APPENDIX A
Environmental Stewardship Assessment: Phosphorus Index

The goal of this assessment tool is to help you confidentially evaluate the risk of P loss from farm fields. The first step in this process is to consult Part A. Screening Tool. The screening tool is intended to reduce your potential workload by easily identifying those fields at greatest risk of P loss.

Part A. Screening tool

Table 34A-1. The P Indexing approach using Pennsylvania's 2002 Index version as an example.

Evaluation category		
Soil test P	> 200 mg P kg^{-1}	If yes to either factor, then proceed to Part B.
Contributing distance	< 150 ft	

Part B. Transport factors (Refer to Tables 34A-2 and -3.)

For each contributing transport factor listed (left column, Table 34A-3), identify the appropriate risk level or complete the calculation (center column, Table 34A-3) and enter the result into the Risk Value column (right column, Table 34A-3).

1. Soil erosion: The calculated soil erosion, using RUSLE, taken directly from a conservation plan. If a conservation plan is not available, soil erosion can be calculated using RUSLE 1.06c, documented at http://www.sedlab.olemiss.edu/rusle1new/description106.html. Description: RUSLE1.06c uses an index method to estimate soil erosion. It uses factors that represent how climate, soil, topography, and land use affect rill and interrill (sheet and rill) soil erosion caused by raindrop impact and surface runoff. In general, erosion depends on the amount and intensity of rainfall and runoff, protective cover provided by land use, susceptibility of soil to erosion as a function of intrinsic soil properties and soil properties modified by land use, and the topography of the landscape as described by slope length, steepness, and shape.

These influences are described in RUSLE1.06c with the equation:

$$A = R\ K\ L\ S\ C\ P$$

where: A = Average annual soil loss (tons/acre), R = K = Soil erodibility factor, L = Slope length factor, S = Slope steepness factor, C = Cover-management factor, and P = Support practices factor. A soil loss (erosion rate) in tons per acre per year is computed by substituting values for each RUSLE1.06c factor to represent conditions at a specific site. RUSLE1.06c is based primarily on the analysis of a large mass of experimental data and uses equations based on fundamental erosion processes so that it can be applied to situations where experimental data are inadequate to define RUSLE1.06c factor values.

K factor: The K factor is an empirical measure of soil erodibility as affected by intrinsic soil properties. Erosion measurements based on unit plot conditions are used to experimentally determine values for K.

R factor: The R factor represents the erosivity of the climate at a particular location. An average annual value of R is determined from historical weather records and is the average annual sum of the erosivity of individual storms. The erosivity of an individual storm is computed as the product of the storm's total energy, which is closely related to storm amount, and the storm's maximum 30-minute intensity.

LS factor: The L and S factors jointly represent the effect of slope length, steepness, and shape on sediment production. RUSLE1.06c estimates the total of rill and interrill erosion combined. Rill erosion is primarily caused by surface runoff and increases in a downslope direction because runoff increases in a downslope direction. Interrill erosion is caused primarily by raindrop impact and is uniform along a slope. Therefore, the influence of slope length, which is represented by the L factor, is greater for those conditions where rill erosion is greater than interrill erosion.

C factor: The C factor for the effects of cover management, along with the P factor, is one of the most important factors in RUSLE1.06c because it represents the effect of land use on erosion. It is the most easily changed single

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factor and is the factor most often considered in developing an erosion control plan. For example, the C factor describes how vegetation, tillage systems, and addition of mulches affect soil loss.

P factor: The support practice P factor describes how practices such as contouring, strip cropping, concave slopes, terraces, sediment basins, grass hedges, silt fences, straw bales, and subsurface drainage affect rill and interrill erosion. These practices are applied to support the basic cultural practices used to control erosion, such as vegetation, cover management system, and mulch additions that are represented by the C factor.

2. Runoff potential: Based on the soil type and can be determined using tables provided by USDA-NRCS regional nutrient management coordinators.

