fields - Determine the Index Surface Runoff (1a) and Wind Erosion (1c) risk factors.

Non-irrigated fields - Determine the Rill and Interrill (1b) and Wind Erosion (1c) risk factors.

Factor 1a. Index Surface Runoff - Irrigated Fields

Index Surface Runoff describes the relationship between field slope and saturated hydraulic conductivity (Ksat). Ksat refers to the ease with which pores in a saturated soil transmit water, expressed in terms of micrometers per second.

Critical Dominant Soil - Fields often include several soil map units with different Soil Physical Properties. To evaluate Index Surface Runoff, select the soil map unit with the lowest surface Ksat value that is of a manageable size, 10 acres or 10 percent of the field. Ksat values and slope ranges for specific soils are available in Soil Survey publications and from the NRCS Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/.

Determine the appropriate Ksat value and average slope percentage for the field, and then identify the Index Surface Runoff risk from Table 1a.

Table 1a. Index Surface Runoff Risk Factor

	Saturated Hydraulic Conductivity µm s^{-1} (in hr^{-1})					
	Very High 705 - 100 (≥ 14)	High 100.0 - 10.0 (14-1.4)	Medium High 10.0 - 1.0 (1.4-0.14)	Medium Low 1.0 - 0.1 (0.14-0.014)	Low 0.1 - 0.01 (0.014-0.0014)	Very Low 0.01 - 0.00 (<0.0014)
Slope %	**Risk Factor**					
< 1	**1**	**1**	**1**	**1**	**2**	**3**
1-5	**1**	**1**	**1**	**2**	**3**	**4**
5-10	**1**	**1**	**2**	**3**	**4**	**4**
10-20	**1**	**1**	**2**	**3**	**4**	**4**
> 20	**1**	**2**	**3**	**4**	**4**	**4**

Factor 1b. Rill and Interrill Erosion - Non-Irrigated Sites

Rill and interrill erosion is the loss of soil along the hill-slope caused by raindrop impact and overland flow surface runoff. It does not include concentrated flow soil loss from irrigation-induced erosion.

Rill and interrill erosion predictions are output from the Revised Universal Soil Loss Equation Version 2 (RUSLE2), as annual and rotational average annual tons of soil loss per acre per year.

Critical Dominant Soil - Fields often include several soil map units with different Soil Erosion Factors. To evaluate rill and interrill erosion, select the soil map unit with the highest K Factor Whole Soil (Kw) that is of a manageable size, 10 acres or 10 percent of the field. Soil Erosion Kw factors for specific soil map units are available in Soil Survey publications and from the NRCS Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/.

Organic P - For P sources such as manure, compost, biosolids or other organic amendments, the risk-assessment erosion rate is the **annual** soil loss rate for the year of organic P application expressed as tons per acre (tons/ac).

Inorganic P - For P sources such as dry inorganic fertilizers, liquid phosphoric acid solutions and rock phosphate, the risk-assessment erosion rate is the rotational **average annual** soil loss rate expressed as tons per acre (tons/ac). For years when both organic and inorganic P fertilizers are applied, use the annual soil loss rate for the year of organic P application.

Determine the RUSLE2 predicted soil loss rate for the identified soil map unit and then identify the rill and interrill erosion risk factor from Table 1b.

Table 1b. Rill and Interrill Erosion Risk Factor

Erosion Rate (tn/ac)	≤ 5	> 5 - 10	> 10 - 15	> 15
Risk Factor	**1**	**2**	**3**	**4**

Factor 1c. Wind Erosion - Irrigated and Non-Irrigated Sites

Wind erosion is the detachment and transport of soil particles including sediment P by saltation, suspension and surface creep. Saltation occurs when individual soil particles lift off the soil surface by wind and return, dislodging other soil particles. Suspension occurs when dislodged soil particles are small enough to remain airborne rather than falling back to the soil surface. Surface creep occurs when sand sized particles set in motion by saltation, move slowly or creep along the soil surface.

Wind erosion estimates are output from the Wind Erosion Prediction System (WEPS), as annual and rotational average annual tons of soil loss per acre per year.

