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Nonpoint Source Control Task Force Report to the Water Quality Board. Appendix 4: Priority Management Areas Identification

Nonpoint Source Control Task Force

APPENDIX IV

TO THE

NONPOINT SOURCE CONTROL TASK FORCE REPORT

TO THE

WATER QUALITY BOARD

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PRIORITY MANAGEMENT AREAS IDENTIFICATION

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The identification of management areas for control of nonpoint source pollution is an important component of any agricultural pollutant control strategy.

The Pollution From Land Use Activities Reference Group (PLUARG) introduced the phrase hydrologically active areas (HAA's). These HAA's were areas which contributed pollutants directly to surface and/or groundwater because of their proximity to streams or aquifer recharge areas.

This was an important concept. It established the idea that all lands do not contribute equally to the pollution problem. This idea is of great significance when the development of management plans is considered. It suggests the need for careful evaluation of where remedial measures may need to be planned for implementation. It also suggests that all basins are not equal.

The validity of the concept of HAA's has been reinforced by the findings of the Black Creek, Indiana, project and the work of the Lake Erie Wastewater Management Study on the U.S. side of the basin. These studies and others have used the term "critical areas" for treatment. Both terms, critical areas and HAA's, recognize that all portions of the landscape are not equal as sources of pollutants. It also follows that all portions of the landscape are not equal candidates for treatment. This concept impacts directly on the development of implementation plans and the delivery of technical and financial resources to nonpoint pollution control.

The concept of priority basins or priority stream segments was introduced in the Water Quality Management Plans that were developed under Section 208 of Public Law 92-500. This terminology recognized that water use impairment did not occur in every stream segment or each basin. Phosphorus, which is the pollutant of concern in the Great Lakes, does not manifest itself as a problem in running water. It is only a source of energy for excessive algae growth in lakes and reservoirs. The concept of priority basins or watersheds as a source of pollutants is emphasized. The conventional wisdom which is evolving in the control of agricultural nonpoint source pollution is one of a hierarchy of priorities.

The Water Quality Board has also recognized this approach in adopting "areas of concern". These areas of concern are defined as a geographic location where water, sediment, or fish quality are degraded and the Great Lakes Agreement water quality objectives or jurisdictional criteria, standards, or guidelines are exceeded. This is an attempt to focus attention toward critical or priority areas.

The traditional approach used to address natural resource problems is to establish a program to address an identified problem in some global way. This approach might best be illustrated by the recognition of soil erosion as a national concern in the United States. This recognition has led to the development of a means to deliver this program to individual landowners through soil and water conservation districts. It includes the creation of a staff of professionals and an annual budget for technical assistance, cost-share funds to encourage participation, and an information and educational program. This approach has been relatively successful in addressing the need to maintain the productive capacity of the soil resource. This program has been criticized as being too global and there is a growing trend to focus resources to critical or priority areas. The control of pollutants from nonpoint sources requires this focused approach. Soil erosion is detrimental to the productivity of the land on which it occurs, whereas water use impairment occurs offsite. Although the source of the impairment is on the land, attention must be focused on the portion of the landscape which is the source of the pollutant in order to solve the problem. It must be recognized that sediment is itself a pollutant and that a large percentage of the phosphorus is delivered attached to sediment. It does not follow that a general soil erosion program is sufficiently focused to accomplish major phosphorus reductions.

The HAA or critical area can be as small as a concentration of animals, such as a feedlot, or as large as several counties. The level lake plain in Western Ohio with its high clay soils and numerous drainage ditches is a critical area because the clays are easily suspended and the opportunity for delivery is great. More typically, the sources that have high delivery are scattered across the landscape.

The hierarchy of priorities which identifies the larger sub-basin, hydrologic unit, and ultimately a field or fields is an important refinement since PLUARG. The degree to which the major pollutant sources, which also have high delivery rates, can be located will to a large extent determine the costs and ultimate success of any control effort.

