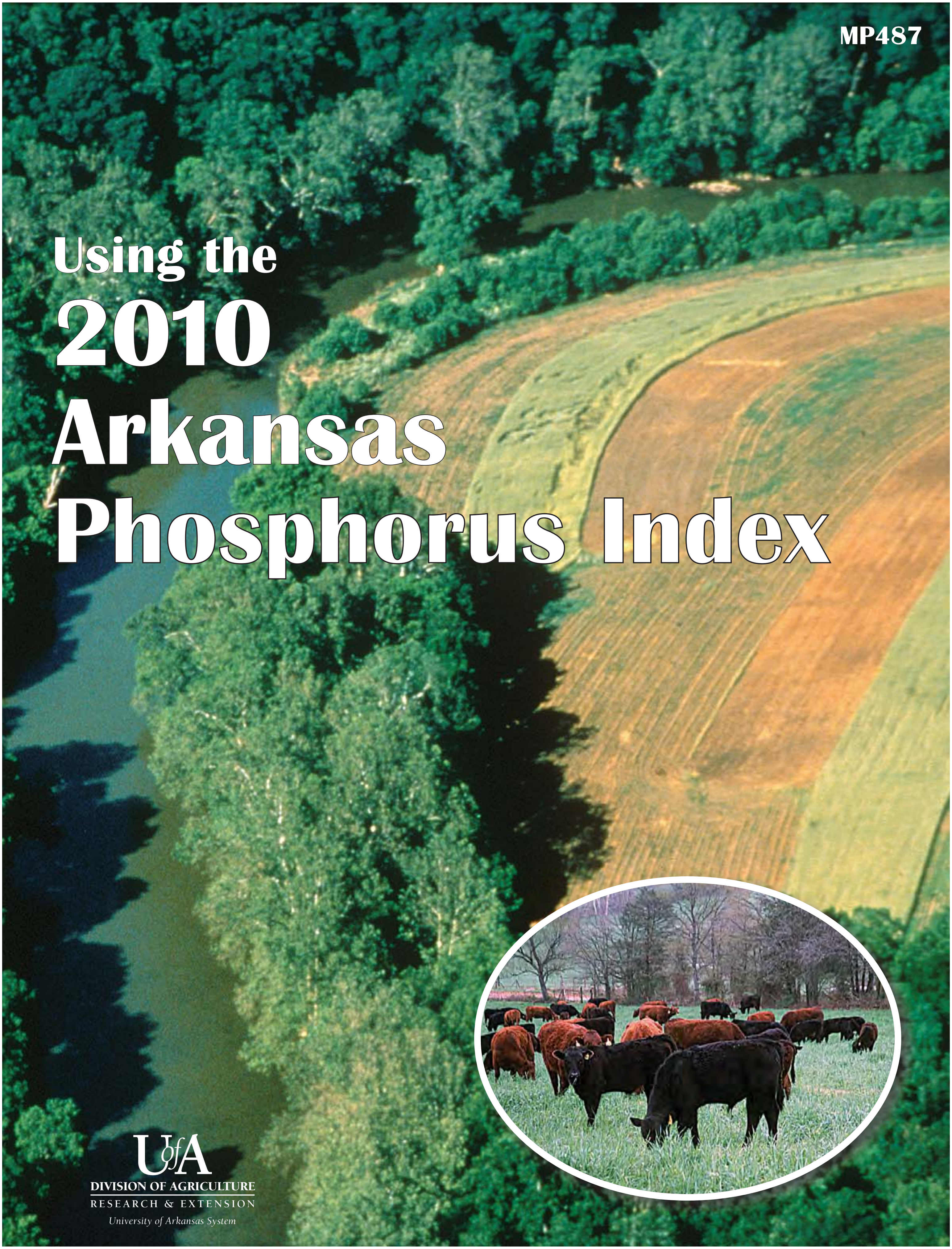
MP487

Using the 2010 Arkansas Phosphorus Index



DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

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Using the 2010 Arkansas Phosphorus Index

Introduction

On January 1, 2010, the Arkansas Natural Resources Commission (ANRC) adopted a revised Arkansas P Index (API). ANRC requires the use of the API to prepare nutrient management plans in those watersheds which Title XXII designates as Nutrient Surplus Areas. The USDA Natural Resources Conservation Service (NRCS) has also adopted the API as part of the 590 nutrient management planning conservation practice standard. As nutrient management plans (NMPs) are required by several regulations pertaining to the application of manure, participation in certain cost-share programs and many integrator contracts, most land application of manure is usually associated with the API and a nutrient management plan.

