Phosphorus Run off Reduction and Annual Ongoing Cost Estimates for common Vermont Agronomic Practices

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The upcoming 2015 legislative session needs to address a crisis in the long standing problem of cleaning up Lake Champlain. EPA has set the goal for Vermont to reduce Phosphorus (P) loss by 281 Tons/year from Load Allocation (LA) (non-point sources) and is looking to the Governor and Legislature to provide assurances that this work can proceed with adequate funding. Agriculture runoff, river channel instability, and forest runoff are the major contributors to LA. Reducing agricultural runoff presents the most practical and cost effective methods to reduce P loss. In this report, **five long-used agronomic practices are prioritized by ability to reduce P loss and their annual cost to producers after initial implementation costs.**

The 2014 revised edition of the Iowa Nutrient Reduction Strategy **http://www.nutrientstrategy.iastate.edu** serves as the main source of information for this report. Actual Vermont crop land acreages are taken from the 2012 USDA Agriculture Census. P loss reduction and costs are calculated by comparing Vermont's reported 87,403 crop acres to Iowa's 21,000,000 total row crop acres. *(In late 2010, the Iowa Department of Agriculture and Land Stewardship and the College of Agriculture and Life Sciences at Iowa State University partnered to develop a statewide nutrient-loss reduction strategy for Iowa. The science team consisting of 23 individuals representing five agencies or organizations was formed to determine nitrogen (N) and phosphorus (P) reduction practices that have the greatest potential to reduce the Iowa contribution of N and P to the Mississippi River.)*

This document includes results of the first step of evaluation from the Iowa State P team. It was done to determine practices expected to have the most potential for cost effective reduction of P export from soil erosion.

P is generally the limiting nutrient for algal production in fresh water systems, meaning that the addition of P to fresh water can lead to eutrophication. Much of the P being delivered to surface water resources is from nonpoint sources via agricultural runoff and/or stream bank erosion. On average, 70% of the total P delivered to streams near agricultural fields has been from sediment bound P. Although the sediment movement and delivery process is complex, sediment delivery is generally greatest for unprotected (bare) soils through erosion and reduction of sediment bound P is the goal of the agronomic practices that are evaluated in this report.

Dissolved P delivery to streams and lakes is also significant, especially in soils with high soil-test P that are located within 10 miles of Lake Champlain. Dissolved P is more readily available for biological uptake, and therefore has a potentially larger impact on eutrophication than sediment-attached forms of P. Currently, a small FNLC research project is focusing on farm field tile drainage's contribution to dissolved P and practical field structures to absorb dissolved P.

Phosphorus Reduction Practices with Associated Costs

Land use options are intended to reduce soil erosion.

1. **Cover Crops** reduce soil erosion by improving soil structure, stability, and permeability in addition to providing ground cover as a physical barrier between raindrops and the soil surface. Because of the Vermont's cold, short growing season and corn silage production systems, fall growth of cover crops has been limited; but growing in acceptance due to technical advances made by UVM Extension Agronomy specialists. The effectiveness of cover crops in reducing erosion is related to the soil cover achieved. This cover is most important in the spring, when most runoff events occur. Cover crop is an annual cost with little to capital investment. Items included in the annual cost are seed and seeding method and crop termination by plow down or spray next spring.

*Estimated annual cost is $86.50/A. NRCS contribution for the first three years is $65.68/A. Overall P loss reduction is 50%. Implementing cover crop on the entire Vermont 87,403 corn silage acres is estimated to reduce elemental P loading by **33.2 tons/year** with an annual ongoing farm cost (without NRCS support) of approximately **$4Million/yr.** statewide.*

2. **Tillage practices** affect soil erosion, which is the primary transport process of sediment bound P delivery in Vermont. Increased tillage reduces ground cover which exposes more soil to raindrop splash effects that contribute to sheet erosion. Some forms of tillage reduce soil aggregate stability, resulting in increased break-up of aggregates during rainfall events, increasing soil erosion and reducing permeability of surface soil. Tillage effects on P loss are site specific, but less P loss generally occurs with minimum or no tillage than with conventional tillage; although no-till can increase the proportion of total P lost as dissolved P, especially in tile drained areas.

Initial capital investment is approximately $70,000: NRCS provides 75:25 EQIP grants and up to 90:10 to new participants. The estimated annual cost of converting from conventional tillage to no till is $12.71 - $22.22/A. NRCS annual payment for the first three years is $34/A. Overall P loss reduction is 39%. Implementing reduced tillage on most VT corn silage acres could reduce elemental

*P loading by **10.305 tons/year** with an annual ongoing farm cost of approximately **$932,000** state wide.*

3. **Extended rotation of corn** and at least 3 years of legume-grass managed for hay harvest is recognized as a P loss reduction strategy because of greater soil cover and high P removal with hay. There is little initial capital investment, but the producer must calculate feed inventory adjustment for switching from high yielding corn silage to hay crop silage. Based on the difference in land rent of hay from corn ground annual cost is $42/Acre and the annual statewide ongoing farm cost is **$19,000.** P loss reduction is 3% and reduction in P would be **2 Tons**.

