Alaska Agronomy Technical Note #14

The Alaska Phosphorus Index
A Phosphorus Assessment Tool for Agriculture

July 2001

Phosphorus Concerns in the Environment

Eutrophication can be caused by the nutrient enrichment of a water body. Nutrient movement in runoff and erosion from agricultural nonpoint sources is a resource management concern. The movement of phosphorus in runoff from agricultural land to surface water can accelerate eutrophication. Undesirable aquatic plant growth results from additions of phosphorus to the water. The net result of the eutrophic condition and excess plant growth in water is the depletion of oxygen in the water due to the heavy oxygen demand by microorganisms as they decompose the organic material. Eutrophication can have devastating impacts on fish populations and impair recreational use of lakes and streams.

Little attention has been given to management strategies designed to minimize the movement of agricultural P in Alaska landscapes because of the historically low levels of P inputs to surface waters and a lack of direct human health risks associated with eutrophication. Phosphorus is generally the limiting nutrient in fresh water systems and any increase in P usually results in more aquatic vegetation. Society is concerned about maintaining clean drinking water. This concern now includes a cost for removing the color, taste, and odor associated with the high trophic condition and vegetation growth in surface water due to excess nutrients.

Phosphorus Movement Factors

The main factors influencing P movement can be separated into the transport, phosphorus source, and phosphorus management factors. Transport factors include the mechanism by which P moves within the landscape. These are rainfall, irrigation, erosion and runoff. Factors which influence the source and amount of P available to be transported are soil P content and form of P applied. Phosphorus management factors include the method of application, timing, and placement in the landscape as influenced by the management of application equipment and tillage.

Phosphorus Movement in the Landscape

Phosphorus movement in runoff occurs as particulate P and dissolved P. Particulate P is attached to mineral and organic sediment as it moves with the runoff. Dissolved P is in the water solution. In general, particulate P is the major portion (75-90%) of the P transported in runoff from cultivated land. Dissolved P makes up a larger portion of the total P in runoff from non-

cultivated lands such as pastures, hayland, and fields with reduced tillage. In terms of their impact on eutrophication of water bodies, particulate P becomes less available to algae and plant uptake than dissolved P because of the chemical form it has with the mineral (particularly iron, aluminum, and calcium) and organic compounds. The availability of particulate P to plants and algae is variable. It ranges from 10 to 90% of the total P, yet can represent a long-term source of P for algae and plant uptake from the water body. Dissolved P is 100% bioavailable to plants. Added together, the bioavailable portion of particulate P and the dissolved P represents the phosphorus that promotes eutrophication of surface waters.

The method by which P in both particulate and dissolved form moves within the landscape are simplified in the following description. Eroding soil material is transported by runoff. During detachment and movement of sediment in runoff, the finer fraction of the source material are preferentially eroded. The P content and reactivity of the eroded material to P are usually greater than the source soil from which it was eroded. The suspended sediment in the runoff can rapidly adsorb the dissolved P in the runoff water.

As runoff moves from the landscape and toward the water body there is generally a progressive dilution of P through additions of water and a reduction in the amount of sediment carried because of sediment deposition. Phosphorus may become more bioavailable by the sorption and resorption processes and by the preferential transport of fine material as sediment moves over the landscape.

The movement of dissolved P begins with the resorption, dissolution, and extraction of P from the soil, plant, and organic material. These processes occur when rain and runoff water interact with the thin layer of surface soil (0.05 to 0.10 inches). Some water infiltrates into the soil and percolates through the profile where desorption of P will result in a low dissolved concentration in subsurface and return flow. High dissolved P concentration can be expected in the water percolating through organic, coarse-textured, and oxygen depleted (reduced), or water-logged soils. Soil pH also affects the movement and availability of phosphorus.

The interaction between the particulate and dissolved P in the runoff is very dynamic and the mechanism of transport is complex. Therefore, it is difficult to predict the transformation and ultimate fate of P as it moves through the landscape.