The API assesses the risk of phosphorus (P) loss in runoff from pastures and hayland as a function of source potential (i.e., P from the soil and manure application), transport potential (i.e., risk P movement offsite as affected by runoff and erosion, field slope, grazing intensity and proximity to streams) and any additional best management practices (BMPs) implemented between the application site and potential receiving waters. As a result, for a specific set of field conditions, the API associates a P runoff risk value to a specific manure or biosolids application rate. The classification of this value into a risk range determines if the application is environmentally acceptable. If acceptable, the nutrient management plan specifies this application rate as the maximum rate for the combination of P source and field in question. During the implementation of a nutrient management plan, application rates up to the specified maximum can be applied. Lower rates are generally considered to be associated with lower environmental P runoff risk and therefore also acceptable. This publication describes the API and how to interpret the assigned risk and provides example calculations.

The Phosphorus Index

The API addresses seven site characteristics which are grouped into either Source or Transport Factors. The P Source Factors are (1) soil test P and (2) soluble P application rate. The P Transport Factors include (3) soil erosion, (4) soil runoff class, (5) flooding frequency, (6) application method and (7) timing of P application. In addition to management practices that influence site characteristics, there are nine additional BMPs that can be considered to reduce P runoff risk. The landowner has the option to implement a combination of diversions, terraces, ponds, filter strips, grassed waterways, paddock fencing, riparian forest buffers, riparian herbaceous buffers and field borders to meet his or her conditions and preferences.

The API is calculated as:

$$\text{P Index} = [(\text{P Source Potential} * \text{P Transport Potential} * \text{BMPs Multiplier}) / 1.8] * 100 \qquad \textit{[Eq. 1]}$$

The product of the P Source Potential, P Transport Potential and BMPs Multiplier is divided by 1.8 and then multiplied by 100 to express the risk value on a 100-point scale to facilitate interpretation. Prior to calculating the overall P Index value, each of its components must be calculated separately as indicated below.

Calculating the P Source Potential

As previously indicated, the P Source Potential considers both the soil and the material applied as potential P sources (equation 2).

$$\text{P Source Potential} = \{WEP_{coef} * [WEP + MNRL_{coef} * (TP - WEP)]\} + \{STP_{coef} * STP\} \qquad \textit{[Eq. 2]}$$

STP is soil test P (lbs/acre) as determined by the Mehlich-3 extraction method for a 0-4 inch soil sample (see FSA1035, *Soil Testing for Manure Management*, and FSA2121, *Test Your Soil for Plant Food and Lime Needs,* for proper soil sampling procedures). Input values of STP in lbs P/acre are determined by multiplying soil test report values in parts per million (ppm) by 1.33 for a standard 4-inch soil sample.

WEP is water extractable P applied (lbs WEP/acre) as manure or biosolids. This value is calculated as the WEP concentration of the material being applied times the amount of material being applied. For example, broiler litter with a WEP concentration of 5 lbs/ton applied at a rate of 1.5 tons/acre would result in 7.5 lbs/acre WEP application.

TP is the total amount of P applied (lbs P/acre) as manure or biosolids. This value is calculated as the TP concentration of the material being applied times the amount of material being applied. For example, broiler litter with a total P concentration of 25 lbs P/ton applied at a rate of 1.5 tons/acre would result in 37.5 lbs P/acre of total P application. Multiplying 37.5 by 2.29 results in 86 lbs P_2O_5 /acre total P application.

$MNRL_{coef}$ is a factor accounting for the continued but slow release of P from manure or biosolid after land application, which can contribute additional P in runoff. MNRL is 0.05 (5% of non-WEP total P) for untreated material and 0.005 (0.5% of non-WEP total P) for alum-treated materials. The intention of treating with alum (aluminum sulfate) is to bind up the soluble P in the litter or manure and therefore reduce the P runoff risk.

WEP_{coef} is a research-derived multiplier that correlates to the potential for land-applied materials to release P to runoff; it is 0.095 for poultry litter, 0.031 for liquid manure, 0.058 for biosolid cake and 0.029 for liquid biosolids.

STP_{coef} is a research-derived multiplier of 0.0018, which describes the fraction of STP that will likely result in runoff P.

Calculating the P Transport Potential

The P Transport Potential is calculated as the sum of the loss rating value for soil erosion, soil runoff class, flooding frequency, application method and application timing. Each of these factors is divided into subclasses where each class is associated with a loss rating value (Table 1). When calculating the P Transport Potential, each site is evaluated in terms of the various factors and the appropriate loss rating values assigned, then summed to estimate the total P Transport Potential. Larger P Transport Potential values indicate greater P runoff risk than lower values.

Soil Erosion as estimated by RUSLE2. Well-managed pasture systems would be expected to have erosion rates less than one ton/acre/year, hence the loss rating value for erosion is typically zero.

Soil Runoff Class is determined from the Runoff Curve Number and Soil Runoff Class tables (Tables 2 and 3). To use these tables, the planned Pasture Management, Soil Hydrologic Group and representative Soil Slope are needed. This information is determined from a combination of NRCS soil classification and survey information (available at http://soildatamart.nrcs.usda.gov and http://websoilsurvey.nrcs.usda.gov), landowner interviews and site visits. In practice, the planned Pasture Management and Soil Hydrologic Group provide the Runoff Curve Number from Table 2. The Runoff Curve Number and Soil Slope provide the Soil Runoff Class from Table 3. The Soil Runoff Class provides the Soil Runoff Class loss rating value from Table 1.