This suggests that the costs for phosphorus reduction from agricultural activities may be less than projected by PLUARG since it envisioned treatment based on reduction of erosion to a tolerable level over the entire basin. Many management type practices do have applicability over large areas. The use of reduced tillage on adapted soils and phosphorus fertilizer applications according to soil test results have been very cost-effective in reducing phosphorus transport and availability. The most significant finding has been that disproportionate quantities of phosphorus are delivered from a relatively small percentage of the landscape.

The planning process must take into consideration the pollutant, the form in which it is transported, and the source. The HAA or critical area for treatment must include a determination of whether it is a source of the pollutant and how much is being delivered to the water body where its effect is manifested. Delivery of the pollutant, the form in which it is delivered, and the ease (costs) of controlling it become a part of the identification of a priority management area.

It is this planning step which is often left to chance. Most often a priority basin is selected based on evidence or perception that it is critical. An implementation project is then begun in that basin. The concept of HAA suggests the need for an additional step before funds are set aside to begin an implementation program. This step is needed to ascertain which areas are delivering the bulk of the pollutant and the form in which it is being transported. Many existing agricultural implementation efforts could be classed as failures because the major sources were not identified or that the land user did not desire to participate. Often point sources or sources such as failing leach fields will mask a good implementation effort focused only on agricultural lands.

This step, which could be called implementation planning, is a necessary one in order to determine the level and the type of effort required to reduce the pollutant in a cost-effective fashion. The Black Creek, Indiana, project and the initial fundings from the Model Implementation Program in seven locations in the U.S. all support a need for a prior planning period before implementation begins.

The concept of HAA's developed by PLUARG has been confirmed by several demonstration projects. It has also resulted in establishing the criteria by which this concept can be used in controlling a nonpoint source pollutant. It requires a detailed evaluation of the suspected critical basin to determine the sources, the form of transport, the amount of delivery, and methods of controlling it. It is only after having gone through this evaluation that an implementation program can be developed.

Priority management area identification requires an additional planning step which goes into more detail than the traditional method of program development. Ideally, it would include a funded evaluation period during which the HAA's would be located, methods of control determined, and costs estimated. It would only be after this step that funds would be made available for technical assistance, cost-sharing if appropriate, and an information program established.

SOIL EROSION AND PHOSPHORUS TRANSPORT*

Soil erosion and sediment are terms which are often used incorrectly. Soil erosion is a process which involved the detachment of soil particles from the land surface by raindrop impact, running water, or wind. Some of the particles fall back to the surface close to the point of detachment. Others are carried a great distance. These detached particles accumulate on the landscape or in water courses when their weight exceeds the capacity of runoff waters to move them. This accumulation is called sediment. During the process of movement or transport across the landscape, the carrying capacity changes allowing the coarser and heavier soil particles to deposit while the finer and lighter particles remain in suspension. During a runoff event when soil particles are in suspension, a sorting process occurs. Finer and lighter particles typically are those that are eventually carried into streams and rivers.

The Universal Soil Loss Equation (USLE) is an equation which evaluates the potential for soil particles to be detached from the soil surface under a predetermined set of conditions. The use of the word "loss" in the name suggests that the USLE determines soil loss or sediment losses from a field. The USLE is correctly used to indicate the relative amounts of soil that are detached over a period of years under a given set of management conditions. The USLE predicts soil erosion. More correctly it predicts potential gross soil erosion since many of the soil particles that are detached are deposited at or very near the point of original detachment.

The USLE is often used as an indication of the pollution potential from agricultural activities. Phosphorus, which is the pollutant of significance from the Great Lakes standpoint, is delivered in the soluble form or adsorbed on sediment. Soluble phosphorus cannot be estimated by the use of the USLE. Phosphorus which is adsorbed to sediment is the only form that can be linked to potential gross erosion as estimated by the USLE. It does not quantify the amount of the erosion which actually is transported to a water course, nor does it measure erosion from gullies or streambanks which also are sources of phosphorus.