Estimation: Runoff potential class is estimated by using Table 34A-2. This table uses a combination of surface slope and the saturated hydraulic conductivity (Ksat) representative value (RV) of the upper 1.0 m of soil material including bedrock or other restrictive material as criteria. Determine the minimum Ksat of the upper 1.0 meter of material. If that minimum Ksat is at or above 0.5 m, use the following table as shown. If the minimum Ksat of the upper 1 m of material occurs between 0.5 and 1.0 m, use the following table but reduce the runoff by one runoff class (for example, from medium to low). For soils with seasonal free water within 50 cm of the soil surface, use a Ksat of <0.01 ¼m s^{-1} in the table.
The concept indicates relative runoff for very specific conditions: (1) The soil surface is assumed to be bare and surface water retention due to irregularities in the ground surface is low. (2) Steady ponded infiltration rate is the applicable infiltration stage. (3) Ice is assumed to be absent unless otherwise indicated. (4) Both the maximum bulk density in the upper 25 cm and the bulk density of the uppermost few centimeters are assumed within the limits specified for the mapping concept. (5) The concept assumes a standard storm or amount of water addition from snowmelt of 50 mm in a 24-hour period with no more than 25 mm in any single 1-hour period. (6) The soil moisture state is assumed to be very moist or wet to the base of the soil, to 0.5 m, or through the horizon or layer with minimum Ksat within 1.0 m, whichever is the greatest depth.

Table 34A-2. Surface runoff potential classes as a function of soil slope and saturated hydraulic conductivity.

Surface runoff potential classes						
Slope percentage	Saturated hydraulic conductivity (¼m s^{-1}), Ksat					
	e•100	< 100-10	< 10-1.0	< 1.0-0.1	< 0.1-0.01	< 0.01
Concave	N	N	N	N	N	N
< 1	N	N	N	L	M	H
1 - 5	N	LV	L	M	H	HV
5 - 10	LV	L	M	H	HV	HV
10 - 20	LV	L	M	H	HV	HV
e•20	L	M	H	HV	HV	HV

Abbreviations: Negligible-N, Very low-LV, Low-L, Medium-M, High-H, and Very high-HV.

Adapted from USDA-NRCS, 2003. *National Soil Survey Handbook*, Title 430-VI. Available online at http://soils.usda.gov/technical/handbook/.

3. Subsurface drainage: Based on whether there is artificial drainage in the field or if the field is near a stream and has rapidly permeable soils. “Random” drainage is a single or a few tile lines in a field, and “Patterned” drainage is when most or the entire field is drained with a fill patterned drainage system.

4. Leaching potential: Based on soil texture
- Low potential–Clay, sandy clay, silty clay, and silty clay loam
- Medium potential–Loam, silt loam, and silt
- High potential–Sandy loam, loamy sand, and sand

5. Contributing distance: The contributing distance to a stream or other water body from the lower edge of the field. Choose the distance category in the P Index that contains the majority of the lower edge of the field.

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6. Modified connectivity: Accounts for management practices that modify P transport.
   - If the field is within 150 ft of water and a riparian buffer is present, select the appropriate Modified connectivity factor (that is, reduces transport value).
   - If a field is more than 150 ft from water but a direct connection, such as a pipe or ditch from field to water, is present, select appropriate Modified connectivity factor (that is, increases transport value).

The transport factor is determined by first adding the transport factors together to get the transport sum, next multiplying by the Modified connectivity, and then dividing by 24.

Table 34A-3. Transport factors.

Characteristics	**Risk levels**					**Risk value**
Soil erosion	Risk value = Annual soil loss = ___________ tons/acre/year					
Runoff potential	Very low **0**	Low **1**	Medium **2**	High **4**	Very high **8**	
Subsurface drainage	None **0**		Random **1**		Patterned** **2**	
Leaching potential	Low **0**		Medium **2**	High **4**		
Contributing distance	> 500 ft **0**	500 to 350 ft **1**	350 to 250 ft **2**	150 to 250 ft **4**	< 150 ft **8**	
Transport sum = Erosion + Runoff potential + Subsurface drainage + Leaching potential + Contributing distance						
Modified connectivity	Riparian buffer *Applies to distances < 150 ft* **0.7**		Grassed waterway or None **1.0**		Direct connection *Applies to distances > 150 ft* **1.1**	
Transport factor = Transport s um x Modified connectivity/24						

**Or a rapidly permeable soil near a stream.

The transport value is divided by 24 (that is, the highest value obtainable) in order to normalize site transport to a value of 1, where full transport potential I realized.

Caution: Many states have a state-specific P Index. Although the principles of most P Index tools are similar, individual factors or weightings of those factors varies among states. If available, review your own state's P Index. For more specific information on the various indices adopted by various states, see Sharpley et al. 2003.