The Concept

The purpose of the Phosphorus Index is to provide field staff, watershed planners, and land users with a tool to assess the various landforms and management practices for potential risk of phosphorus movement to water bodies. The ranking of Phosphorus Index identifies sites where the risk of phosphorus movement may be relatively higher than that of other sites. When the parameters of the index are analyzed, it will become apparent that an individual parameter or parameters may be influencing the index disproportionately. These identified parameters can be the basis for planning corrective soil and water conservation practices and management techniques. If successful in reducing the movement of phosphorus, the concern of phosphorus enrichment of surface waters will also be reduced.

The Phosphorus Index is a matrix using a limited number of site and management characteristics to estimate the overall risk of offsite transport of P to surface water. The input to the matrix will be readily accessible field data. This index will be used as a tool for understanding the

contribution that individual landform and management parameters have toward risk of phosphorus movement and will provide a method for developing management guidelines for phosphorus at a specific site to lessen their impact on water quality. It must be emphasized that two things are necessary before phosphorus transport becomes a concern. There must be a high level of applied or soil phosphorus, plus conditions must exist that could result in the transport of P to a water body or wetland.

A number of soil, hydrology, and land management site characteristics will describe the landform. The Phosphorus Index uses parameters that can have an influence on phosphorus availability, retention, management, and movement. These include the erosion rate in tons per acre per year, runoff, available phosphorus soil test levels given in soil laboratory test units, phosphorus application rates in pounds available phosphate per acre, phosphorus application methods, and the potential to affect surface water (vulnerability of the water body or presence of mitigating practices). Field specific data for the nine site characteristics selected for this version of the Phosphorus Index are readily available at the field level. Some analytic testing of the soil and organic material is required to determine the rating levels.

The P Index is a simple matrix that relates site and management characteristics with a range of value categories. The nine characteristics are:

- soil erosion
- runoff potential
- average precipitation
- slope
- soil test P
- P application rate
- P application timing
- P application method
- Potential to affect surface water

The four value categories are:

- low
- medium
- high
- very high

There are nine characteristics used in the P Index to assess a particular site. Each characteristic is rated LOW, MEDIUM, HIGH, or VERY HIGH by determining the range for each category. Although ranges have been given in this version of the index, users are encouraged to give feedback concerning the range of values for each characteristic. Each user should report concerns

about ranges for characteristics and the possibility of adding or eliminating characteristics to better represent field conditions and accurately asses the risk of P transport to surface water.

The definition of each of the nine site and management characteristics is:

Runoff Potential (Soil Hydrologic Group)

The runoff potential of the site is determined from soil survey data. The Alaska P index uses the soil hydrologic group along with slope and precipitation, as an indicator of potential runoff. The soil hydrologic group can be obtained from the soil survey or the Field Office Technical Guide, Section II, Cropland Interpretations. The soil hydrologic group, designated A, B, C, or D, is a group of soils that, when saturated, have the same runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to seasonally high water table, intake rate, permeability after prolonged wetting, and depth to very slowly permeable layer. The influences of ground cover and slope are treated independently, not in hydrologic soil groups.

Average Annual Precipitation

Precipitation, in combination with slope and hydrologic soil group are used to predict runoff potential. As precipitation increases, the risk of runoff increases, all other factors being equal. Much of Alaska, particularly the areas with significant agricultural production, experience very low annual precipitation. In some areas over half of the precipitation occurs as snow and is not available to influence runoff during the growing season when phosphorus is applied. Rainfall events tend to be low energy rather than high energy storms common in the interior portion of the contiguous states. High precipitation areas tend to be coastal and are characterized by long duration, low intensity rainfall. Therefor, storm intensity can be considered to be constant and inches of precipitation can be used along with slope and hydrologic soil group to predict the likelihood of runoff events.

Slope

Slope should be measured in the field if possible. As slope increases the risk of detachment and transport of P offsite increases. Slope has a relatively low multiplier because it is partially accounted for in the water erosion prediction model.