Flooding Frequency falls into four categories: none to very rare, rare, occasional and frequent as classified by NRCS soil classification/survey information (available at http://soildatamart.nrcs.usda.gov and http://websoilsurvey.nrcs.usda.gov). Flooding frequency is used as a surrogate for proximity of a field to a stream and assumes that the potential for runoff from a field to enter a stream increases as its flooding frequency increases.

Table 1. P Transport Potential Loss Rating Values

<table>
<tr><th>Factor</th><th colspan="8">Rating</th></tr>
<tr><td>Soil erosion (tons/acre/year)</td><td><1</td><td colspan="3">1 to 2</td><td colspan="2">2 to 3</td><td>3 to 5</td><td>>5</td></tr>
<tr><td>Loss rating value</td><td>0</td><td colspan="3">0.1</td><td colspan="2">0.2</td><td>0.4</td><td>1.0</td></tr>
<tr><td>Soil runoff class</td><td>Negligible</td><td colspan="2">V. Low</td><td colspan="2">Low</td><td>Moderate</td><td>High</td><td>V. High</td></tr>
<tr><td>Loss rating value</td><td>0.1</td><td colspan="2">0.15</td><td colspan="2">0.2</td><td>0.5</td><td>1.0</td><td>1.5</td></tr>
<tr><td>Flooding frequency</td><td colspan="2">None to very rare</td><td colspan="2">Rare</td><td colspan="2">Occasional</td><td colspan="2">Frequent</td></tr>
<tr><td>Loss rating value</td><td colspan="2">0</td><td colspan="2">0.2</td><td colspan="2">0.5</td><td colspan="2">2.0</td></tr>
<tr><td>Application method</td><td colspan="2">Incorporated</td><td colspan="4">Surface applied</td><td colspan="2">Surface applied on frozen ground or snow</td></tr>
<tr><td>Loss rating value</td><td colspan="2">0.1</td><td colspan="4">0.2</td><td colspan="2">0.5</td></tr>
<tr><td>Application timing</td><td colspan="2">July-Oct.</td><td colspan="4">March-June</td><td colspan="2">Nov.-Feb.</td></tr>
<tr><td>Loss rating value</td><td colspan="2">0.1</td><td colspan="4">0.25</td><td colspan="2">0.6</td></tr>
<tr><td colspan="9">P Transport Potential = (soil erosion + runoff class + flooding frequency + application method + application timing)</td></tr>
</table>

Table 2. Runoff Curve Number

Pasture Management	Soil Hydrologic Group			
	A	B	C	D
Continuously grazed > 0.75 Animal Units/Acre	68	79	86	89
Continuously grazed < 0.75 Animal Units/Acre	49	69	79	84
Rotational Grazing	39	61	74	80
Hayland	30	58	71	78

Table 3. Soil Runoff Class

	Runoff Curve Number						
Slope %	<60	60-65	66-70	71-75	76-80	81-85	>85
<1	N	N	N	N	VL	VL	VL
1	N	N	VL	VL	VL	L	L
2	N	VL	VL	VL	L	L	M
3	N	VL	VL	L	L	M	M
4	N	VL	L	L	M	M	H
5	N	VL	L	L	M	M	H
6	N	VL	L	M	M	H	H
7	N	L	L	M	M	H	H
8	N	L	L	M	M	H	VH
9	N	L	L	M	H	H	VH
10	N	L	M	M	H	H	VH
11	N	L	M	M	H	H	VH
12	N	L	M	M	H	VH	VH
13	N	L	M	M	H	VH	VH
14	N	L	M	H	H	VH	VH
15	N	L	M	H	H	VH	VH
>15	N	L	M	H	H	VH	VH

N = Negligible, VL = V. Low, L = Low, M = Moderate, H = High, VH = V. High

Application Method describes how manure or biosolids are land-applied with the choices of incorporated, surface applied or surface applied to frozen or snow-covered ground. It should be noted that surface application to frozen or snow-covered ground may not be an option, depending on which regulations may apply.

Application Timing is categorized into July-Oct, March-June and Nov-Feb, as a function of the propensity for rainfall and runoff to occur based on historical rainfall and stream flow data.

Calculating the Best Management Practices (BMPs) Multiplier

The presence of NRCS Conservation Practices or BMPs can decrease P runoff with varying degrees of effectiveness (Table 4). The multiplier associated with each BMP is calculated as one minus the effectiveness of the BMP implemented. The multiplier for all the BMPs implemented is the product of the multiplier for each BMP (Equation 3).

BMPs Multiplier = *[Eq. 3]*
(1 – Effectiveness 1) * (1 – Effectiveness 2) * (1 – Effectiveness n)

Effectiveness rating values from Table 4 are expressed as values between 0 and 1. Multiplier values will be between 0 and 1. If no additional BMPs are implemented, the BMPs Multiplier value will be 1.