Part C. Source and site factors (Refer to Tables 34A-4 and -5.)

1. Soil test P: The soil test level is taken from a soil test report as either ppm (multiplied by 0.20 for the Risk Value) or lbs P_2O_5/acre (multiplied by 0.05 for the Risk Value). A coefficient of 0.20 or 0.05 is used to convert soil test P to a value that directly relates to the risk of P loss in surface runoff from P in manure and mineral fertilizers. This conversion is based on field data that show a fivefold greater concentration of dissolved P in surface runoff with an increase in mineral fertilizer or manure addition compared to an equivalent increase in soil test P (as Mehlich-3 extractable soil P).

2. Fertilizer P risk is the product of
   - The Fertilizer P Rate (amount of chemical fertilizer P being applied to the field in lbs P_2O_5/acre).
   - The Loss Rating for P application (reflects the timing and method of application).

3. Manure P Risk is the product of
   - The Manure P Rate (amount of chemical fertilizer P being applied to the field in lbs P_2O_5/acre).
   - The Loss Rating for P application (reflects the timing and method of application).
   - Manure P Availability Coefficient (reflects the availability of P in manure or biosolid to be released to surface runoff). This coefficient is greatly affected by manure or biosolid treatment, such as alum addition to poultry manure and litter, and can be determined using Table 34A-4.

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Table 34A-4. Organic P source availability coefficients.
Updates on these coefficients can be checked at http://panutrientmgmt.cas.psu.edu/.

Swine	
Swine slurry	1.0
Poultry	
Broiler	0.8
Layer	0.9
Turkey	0.9
Duck	0.9
Dairy	
Liquid	0.9
Bedded pack	0.8
Beef	0.8
Alum treated	0.5
Biosolids	
Biological nutrient removal	0.8
Alkaline stabilized	0.4
Conventionally stabilized	0.3
Composted	0.3
Heat-dried	0.2
Advanced-alkaline stabilized	0.2

Table 34A-5. Phosphorus loss potential due to source and site management factors in the P index.

Contributing factors	Risk levels					Risk value
	Very low	Low	Medium	High	Very high	
Soil test P risk	Risk value = soil test P (ppm) x 0.20 = ______ ppm x 0.20 = **OR** Risk value = Soil test P (lbs P_2O_5/acre) x 0.05 = ______ lbs P_2O_5/acre x 0.05 =					
Loss rating for P application method and timing	Placed with plant-er or injected more than 2" deep **0.2**	Incorporated < 1 wk after application **0.4**	Incorporated > 1 wk or not incorporated > 1 following application in spring-summer **0.6**	Incorporated > 1 wk or not incorporated following application in autumn – winter **0.8**	Surface applied on frozen or snow-covered soil **1.0**	
Fertilizer P risk	Risk value = Fertilizer P application rate x Loss rating for P application = Risk value = ______ lbs P_2O_5/acre x ______ =					
Manure P availability	Refer to Table 34A -4. Organic P source availability coefficients.					
Manure P risk	Risk value = Manure P application rate x Loss rating for P application x P availability coefficient = Risk value = ______ lbs P_2O_5/acre x ______ x ______ =					
Total of management risk factors	**Sum of management factors =**					

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To solve for the P Index,

1. Sum all numbers in Part B (Table 34A-3 and divide by 24) and all numbers in Part C (Table 34A-5).
2. Write these numbers in the worksheet below.
3. Multiply Part B by Part C by 2. The factor of 2 normalizes the final Index rating to 100. This is your fine P Index rating.
4. Look up Interpretation of P Index risk in Table 34A-6 below.

Field	Part A Transport risk	Part C Management risk	P Index B x C	Interpretation of the P index
Example	*0.55*	*92*	*101*	*Very high*

Table 34A-6. General interpretations and management guidance for the P Index.

P Index Value	Rating	General Interpretation	Management Guidance
< 59	Low	If current farming practices are maintained, there is a low risk of adverse impacts on surface waters.	N-based applications
60 - 79	Medium	Chance of adverse impacts on surface waters exists, and some remediation should be taken to minimize P loss.	N-based applications
80 - 100	High	Adverse impact on surface waters. Conservation measures and P management plan are needed to minimize P loss.	P application limited to crop removal of P
> 100	Very high	Adverse impact on surface waters. All necessary conservation measures and P management plan must be implemented to minimize P loss.	No P applied

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