Soil Erosion

Soil erosion is defined as the loss of soil along the slope or unsheltered distance caused by the processes of water and wind. Soil erosion is estimated from erosion prediction models currently used (USLE or RUSLE for water erosion and WEQ for wind erosion). Erosion induced by irrigation is calculated by other convenient methods. The value category is given in tons of soil loss per acre per year (ton/acre/year). These soil loss prediction models do not predict sediment transport and delivery to a water body. The prediction models are used in this index to indicate a movement of soil, thus potential for sediment and attached phosphorus movement across the slope or unsheltered distance and toward a water body.

Potential to Affect Surface Water

This factor considers the potential for discharge of runoff into surface water. It also assigns a relative value to certain water bodies based on the state of Alaska 303(d) list and federal, state or local designations for high value water bodies.

Soil P Test

A soil sample from the site is necessary to assess the level of "available P" in the surface layer of the soil. The available P is the level customarily given in a soil test analysis by the Cooperative Extension Service or commercial soil test laboratories. The user of the P Index must determine the ranges of soil test P in each value category (V LOW, LOW, MEDIUM, HIGH, and V. HIGH). The soil test for "available P" does not determine total P in the surface soil. However, monitoring soil test P levels can indicate that total P is increasing and that a change in P management may be needed. A HIGH or V. HIGH soil test P, at a minimum, indicates that there is no need for additional P application.

P Application Rate

The P application rate is the amount, in pounds per acre (lb/acre), of P_20_5, or potential P_20_5 from organic sources, that is applied to the soil. This phosphate fertilizer includes phosphorus from commercial fertilizer and organic sources. An analysis of the organic material is necessary to determine the phosphate content of the manure. The P contained in the organic fertilizer source (determined by total analysis) is generally considered to be plant available in the year of application.

P Application Method

The manner in which P is applied to the soil and the amount of time that the material is exposed on the soil surface until crop utilization effects potential P movement. Incorporation implies that the P is buried below the soil surface at a minimum of two inches. The value categories of increasing severity, LOW to VERY HIGH, depict the longer surface exposure time between fertilizer application, incorporation, and crop utilization.

P Application Timing

Timing can effect potential P movement because of prevailing weather conditions or cover conditions of the soil. The LOW, MEDIUM, HIGH, and VERY HIGH ratings reflect increased risk of runoff on frozen, snow covered, or saturated ground and the increased risk of dissolved P and sediment movement from fields with no winter cover.

The Procedures for Making an Assessment

- The site characteristics have been assigned a weighting based on the reasoning that particular site characteristics may be more prominent than others in allowing potential phosphorus movement from the site. There is scientific basis for concluding that these

relative differences exist, however, the absolute weighting factors given are based currently on professional judgment.

The value categories range from 1 to 4. The greater the ratings, the proportionally higher are the values. The higher the value, the higher potential for significant problems related to phosphorus movement.

The value ratings are:

- low = 1
- medium = 2
- high = 3
- very high = 4

To make an assessment using the P Index, select a rating value for each site characteristic using the categories LOW, MEDIUM, HIGH, or VERY HIGH. Multiply the site characteristic weighting factor by the rating value to get the weighted value for that characteristic. Proceed to rate and factor each characteristic of the index. Sum the weighted values for all eight characteristics, and compare the total with site vulnerability chart.

A description of vulnerability is given to appraise the assessment of the P Index.

Interpretations of Site Vulnerability Rating for the P Index

LOW - This site has a LOW potential for P movement from the site. If farming practices are maintained at current level, the probability of an adverse impact to surface water resources from P losses from this site would be low.

MEDIUM - This site has a MEDIUM potential for P movement from the site. The probability for an adverse impact to surface water resources is greater than that from a LOW vulnerability rated site. Some remedial action should be taken to lessen the probability of P movement.

HIGH - This site has a HIGH potential for P movement from the site. There is a high probability for an adverse impact to surface water resources unless remedial action is taken. Soil and water conservation as well as phosphorus management practices are necessary to reduce the risk of P movement and probable water quality degradation.