If only a portion of the field drains to a particular BMP, the multiplier for that BMP should be reduced to reflect the fraction of the field that drains to it.

Table 4. Approved BMPs for Use in the Arkansas Phosphorus Index

Best Management Practice	CPS†	Effectiveness
Diversion	362	5%
Fencing	382	30%
Field borders	386	10%
Filter strip	393	20%
Fenced filter strip		30%
Grassed waterway	412	10%
Pond‡	378	20%
Fenced pond		30%
Riparian forest buffer	391	20%
Fenced riparian forest buffer		35%
Riparian herbaceous cover	390	20%
Fenced riparian herbaceous cover		30%
Terrace	600	10%

† CPS is the NRCS Conservation Practice Standard; see http://www.nrcs.usda.gov/technical/Standards/nhcp.html

‡ The effectiveness rating for any given pond will depend on how much of field drains into the pond. Nutrient management plan writers must make a professional judgment on percentage of a field that drains into pond based on topographic maps and site visits. The assigned effectiveness is adjusted by that percentage.

Professional judgment based on available maps and site visits should normally be sufficient to guide decisions regarding the modification of the multiplier.

Risk Interpretation

After a P Index value is determined from Equation 1, fields are assigned a P Index risk class of low, medium, high or very high based on the normalized risk value (Table 5). Each class is associated with interpretations and recommendations. Recommendations range from cautions regarding buildup of STP levels for the low risk class to no additional P applications until the API rating is reduced from the very high class. While the API does not address environmental concerns associated with N applications, application rates should never exceed the crops' N requirement after N storage and application losses are considered. Although most nutrient management plans will be written for a five-year period, plans for fields receiving biosolids (sewage sludge) will only be valid for one year.

Table 5. Interpretation and Recommendations for the Arkansas P Index

P Index Value	Site Interpretations and Recommendations
Low < 33	Caution against long-term buildup of P in the soil.
Medium 33-66	Evaluate the Index and determine any field areas that could cause long-term concerns. Consider adding BMPs.
High 67-100	Reduce litter application rate and re-run PI until the P index is in the Medium range.
Very High > 100	No P application. Add BMPs to decrease this value below the Very High class in the short term and develop a conservation plan that would reduce the API value to a lower risk category, with a long-tem goal of a value in the Medium class or lower.

Using the Index

Several scenarios are presented below to demonstrate how the API works and how BMPs can reduce the risk of P loss as a function of the API. Obviously, these scenarios do not cover all eventualities but are meant to show the flexibility of management options resulting from an API assessment. Further, the concepts of a split-litter application (spring and fall) and manure-nutrient banking are presented. For Scenarios 2 to 5, the source and transport variables changing from the previous scenario are in red type for ease of comparison.

Scenario 1 – In this scenario, STP is 100 lbs/acre, litter is surfaced applied at 1.5 tons/acre in September, litter WEP is 5 lbs P/ton, litter total P is 25 lbs P/acre, soil erosion is negligible, runoff class is negligible (Soil Hydrologic Group C, Rotational Grazing, RCN 74, Slope <1%), no flooding occurs and there are no BMPs in place.

Scenario 2 – In this scenario, STP is 500 lbs/acre, litter is surface applied at 1.5 tons/acre in April, litter WEP is 5 lbs P/ton, litter total P is 25 lbs/ton, soil erosion is negligible, runoff class is moderate (Soil Hydrologic Group C, Rotational Grazing, RCN 74, Slope 6%), no flooding occurs and there are no BMPs.

Scenario 3 – In this scenario, STP is 500 lbs/acre, litter is surface applied at 1.5 tons/acre in April, litter WEP is 5 lbs P/ton, litter total P is 25 lbs/ton, soil erosion is negligible, runoff class is moderate (Soil Hydrologic Group C, Rotational Grazing, RCN 74, Slope 6%), no flooding occurs, there is a riparian herbaceous buffer and 50% of the field's runoff enters a pond.

Scenario 4 – In this scenario, STP is 500 lbs/acre, litter is surface applied at 1.5 tons/acre in April, litter WEP is 5 lbs P/ton, litter total P is 25 lbs P/ton, soil erosion is negligible, runoff class is high (Soil Hydrologic Group C, RCN 86 continuous grazing at >0.75 animal units/acre, Slope 6%), no flooding occurs and there is a fenced riparian herbaceous buffer.

Scenario 5 – Split application of litter: For split applications the API is calculated three times to estimate the P runoff risk associated with soil only (WEP = 0, TP = 0, Application Timing same as higher risk application timing window), first litter application only (STP = 0) and second litter application only (STP = 0). The three values are then summed to estimate the total P runoff risk.

In this scenario, STP is 50 lbs/acre, litter is surface applied at 1.5 tons/acre in April and again in September, litter WEP is 5 lbs P/ton, litter total P is 25 lbs P/ton, soil erosion is negligible, runoff class is negligible (Soil Hydrologic Group C, Rotational Grazing, RCN 74, Slope <1%), no flooding occurs and there is a fenced riparian herbaceous buffer.