   Some areas of Vermont are in **permanent pasture.** Pastures typically have lower soil erosion rates than corn-hay rotation but higher dissolved P concentration in runoff because of fertilizer application and fecal P on soil surface. Delivery of P to water bodies is highly affected by pasture management. Phosphorus delivery is greater with excessive and prolonged over-grazing and unrestricted animal access to streams, compared with intensively managed rotational grazing and restricted animal access to streams.

*Initial costs include stream bank exclusion fencing. Based on the difference in land rent from corn to hay land and twice yearly mowing, annual estimated cost is $159/A. On the following table, Pasture and Land Retirement are estimated together as annual ongoing expense state wide of **$137,000.** P loss is reduced 71% and a statewide P loss reduction of **6 Tons** when combined with land retirement.*

4. **Land retirement** is a long term (10-15 year) NRCS program intended to limit soil erosion. Reduced P loss results from return to a near "natural" system of plant and animal habitat.

Considering loss of land rent the annual cost is $242/A. Expected P loss reduction is 85%.

5. **Edge-of-field constructions** are designed primarily to remove sediments or to capture dissolved P.
   a. A **buffer** is a vegetated area strategically placed between cropland and a stream or other water body, which acts as a filter. By removing particulate P from runoff water through filtration and sedimentation and removing dissolved P by plant uptake or soil binding, buffers

reduce P delivery from fields to water bodies. Riparian buffers have the added benefit of stabilizing stream banks.

*Based on the average difference in land rent from corn to hay land after the establishment of a 35 foot buffer, the annual cost is $228/Acre and state wide cost is **$170,000.** P loss reduction is 18% and **12 T** P loss could be saved annually by requiring 35 foot buffers between row crop farm land and streams and other water bodies.*

b. **<u>Sediment Control practices</u>** are installed to reduce gully erosion and capture sediment. They were not *reported in the Iowa Strategy, so they are not included in the top five practices, but they have value on Vermont's steep farmland.*
   i. **Terraces**
   ii. **Strip Cropping**
   iii. **Contour Plowing**
   iv. **Grassed waterways** to reduce gully erosion
   v. **Water and sediment control basins (WASCOBs)** to capture sediment in water ways and ponds.

These are higher cost practices that make longer contributions to P loss reduction. After the initial construction expense, there is little annual cost for terraces. Grassed waterways require annual mowing or they could be harvested for hay or bedding. The amount of acreage that could be converted to grass water ways is unknown, but P loss reduction would be 71% and annual cost/Acre to the producer would be $159/Acre as determined for permanent pasture. WASCOBS require removal of sediment every 3-7 years depending on fill rate. Examples of construction costs are given on the individual FNLC/NRCS projects but it is not possible to predict how many structures or acres could be served by these structures so an estimate of reduced P loss for the state would be a wild guess.

Results for Individual Practices at Estimated maximum Potential Acres, Phosphorus Reduction and Farm-Level Costs as adapted from the 2012 USDA Census for Vermont and 2014 revised Iowa Nutrient Reduction Strategy.

Notes: Research indicates large variation in reductions. Some practices interact such that the reductions are not additive. Additional costs could be incurred for some of these scenarios due to industry costs or market impacts. A positive $/lb. P reduction, total cost or EAC is a cost. A negative $/lb. P reduction, total cost or EAC is a benefit.

Practice/Scenario	P Reduction % (from baseline)	Potential Area Impacted for practice (Acres)*	Total Load P reduction (short ton)	Cost of P Reduction $/lb. (from baseline)	Total EAC** (million/$year)	State Average EAC** ($/Acre)
Baseline		87,403 A	67.2T			
Cover crops (rye) on all Corn and Soya Bean Acres	50%	87,403 A	34 T	$60/lb.	**$4 million**	$86.50/A
Convert all tillage to **no-till******	39%	67,009 A	26.208 T	$14/lb.	**$937,000**	$12-22/A
Establish streamside **Buffers** (35 ft.) on all row crop land*** ****	18%	1,665 A	12.096 T	$14/lb.	**$170,000**	$228/A
Land Retirement to equal acreage of Pasture/Hay and CRP, taking acres from Row crops ****	9%	7,907 A	6.048 T	$120/lb.	**$137,000**	$192/A
Doubling the amount of extended **crop rotation** acreage	3%	7,492	2.016 T	$53/lb.	**$19,265**	$30/A

***Acres impacted include soybean acres in corn-soybean rotation as the practice has a benefit to water quality from the rotation.**

****EAC stands for Equal Annualized Cost (50 year life and 4% discount rate) and factors in the cost of any corn yield impact as well as the cost of physically implementing practice. Average cost based on 87,403 acres, costs will differ by region, farm and field.**

*****Acres impacted for buffers are acres of buffers implemented and EAC are per acre of buffer.**

******This practice includes substantial initial investment costs.**