Critical Dominant Soil - Fields often include several soil map units with different Soil Erosion Factors. To evaluate wind erosion, select the soil map unit with the highest Wind Erodibility Index Rating that is of a manageable size, 10 acres or 10 percent of the field. Soil Erosion Factors for specific soils including the Wind Erodibility Index Rating are available in Soil Survey publications and from the NRCS Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/.

Organic P - For P sources such as manure, compost, biosolids or other organic amendments, the risk-assessment erosion rate is the **annual** soil loss rate for the year of organic P application expressed as tons per acre (tn/ac).

Inorganic P - For P sources such as dry inorganic fertilizers, liquid phosphoric acid solutions and rock phosphate, the risk-assessment erosion rate is the rotational **average annual** soil loss rate expressed as tons per acre (tn/ac). For years when both organic and inorganic P fertilizers are applied, use the annual soil loss rate for the year of organic P application.

Determine the WEPS predicted soil loss rate for the Critical Dominant soil map unit and then identify the wind erosion risk factor from Table 1c.

Table 1c. Wind Erosion Risk

Erosion Rate (tn/ac)	≤ 5	> 5 - 10	> 10 - 15	> 15
Risk Factor	**1**	**2**	**3**	**4**

Factor 2. Soil Test P

Different Soil Test P extractants are appropriate for different pH soils. The Bray P1 extractant is for acidic or low pH soils. The Olsen and AB-DTPA extractants are for soils with a pH greater than 7.0 that contain calcium carbonate. The Mehlich 3 extractant is appropriate for both low and high pH soils.

An appropriate sampling depth for soil test phosphorus for continuous no-till cropland, hayland and pastures is 2 to 3 inches. For tilled cropland, the recommended sampling depth is the depth of tillage.

Table 2. Soil Test P (STP) Risk Factor

P Extractant	**STP Concentration, parts per million (ppm)**			
AB-DTPA	< 10	10-20	21-40	> 40
Olsen ($NaHCO_3$)	< 20	20-40	41-80	> 80
Bray P1	< 30	30-60	61-120	> 120
Mehlich 3	< 40	40-100	101-200	> 200
Risk Factor	**1**	**2**	**3**	**4**

Factor 3. P Application Rate

The P application rate is the amount of phosphate (P_2O_5) applied to a field in pounds per acre (lb/ac). It includes all sources, both inorganic and organic fertilizers.

Calculate the planned P_2O_5 application rate in pounds per acre (lb/ac) from all sources, and then refer to Table 3 to determine the P Application Rate Risk.

Table 3. P Application Rate Risk

P_2O_5 Application Rate (lb/ac)	< 50	51 - 100	101 - 200	> 200
Risk Factor	**1**	**2**	**3**	**4**

Factor 4. P Application Method and Timing

The manner in which phosphorus is applied and the amount of time it is exposed on the soil surface impact potential phosphorus losses. Incorporation implies mixing the phosphorus into the soil to a minimum depth of two to three inches. The categories of increasing severity, Low to Very High, depict the longer surface exposure time between phosphorus application, incorporation and crop utilization.

Additionally, the risk of irrigation overland flow losses from topdress P applications made to surface or flood irrigated pasture and hayland is Very High when spring applied immediately prior to the first irrigation, and High when fall applied. Effluent P applied through a sprinkler at a rate that does not exceed the infiltration rate of the soil is a Medium risk.

For multiple P applications, select the highest applicable application method and timing risk rating.

Table 4. Phosphorus Application Method and Timing Risk

P Application Method	None Applied, or P is Banded, Injected or Subsurface Applied	Spring Applied and Incorporated within 2 weeks, or Sprinkler Applied	Fall/Winter Applied and Incorporated within 2 weeks, or Fall Topdress (Pasture, Hayland, Notill Cropland)	Spring Applied with No Incorporation, includes Spring Topdress (Pasture, Hayland, Notill Cropland)
Risk Factor	**1**	**2**	**3**	**4**

Factor 5. Best Management Practice (BMP) and Mitigation Credits

Planning and application of certain BMPs and mitigation can decrease the potential for off-site P movement. To take a credit, subtract one point from the gross score for each of the following BMPs or mitigation that is applicable to the field.