Scenario 6 – Manure Nutrient Banking – When the P Index value is classified as high or lower and the application rate used to calculate this value is no more than 1 ton/acre, or 300 gallons/acre, manure banking can be considered. Manure banking is typically applying twice the volume of manure every other year. In the off-year(s), no application of P is made. The intent is to allow farm management options that include practical nutrient applications with acceptable uniformity, while addressing water quality concerns.

Scenario 1

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 100 lbs/acre	WEP = 5 lbs/ton * 1.5 tons/acre = 7.5 lbs WEP/acre	TP = 25 lbs/ton * 1.5 tons/acre = 37.5 lbs TP/acre					
P Source Potential = {0.095 * [7.5 + 0.05 * (37.5 – 7.5)]} + {0.0018 * 100}							**1.04**
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2	2 to 3	3 to 5	> 5		
Loss rating value	***0***	***0.1***	***0.2***	***0.4***	***1***		**0**
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	**0.1**
Flooding frequency	None to very rare	Rare	Occasional	Frequent			
Loss rating value	***0***	***0.2***	***0.5***	***2.0***			**0**
Application method	Incorporated	Surface applied	Surface applied on frozen ground or snow				
Loss rating value	***0.1***	***0.2***	***0.5***				**0.2**
Application timing	July-Oct.	March-June	Nov.-Feb.				
Loss rating value	***0.1***	***0.25***	***0.6***				**0.1**
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							**0.4**
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.0)							**1.0**
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(1.04 * 0.4 * 1.0) / 1.8] * 100							**23 (Low)**

Scenario 2

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [(WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 500 lbs P/acre	WEP = 5 lbs/ton * 1.5 tons/acre = 7.5 lbs WEP/acre	TP = 25 lbs/ton * 1.5 tons/acre = 37.5 lbs TP/acre					
P Source Potential = {0.095 * [7.5 + 0.05 * (37.5 – 7.5)]} + {0.0018 * 500}							**1.76**
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2	2 to 3	3 to 5	> 5		
Loss rating value	***0***	***0.1***	***0.2***	***0.4***	***1***		**0**
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	**0.5**
Flooding frequency	None to very rare	Rare	Occasional	Frequent			
Loss rating value	***0***	***0.2***	***0.5***	***2.0***			**0**
Application method	Incorporated	Surface applied	Surface applied on frozen ground or snow				
Loss rating value	***0.1***	***0.2***	***0.5***				**0.2**
Application timing	July-Oct.	March-June	Nov.-Feb.				
Loss rating value	***0.1***	***0.25***	***0.6***				**0.25**
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							**0.95**
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.0)							**1.0**
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(1.76 * 0.95 * 1.0) / 1.8] * 100							**93 (High)**

Scenario 3

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 500 lbs P/acre	WEP = 5 lbs/ton * 1.5 tons/acre = 7.5 lbs WEP/acre			TP = 25 lbs/ton * 1.5 tons/acre = 37.5 lbs TP /acre			
P Source Potential = {0.095 * [7.5 + 0.05 * (37.5 – 7.5)]} + {0.0018 * 500}							1.76
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2		2 to 3	3 to 5	> 5	
Loss rating value	***0***	***0.1***		***0.2***	***0.4***	***1***	0
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	0.5
Flooding frequency	None to very rare	Rare		Occasional	Frequent		
Loss rating value	***0***	***0.2***		***0.5***	***2.0***		0
Application method	Incorporated	Surface applied			Surface applied on frozen ground or snow		
Loss rating value	***0.1***	***0.2***			***0.5***		0.2
Application timing	July-Oct.	March-June			Nov.-Feb.		
Loss rating value	***0.1***	***0.25***			***0.6***		0.25
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							0.95
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 2.0) * (1 – 0.20 * 0.5)							0.72
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(1.76 * 0.95 * 0.72) / 1.8] * 100							**67 (High)**

Scenario 4

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 500 lbs P/acre	WEP = 5 lbs/ton * 1.5 tons/acre = 7.5 lbs WEP/acre			TP = 25 lbs/ton * 1.5 tons/acre = 37.5 lbs TP /acre			
P Source Potential = {0.095 * [7.5 + 0.05 * (37.5 – 7.5)]} + {0.0018 * 500}							1.76
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2		2 to 3	3 to 5	> 5	
Loss rating value	***0***	***0.1***		***0.2***	***0.4***	***1***	0
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	1.0
Flooding frequency	None to very rare	Rare		Occasional	Frequent		
Loss rating value	***0***	***0.2***		***0.5***	***2.0***		0
Application method	Incorporated	Surface applied			Surface applied on frozen ground or snow		
Loss rating value	***0.1***	***0.2***			***0.5***		0.2
Application timing	July-Oct.	March-June			Nov.-Feb.		
Loss rating value	***0.1***	***0.25***			***0.6***		0.25
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							1.45
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.7)							0.7
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(1.76 * 1.45 * 0.7) / 1.8] * 100							**99 (High)**