VERY HIGH - This site has a VERY HIGH potential for P movement from the site. The probability for an adverse impact to surface water resources is very high. Remedial action is required to reduce the risk of P movement. All necessary soil and water conservation practices plus a phosphorus management plan must be put in place to reduce the potential of water quality degradation.

Precautions in the Use of the Phosphorus Index

The Phosphorus Index is an assessment tool to be used by planners and landusers to assess the risk that exists for phosphorus leaving the landform site and travelling toward a water body. It also can be used to identify the critical parameters of soil, topography, and management that most influence the movement. Using these parameters, the index then can help in the selection of management alternatives that would significantly address the potential impact and reduce the risk. The index is intended to be part of the planning process that takes place between the landuser and resource planner. It can be used to communicate the concept, process, and results that can be expected if various alternatives are used in the management of the natural resources at the site. **THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES**. Any attempt to use this index as a regulatory scale would be grossly beyond the intent of the assessment tool and the concept and philosophy of the working group that developed it. As discussed in this technical note the Phosphorus Index is proposed to be adapted to local conditions by a process of regional adaptations of the site characteristic parameters. This local development process must involve those local and state agencies and resource groups that are concerned with the management of phosphorus. After the index is adapted to a locality, it must be tested by the development group to assure that the assessments are giving valid and reasonable results for that region. Field testing of the index is one of the most appropriate methods for assessing the value of the index.

Use of the Phosphorus Index in the Natural Resources Conservation Service

The Phosphorus Index is a planning tool that can be used in resource management plans, for water and soil quality, nutrient management, and ecosystem based planning assistance in watersheds. It is intended to be used by the planner to communicate to the landuser the relative potential for phosphorus movement in the landscape. The NRCS does not condone or promote the use of the index for placing any restrictions on land use or other regulatory purposes that could be construed by manipulating the parameters of the index.

www.ak.nrcs.usda.gov/

Alaska Phosphorus Index
Worksheet

AK-590
Nutrient Management

Natural Resources Conservation Service (USDA-NRCS) **December 2012**

Landuser _____ **Assisted By** _____

Farm # _____ **Field #** _____ **Soil Type** _____ **Date** _____

Section 1. Phosphorus Loss Potential Due To Site and Transport

Site and Transport	Multiplier	LOW 1 Point	MEDIUM 2 Points	HIGH 3 Points	VERY HIGH 4 Points	VALUE
(See Definitions Pg 2)	- - M - -	- - - - - Phosphorus Loss Rating (PLR) - - - - -				- - M x PLR - -
Runoff Potential Soil Hydrologic Group	**2**	A	B	C	D	
Avg. Precipitation Inches/Year	**2**	<10	10 - 15	15 - 30	>30	
Slope Percent	**2**	0 - 4.9%	5 - 6.9%	7 - 11.9%	>12%	
Avg. Soil Erosion Tons/Acre-Year	**3**	<1 Ton	1 - 2 Ton	2.1 - 5 Ton	>5 Ton	
Potential to Affect Surface Water	**3**	1	2	3	4	
					Section 1 (Site & Transport) Total Value =	

Section 2. Phosphorus Loss Potential Due To Management

Management	Multiplier	LOW 1 Point	MEDIUM 2 Points	HIGH 3 Points	VERY HIGH 4 Points	VALUE M x PLR
	- - M - -	- - - - - Phosphorus Loss Rating (PLR) - - - - -				
Soil Test Phosphorus AK Extension Category	**4**	VL to Low	Medium	High	VH to Extr.H.	
Rate P_2O_5 Applied Lbs/Ac. Incl. Organic	**1**	< 60	61 - 120	121 - 180	> 180	
Method P Applied Above or Below Ground	**1**	Injected >2"	Incorporated <48 Hrs or Sprinkler	Surface Appl. & Incorporated >2 Days	Surface Applied & Not Incorporated	
Timing P Applied Month Applied	**2**	May - Sept.	Apr. or Oct. Winter Cover	Apr. or Oct. No Winter Cover	Nov. - March	
					Section 2 (Management) Total Value =	