- **Cover Crop** - Planted after harvest or crop failure to utilize excess nutrients
- **Constructed Wetland** - Created down slope from irrigated cropland to collect and assimilate runoff and nutrients
- **Diversion** - A grass channel constructed across the slope, uphill of a tilled field, to divert excess water to areas where it can be managed properly
- **Grassed Waterways** - Installed to convey runoff and decrease erosion
- **Irrigation Tailwater Recovery System** - To collect, store and transport irrigation tailwater for reuse
- **Linear Polyacrylamide or PAM** - For use with flood or furrow systems to decrease irrigation-induced erosion
- **Sediment Control Basin** - Basins constructed to collect runoff and trap sediments
- **Soil Test Free Lime** - The amount of soil test free lime ($CaCO_3$) is equal to or greater than 4 percent

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Colorado Phosphorus Index Risk Assessment, Version 5

Cooperator _____ Tract/Field No. _____ Crop Year _____

1. P Transport - Enter the higher of the risk factors for 1a and 1c (irrigated), or 1b and 1c (nonirrigated)…….... ☐

1a. Index Surface Runoff (irrigated)

	Saturated Hydraulic Conductivity µm s^{-1} (in hr^{-1})					
	Very High ≥100 (≥ 14)	High <100-10 (<14-1.4)	Medium High <10.0-1.0 (<1.4-.14)	Medium Low <1.0-0.1 (<.14-.014)	Low <0.1-0.01 (<.014-.0014)	Very Low <0.01 (<.0014)
Slope %	Risk Factor					
< 1	1	1	1	1	2	3
1-5	1	1	1	2	3	4
5-10	1	1	2	3	4	4
10-20	1	1	2	3	4	4
> 20	1	2	3	4	4	4

1b. Rill and Interrill Erosion (nonirrigated)

Erosion Rate (tn/ac)	≤ 5	> 5 - 10	> 10 - 15	> 15
Risk Factor	1	2	3	4

1c. Wind Erosion (irrigated and nonirrigated)

Erosion Rate (tn/ac)	≤ 5	> 5 - 10	> 10 - 15	> 15
Risk Factor	1	2	3	4

2. Soil Test P (STP)…… ☐

P Extractant	STP Concentration, parts per million (ppm)			
AB-DTPA	< 10	10-20	21-40	> 40
Olsen ($NaHCO_3$)	< 20	20-40	41-80	> 80
Bray P1	< 30	30-60	61-120	> 120
Mehlich 3	< 40	40-100	101-200	> 200
Risk Factor	1	2	3	4

3. P Application Rate ……. ☐

P_2O_5 Application Rate (lb/ac)	< 50	51 - 100	101 - 200	> 200
Risk Factor	1	2	3	4

4. P Application Method and Timing…….. ☐

P Application Method and Timing	None Applied, or P is Banded, Injected or Subsurface Applied	Spring Applied and Incorporated within 2 weeks, or Sprinkler Applied	Fall/Winter Applied and Incorporated within 2 weeks, or Fall Topdress (Pasture, Hayland, Notill Cropland)	Spring Applied with No Incorporation, includes Spring Topdress (Pasture, Hayland, Notill Cropland)
Risk Factor	1	2	3	4

5. BMP/Mitigation Credits - Subtract 1 point (enter **-1**) for each of the following that apply to this field/crop year:…. ☐
Cover Crop to recover excess nutrients; **Constructed Wetland** to collect and assimilate runoff and nutrients; **Diversion** to manage excess water ; **Grassed Waterway** to convey runoff; **Irrigation Tailwater Recovery System** to collect irrigation tailwater for reuse; **Linear Polyacrylamide (PAM)** applied to decrease erosion; **Sediment Control Basin** constructed to collect runoff and trap sediment; **Soil Test Free Lime** > 4%

Sum of Risk Factors 1 - 5…….. ☐

Colorado Phosphorus Index Risk Assessment Interpretations

4 - 11 **Low** - Organic P application rate may exceed the crop P requirement if the application rate does not exceed the N requirement for the next crop (includes applications to meet multiple year crop P requirements).

12 - 13 **Medium** - P application rate is restricted to the crop P requirement for the next crop.

14 - 15 **High** - P application rate is restricted to crop P removal for the next crop if a P draw-down strategy is implemented for the crop rotation (rotational P application rate is less than rotational crop P removal).

16 **Very High** - Do not apply P to this field until the risk of P movement off-site is decreased.

Prepared by_____ Date _____