Scenario 5 – Part A. Soil Only Sub API

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 50 lbs/acre	WEP = 0 lbs/acre			TP = 0 lbs/acre			
P Source Potential = {0.095 * [0 + 0.05 * (0 – 0)]} + {0.0018 * 50}							0.09
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2	2 to 3	3 to 5	> 5		
Loss rating value	***0***	***0.1***	***0.2***	***0.4***	***1***		0
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	0.1
Flooding frequency	None to very rare	Rare	Occasional	Frequent			
Loss rating value	***0***	***0.2***	***0.5***	***2.0***			0
Application method	Incorporated	Surface applied	Surface applied on frozen ground or snow				
Loss rating value	***0.1***	***0.2***	***0.5***				0.2
Application timing	July-Oct.	March-June	Nov.-Feb.				
Loss rating value	***0.1***	***0.25***	***0.6***				0.25
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							0.55
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.3)							0.7
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(0.09 * 0.55 * 0.7) / 1.8] * 100							**2 (Low)**

Scenario 5 – Part B. April Application Only Sub API

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 0 lbs/acre	WEP = 5 lbs/ton * 1.5 tons/acre = 7.5 lbs WEP/acre			TP = 25 lbs/ton * 1.5 tons/acre = 37.5 lbs TP /acre			
P Source Potential = {0.095 * [7.5 + 0.05 * (37.5 – 7.5)]} + {0.0018 * 0}							0.86
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2	2 to 3	3 to 5	> 5		
Loss rating value	***0***	***0.1***	***0.2***	***0.4***	***1***		0
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	0.1
Flooding frequency	None to very rare	Rare	Occasional	Frequent			
Loss rating value	***0***	***0.2***	***0.5***	***2.0***			0
Application method	Incorporated	Surface applied	Surface applied on frozen ground or snow				
Loss rating value	***0.1***	***0.2***	***0.5***				0.2
Application timing	July-Oct.	March-June	Nov.-Feb.				
Loss rating value	***0.1***	***0.25***	***0.6***				0.25
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							0.55
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.3)							0.7
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(0.86 * 0.55 * 0.7) / 1.8] * 100							**18 (Low)**

Scenario 5 – Part C. September Application Only Sub API

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 0 lbs/acre	WEP = 5 lbs/ton * 1.5 tons/acre = 7.5 lbs WEP/acre			TP = 25 lbs/ton * 1.5 tons/acre = 37.5 lbs TP /acre			
P Source Potential = {0.095 * [7.5 + 0.05 * (37.5 – 7.5)]} + {0.0018 * 0}							**0.86**
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2		2 to 3	3 to 5	> 5	
Loss rating value	***0***	***0.1***		***0.2***	***0.4***	***1***	**0**
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	**0.1**
Flooding frequency	None to very rare	Rare		Occasional	Frequent		
Loss rating value	***0***	***0.2***		***0.5***	***2.0***		**0**
Application method	Incorporated	Surface applied			Surface applied on frozen ground or snow		
Loss rating value	***0.1***	***0.2***			***0.5***		**0.2**
Application timing	July-Oct.	March-June			Nov.-Feb.		
Loss rating value	***0.1***	***0.25***			***0.6***		**0.1**
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							**0.4**
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.3)							**0.7**
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(0.86 * 0.4 * 0.7) / 1.8] * 100							**13 (Low)**

Example 5. Calculating Total PI From Sub APIs A, B, C

	P Index Rating
Part A, Soil Only Sub PI	2 (Low)
Part B, April Application Only Sub PI	18 (Low)
Part C, September Application Only Sub PI	13 (Low)
Total P Index Rating	33 (Medium)

If banking is used, the application must occur in July, August, September or October. In all cases when an application is made, the agronomic N rate for year of application should not be exceeded. The average P Index value for the application and non-application years should be classified as low or medium.

In this scenario, STP is 500 lbs/acre. Initially the litter was to be surface applied at 1 ton/acre in September; litter WEP is 5 lbs P/ton, litter total P is 25 lbs P/ton, soil erosion is negligible, runoff class is moderate (Soil Hydrologic Group C, Rotational Grazing, RCN 74, Slope 6%), no flooding occurs and there is a riparian herbaceous buffer. The decision was made to apply 2 tons/acre every other year.

Summary

These scenarios demonstrate how the API functions. For example, with an increase in STP from 100 to 500 lbs P/acre with 1.5 tons litter applied in April rather than September, and with all other factors remaining the same, there is an increase in site risk from Low to High (i.e., Scenarios 1 and 2, respectively). However, having a herbaceous buffer in place and where half the field drains into a pond reduces the site risk from High to Medium (Scenarios 2 and 3, respectively). If that same field is continuously grazed with more than 0.75 AU/acre, the potential for runoff from that field increases to such an extent that the site risk value is elevated from Medium to High (i.e., Scenarios 3 and 4, respectively).