(Circle Rating Below)	**Phosphorus Index Value (Section 1 + Section 2)**	

Nutrient Management Plans Shall Be Based On:	Generalized Interpretation of P Index Does P Move From Field & Impact Waterbodies?	P Index Rating	Phosphorus Index Value
NITROGEN BASED Soil P Not A Risk Concern	**Low** potential that P moves from field & impacts waterbodies. May reduce risk by buffers, setbacks, etc.	Low	Less than 40
NITROGEN BASED Soil P Test To Observe Status	**Medium** potential that P moves from field & impacts waterbodies. May reduce risk by buffers, setbacks, etc.	Medium	41 - 55
PHOSPHORUS BASED Soil P Test Recommendation	**High** potential that P moves from field & impacts waterbodies. Nutrient Mgt. is **needed** in this field.	High	56 - 70
PHOSPHORUS BASED P Crop Removal Rates	**Very High** potential that P moves from field & impacts waterbodies. Nutrient Mgt. is **essential** in this field.	Very High	More than 70

Explanations for Section 1. P Loss Potential Due To Site and Transport

Soil Hydrologic Group: See NEH 210-630-7 for Dual Groups & Matrix

Group	Runoff When Wet	Water Transmission	Sand	Clay	Impenetrable	Water Table
A	Low	Freely	>90%	<10%	> 20"	> 24"
B	Moderate	Unimpeded	50-90%	10-20%	> 20"	> 24"
C	Moderately High	Some restricted	<50%	20-40%	> 20"	> 24"
D	High	Restricted to Very	<50%	>40%	< 20"	< 24"

Sources: Part 618 – Soil Properties and Qualities 618.35 Hydrologic Group
http://soils.usda.gov/technical/handbook/contents/part618.html

Title 210, National Engineering Handbook, Part 630, Chapter 7, Hydrologic Soil Groups
http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=21422

Average Precipitation

-1-	Find AK Precipitation in FOTG Section II, Climatic Data, Agricultural Applied Climate Info. System http://efotg.sc.egov.usda.gov/efotg_locator.aspx?map=AK
-2-	A secondary source of AK precipitation is the Western Regional Climate Center. http://www.wrcc.dri.edu/summary/lcdak08.html

Average Soil Erosion: Sum of RUSLE2 + WEPS

-1-	Calculate water erosion as predicted by the **RUSLE2** computer model. http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm
-2-	Add to this the predicted soil erosion by wind, using the **WEPS** computer model. http://www.weru.ksu.edu/nrcs/wepsnrcs.html

Potential to Affect Surface Water

Low -1-	No direct discharge from the edge of the field into surface waterbodies, wetlands, or a karst or karst area (limestone area).
Medium -2-	Discharge is through a buffer that removes most nutrients , such as a filter strip, riparian buffer or constructed wetland.
High -3-	Direct discharge into a water body of EPA Category 3, 4 or 5. See 2006 IRG Page 46. http://www.epa.gov/owow/tmdl/2006IRG/report/2006irg-report.pdf See AK-DEC-DOW Impaired Waterbodies (Category 4 or 5): http://dec.alaska.gov/water/wqsar/map.html
Very High -4-	Direct discharge into a lake, karst or wild or scenic river. See AK FOTG Sect. I, Ref, 3. Or EPA Category 1 or 2, "Outstanding" or high value like Drinking Water Protection. http://dec.alaska.gov/eh/dw/DWP/protection_areas_map.html

Explanations for Section 2. P Loss Potential Due To Management

Soil Test Phosphorus

-1-	Use AK Soil Test Recommendation Guide Sheet for Area and crop type (Forages, Cereals, Potato, Veg.). AK FOTG Section I, Reference Lists, Tech Notes, Agronomy, Tech. Note 16. http://efotg.sc.egov.usda.gov/efotg_locator.aspx?map=AK

Generalized Interpretation of P Index

-1-	Seek conservation assistance from Certified Planners of NRCS, SWCD and TSPs.
	NRCS Alaska: 907-761-7760. Alaska Assoc. Conservation Districts: 907-373-7923.