Why We Need the Phosphorus Management Tool (PMT)

Many surface waters in Maryland are impaired by excessive inputs of nutrients and sediments. Human inputs of both nitrogen and phosphorus have stimulated algal growth, thus decreasing water clarity and depleting dissolved oxygen levels. The waters so impaired have been identified through monitoring and assessment of nutrient inputs and include both non-tidal (streams, rivers and lakes) and tidal (tidal rivers and creeks and the mainstem Chesapeake Bay) waters. Both nitrogen and phosphorus contribute to the impairment, with freshwater systems being particularly sensitive to phosphorus inputs.

Agriculture is presently the largest source of phosphorus inputs to the Chesapeake Bay. Various steps have been taken to reduce phosphorus pollution of surface waters with significant and quantifiable reductions achieved from the phosphate detergent ban and advanced wastewater treatment. Based on the Chesapeake Bay Program (CBP) watershed model used to guide mandated Watershed Implementation Plans, phosphorus inputs to the Bay from wastewaters have declined by 70% since 1985, while inputs from agricultural sources have remained relatively unchanged (6% reduction). Consequently, agriculture sources are estimated by the model now to account for about 64% of the phosphorus that enters the Chesapeake Bay as a result of human activities, surpassing the amount coming from either wastewater discharges (18%) or urban stormwater runoff (19%).

Significant reductions of phosphorus inputs from agriculture will be required in order to alleviate documented water quality impairment. The pollutant load that can be handled and not impair water quality has been determined using the best available science for the Chesapeake Bay and for other smaller tidal and nontidal water bodies. This maximum load is commonly called the TMDL or pollution diet. Under the provisions of the Clean Water Act and multi-state agreements, the Bay states have an obligation to achieve the pollutant load reductions necessary to alleviate water quality impairment by 2025. Although considerable progress has been made as a result of wastewater treatment, it is estimated that additional reductions totaling 5.2 million pounds of phosphorus per year will be required Bay-wide. Maryland must still reduce 0.7 million pounds per year in order to achieve the load limit under the state's Watershed Implementation Plan. That plan relies on reductions from agriculture for more than one-half of that total. These estimates of reductions required are computed by the CBP watershed model based on best management practice implementation reported by the states. The efficiencies of the practices are determined by panels of experts using multiple lines of evidence. Because advanced wastewater treatment has successfully reduced phosphorus concentrations in effluents to levels approaching the limits of technology and because septic systems contribute virtually no phosphorus, the burden of achieving the remaining phosphorus loading to the Chesapeake Bay must fall principally on the largest remaining sources, agriculture and urban stormwater runoff. Similar to the agricultural sector, additional phosphorus load reductions are being sought from urban stormwater runoff sources.

High soil phosphorus concentrations exist as a result of repeated phosphorus applications over many years in excess of crop removal rates. The buildup of soil phosphorus in some portions of the Chesapeake Bay watershed is not surprising. Phosphorous is imported into particular regions within the watershed in the form of animal feed, plant fertilizer and food for humans. A significant part of the phosphorus imported is in the form of grain for animal feed because we do not grow enough grain locally to feed the large number of animals produced in certain regions. Animal manures and human biosolids are typically applied to agricultural soils primarily to supply essential crop nutrients and this may also improve soil organic matter content and other soil characteristics. For many organic nutrient sources, nitrogen and phosphorus are in relatively equal proportions but the crop requirement for additional added nitrogen far exceeds the need for additional added phosphorus. Thus, if one applies enough animal manure to meet the crop's nitrogen needs, then much more phosphorus is applied than is needed by the crop. Due to the high phosphorus sorption capacity of most soils the excess applied phosphorus tends to persist in the soil and not be rapidly lost to the atmosphere or to groundwater, as is the case for nitrogen. As a result phosphorus has built up in some surface soils where animal manures or biosolids have been repeatedly applied over many years. So, our management solutions must involve more efficient use and recycling of phosphorous, including redistribution from regions where there is too much to regions where phosphorus can be effectively used to support crop growth.

Phosphorus in runoff water and subsurface drainage is a function of the concentration and form of soil phosphorus present, field management, and hydrologic connectivity. While the soil does have a large capacity to retain phosphorus, at some point it will become saturated and dissolved phosphorus losses rapidly increase. It was previously thought that preventing soil erosion would prevent phosphorus transport to nearby waterways, because phosphorus in soils is tightly bound to soil particles. However, scientific research has clearly demonstrated that as soluble soil phosphorus concentrations increase so does dissolved phosphorus loss in surface runoff and subsurface drainage. The science to support this conclusion is sound. Soils with a high degree of phosphorus saturation can pose a risk of water pollution, but the risk depends greatly on site characteristics, such as soil type and slope, crop rotation, tillage, etc. Consequently, site-specific management practices are required to minimize phosphorus loss from soils with a high risk for phosphorus losses.

The Phosphorus Management Tool (PMT) was developed as a practical means to identify critical areas where there is a high risk for phosphorus loss from agriculture production fields and guide effective management practices to reduce the potential for phosphorus loss to surface waters. The development of a phosphorus index tool tailored to Maryland's soils, agricultural management practices, climate, topography, hydrology and surface water characteristics began in 1994. Tools designed to evaluate the relative risk of phosphorus loss from agricultural fields have been integral components of nutrient management plans since 2000 when the original Maryland Phosphorus Site Index (PSI) was adopted. The PSI was updated in 2005 to include new science. The PMT is the third generation of the phosphorus risk assessment tool used in nutrient management plan development in Maryland. It incorporates the most reliable science into a method that improves our ability to identify these most critical areas for potential phosphorus losses. It is an enhancement rather than a fundamentally new approach and was developed through extensive professional collaboration and stakeholder engagement.

Scientists continue to perform research on the best strategies for phosphorus management and the evolving science must continue to be incorporated into effective policy. In the years ahead, as the science evolves, revisions to the PMT that incorporate the new science can be expected on similar intervals (i.e. approximately five to eight years) and information gathered as the implementation of the PMT is phased in will be very valuable in subsequent revisions. Agricultural fields with PMT scores greater than 100 are considered to have a high potential for phosphorus loss and no additional phosphorus should be applied to these sites.

The PMT is designed to identify site-specific relative risk for phosphorus loss and guide management to reduce this risk. It took many years of phosphorus application in excess of crop removal to build soil phosphorus concentrations to levels of environmental concern. Accordingly, it will take many years for soil phosphorus concentrations to decline after phosphorus applications are reduced or cease and, consequently, for water quality benefits to be seen. There are multiple pathways through which phosphorus can be lost from a farm field. One significant feature of the PMT is that it is designed to identify sites where a substantial risk for phosphorus loss may be limited to a single physical loss pathway, such as soil erosion from steep slopes with shallow soils in western Maryland or subsurface drainage in relatively flat ditch-drained systems of the lower eastern shore. However, without action, high phosphorus "hot spots" will continue to contribute phosphorus to surface waters, counteracting our best practices elsewhere to attain the required 2025 load reductions. Active remediation techniques (e.g. purposeful crop drawdown of soil phosphorus, installation of phosphorus-trapping filters, and intensified drainage water management) will be required to reduce the phosphorus losses from PMT-identified high-risk sites and thus significantly diminish phosphorus inputs to surface waters.

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