The benefit of a split application and manure-banking in certain cases is demonstrated in Scenarios 5 and 6, respectively. However, it must be recognized that the continual, long-term application of P above crop P removal rates will eventually elevate STP levels to an extent that alternatives to application may be needed. This is an integral part of the API and nutrient management planning process in general to educate farmers and applicators to the various options available to manage manures in ways that maintain pasture productivity and protect natural resources.

Scenario 6 – Part A. Initial 1 ton/acre API

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 500 lbs/acre	WEP = 5 lbs/ton * 1 ton/acre = 5 lbs WEP/acre			TP = 25 lbs/ton * 1 ton/acre = 25 lbs TP/acre			
P Source Potential = {0.095 * [5 + 0.05 * (25 - 5)]} + {0.0018 * 500}							1.47
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2		2 to 3	3 to 5	> 5	
Loss rating value	***0***	***0.1***		***0.2***	***0.4***	***1***	0
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	0.5
Flooding frequency	None to very rare	Rare	Occasional		Frequent		
Loss rating value	***0***	***0.2***	***0.5***		***2.0***		0
Application method	Incorporated	Surface applied			Surface applied on frozen ground or snow		
Loss rating value	***0.1***	***0.2***			***0.5***		0.2
Application timing	July-Oct.	March-June			Nov.-Feb.		
Loss rating value	***0.1***	***0.25***			***0.6***		0.1
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							0.8
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.2)							0.8
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(1.47 * 0.8 * 0.8) / 1.8] * 100							**52 (Medium)**

Scenario 6 – Part B. 2 tons/acre API

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 500 lbs/acre	WEP = 5 lbs/ton * 2 tons/acre = 10 lbs WEP/acre			TP = 25 lbs/ton * 2 tons/acre = 50 lbs TP /acre			
P Source Potential = {0.095 * [10 + 0.05 * (50 - 10)]} + {0.0018 * 500}							2.04
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2		2 to 3	3 to 5	> 5	
Loss rating value	***0***	***0.1***		***0.2***	***0.4***	***1***	0
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	0.5
Flooding frequency	None to very rare	Rare	Occasional		Frequent		
Loss rating value	***0***	***0.2***	***0.5***		***2.0***		0
Application method	Incorporated	Surface applied			Surface applied on frozen ground or snow		
Loss rating value	***0.1***	***0.2***			***0.5***		0.2
Application timing	July-Oct.	March-June			Nov.-Feb.		
Loss rating value	***0.1***	***0.25***			***0.6***		0.1
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							0.8
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.2)							0.8
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(2.04 * 0.8 * 0.8) / 1.8] * 100							**73 (High)**

Scenario 6 – Part C. 0 ton/acre API

Characteristic	Description						Rating
P Source Potential							
P Source Potential = {WEP_{coef} * [WEP + $MNRL_{coef}$ * (TP – WEP)]} + {STP_{coef} * STP}							
STP = 500 lbs/acre	WEP = 0 lbs/acre			TP = 0 lbs/acre			
P Source Potential = {0.095 * [0 + 0.05 * (0 - 0)]} + {0.0018 * 500}							0.9
P Transport Potential							
Soil erosion (tons/acre/yr)	< 1	1 to 2		2 to 3	3 to 5	> 5	
Loss rating value	***0***	***0.1***		***0.2***	***0.4***	***1***	0
Soil runoff class	Negligible	V. Low	Low	Moderate	High	V. High	
Loss rating value	***0.1***	***0.15***	***0.2***	***0.5***	***1.0***	***1.5***	0.5
Flooding frequency	None to very rare	Rare		Occasional	Frequent		
Loss rating value	***0***	***0.2***		***0.5***	***2.0***		0
Application method	Incorporated	Surface applied			Surface applied on frozen ground or snow		
Loss rating value	***0.1***	***0.2***			***0.5***		0.2
Application timing	July-Oct.	March-June			Nov.-Feb.		
Loss rating value	***0.1***	***0.25***			***0.6***		0.1
P Transport = (soil erosion + runoff class + flooding frequency + application method + application timing)							0.8
BMPs Multiplier							
BMPs Multiplier = (1 – Effectiveness 1) * (1 – Effectiveness 2) * … * (1 – Effectiveness n)							
BMPs Multiplier = (1 – 0.2)							0.8
P Index = [(P Source Potential * P Transport Potential * BMPs Multiplier) / 1.8] * 100							
P Index = [(0.9 * 0.8 * 0.8) / 1.8] * 100							32 (Medium)

Example 6. Calculating Total PI From Sub APIs A, B, C

	P Index Rating
Part A, Initial 1 ton/acre API	52 (Medium)
Part B, Application Year, 2 tons/acre API	73 (High)
Part C, Non-Application Year, 0 ton/acre API	32 (Medium)
Average of Application and Non-Application Years	53 (Medium)

BMP Descriptions

Diversion (Code 362)

A diversion is a channel constructed across the slope, generally with a supporting ridge on the lower side, in order to:

- Break up and intercept concentrated flows on long slopes, on undulating land surfaces and on land generally considered too flat or irregular for terracing.
- Divert water away from farmsteads, manure storage systems and other improvements.
- Collect or direct water for water-spreading or water-harvesting systems.
- Increase or decrease the drainage area above ponds.
- Protect terrace systems by diverting water from the top terrace where topography, land use or land ownership prevents terracing the land above.
- Divert water away from active gullies or critically eroding areas.

- Supplement water management on conservation cropping or strip cropping systems.

This applies to all cropland and other land uses where surface runoff water control and/or management are needed.

Fencing (Code 382)

Fencing is a constructed barrier to livestock, wildlife or people. This practice may be applied on any area where livestock and/or wildlife control is needed. Fences are not needed where natural barriers will serve the purpose. The practice may be applied as part of a management plan to facilitate application of conservation practices that treat soil, water, air and plant animal resource concerns.

Field Border (Code 386)

A field border is a strip of permanent vegetation established at the edge or around the perimeter of a field to:

- Reduce erosion and nutrients in runoff.
- Provide wildlife food and cover.

- Increase carbon storage.

This practice is applied around the perimeter of fields. Its use can support or connect other buffer practices within and between fields.

Filter Strip (Code 393)

A filter strip is a strip or area of herbaceous vegetation to:

- Reduce erosion and nutrients in runoff.

- Reduce dissolved nutrient loadings in runoff.
- Reduce suspended solids and associated nutrients in irrigation tailwater.

Grassed Waterway (Code 412)

A grassed waterway is a shaped or graded channel that is established with suitable vegetation to:

- Carry runoff water at a nonerosive velocity from terraces, diversions or other water concentrations without causing erosion or flooding.
- Reduce gully erosion.
- Protect/improve water quality.

Grassed waterways are used in areas where added water conveyance capacity and vegetative protection are needed to control erosion resulting from concentrated runoff.

Pond (Code 378)

A pond is a water impoundment made by constructing a dam or an embankment or by

excavating a pit or dugout. In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at spillway elevation is three feet or more. Ponds are designed to:

- Provide a trap for erosion and associated nutrient runoff.
- Provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying and other related uses.

Riparian Forest Buffer (Code 391)

A riparian forest buffer is an area of trees and shrubs located adjacent to streams, lakes, ponds or wetlands. Riparian forest buffers of sufficient width intercept sediment and nutrients in surface runoff and reduce nutrients in shallow subsurface water flow.

Woody vegetation in buffers provides food and cover for wildlife, helps lower water temperatures by shading the stream or waterbody and slows out-of-bank flood flows. In addition, the vegetation closest to the stream or waterbody provides litter fall and large wood important to fish and other aquatic organisms as a nutrient source and structural components to increase channel roughness and habitat complexity. Also, the woody roots increase the resistance of streambanks to erosion caused by high water flows or waves. Some tree and shrub species in a riparian forest buffer can be managed for timber, wood fiber and horticultural products.

Riparian Herbaceous Cover (Code 390)

Riparian herbaceous covers are grasses, sedges, rushes, ferns, legumes and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats.

This practice may be applied as part of a conservation management system to accomplish one or more of the following purposes:

- Provide or improve food and cover for fish, wildlife and livestock.
- Improve and maintain water quality.
- Establish and maintain habitat corridors.
- Increase water storage on floodplains.
- Reduce erosion and associated nutrient runoff and improve stability to stream banks.
- Increase net carbon storage in the biomass and soil.
- Enhance pollen, nectar and nesting habitat for pollinators.
- Restore, improve or maintain the desired plant communities.
- Dissipate stream energy and trap sediment and associated nutrients.
- Enhance stream bank protection as part of stream bank soil bioengineering practices.

Conditions where riparian herbaceous buffers apply are:

- Areas adjacent to perennial and intermittent watercourses or waterbodies where the natural plant community is dominated by herbaceous vegetation that is tolerant of periodic flooding or saturated soils. For seasonal or ephemeral watercourses and waterbodies, this zone extends to the center of the channel or basin.
- Where channel and stream bank stability is adequate to support this practice.
- Where the riparian area has been altered and the potential natural plant community has changed.

Terrace (Code 600)

A terrace is an earthen embankment, a channel or a combination ridge and channel constructed across the slope to:

- Reduce slope length.
- Reduce erosion.

- Reduce sediment and associated nutrients in runoff water.
- Improve water quality.
- Intercept and conduct surface runoff at a nonerosive velocity to a stable outlet.
- Retain runoff for moisture conservation.
- Prevent gully development.
- Reduce flooding.

All photographs appear courtesy of USDA-NRCS Photo Gallery, http://photogallery.nrcs.usda.gov/.

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