PHOSPHORUS

The phosphorus content in most soils is low, between 0.01 and 0.2 percent by weight. Most of this is unavailable for plant uptake. Manure and fertilizers are used to increase the level of available phosphorus in the soil to promote plant growth. If runoff and erosion occur, some of the applied phosphorus can reach nearby bodies of water. High-intensity storms increase the loss of particulate inorganic phosphorus from croplands because this form of phosphorus is associated with eroding sediments.

Phosphorus can be found in the soil in dissolved, colloidal, or particulate forms. It occurs as inorganic orthophosphate or polyphosphate or as organic phosphorus. In many lakes, organic phosphorus comprises as much as 95 percent of the total phosphorus and will largely be in aquatic plants. However, dissolved inorganic phosphorus (orthophosphate phosphorus) is probably the only form directly available to algae. Algae consume dissolved inorganic phosphorus and convert it to the organic form. Phosphorus is rarely found in concentrations high enough to be toxic to higher organisms.

Phosphorus unavailable in the soil system may erode with soil particles and later be released when the bottom sediment of a stream or lake becomes anaerobic, creating water quality problems. Most researchers believe, however, that the conversion of particulate phosphorus to soluble phosphorus does not exceed 20-30 percent. Resuspended bottom sediment in shallow lakes continually provides a new supply of available phosphorus to algae.

Inorganic phosphorus can be either dissolved in surface or subsurface waters or associated with sediments. Although much of the sediment-held portion acts as if it were permanently fixed on the soil, some of it serves as a source of the dissolved (available) form. The portion of the phosphorus held by the soil that is subject to change is referred to as the labile fraction. This portion is normally several hundred times larger than the dissolved portion. The equilibrium between labile and dissolved inorganic phosphorus depends, in part, on the chemical and biological characteristics of the water regime in the soil or water body.

The amount of dissolved phosphorus changes during transport from cropland to stream and lakes. Estimating the potential impact of phosphorus on water quality is difficult because the relationships between various forms of phosphorus in the soil and sediments, water, and biota are poorly understood. Despite the lack of understanding, soil and water conservation practices are known which will significantly reduce phosphorus losses from agricultural lands.

SEDIMENT

Sediment is the result of erosion. It is the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site or origin by air, water, gravity, or ice. The types of erosion that produce sediment are (1) sheet and rill erosion, (2) gully erosion, (3) stream channel erosion, (4) road and roadside erosion, and (5) other types of erosion, such as that associated with urban development, construction sites, etc. Only potential sheet and rill erosion is estimated by the USLE. Sediments from the different sources vary in the kinds and amounts of pollutants that are adsorbed to the particles. Sheet and rill erosion mainly move soil particles from the surface or plow layer of the soil. Eroded soil is either redeposited on the same field or transported from the field in runoff.

Sediment which originates from surface soils will have a higher pollution potential than that from subsurface soils. The topsoil of a field is usually richer in nutrients and other chemicals because of past fertilizer and pesticide applications, as well as nutrient cycling and biological activity. Topsoil is also more likely to have a greater percentage of organic matter. Sediment from gullies and streambanks usually carries less adsorbed pollutants than sediment from surface soils.

Sediment from cropland usually contains a higher percentage of finer and less dense particles than the soil from which it originates. Large particles such as sand grains are more readily detached from the soil surface because they are less cohesive. They will also settle out of suspension more quickly because of their size. Organic matter is not easily detached because of its low density. Clay particles and organic residues will remain suspended for longer periods and at slower flow velocities. This selective erosion process can increase overall pollutant delivery, because small particles have a much greater adsorption capacity per mass than larger particles. As a result, eroding sediments generally contain higher concentrations of phosphorus, nitrogen, and pesticides than the original soil.

The concept of an enrichment ratio is used to characterize the quantity of a substance in sediment relative to that in the original soil. The enrichment ratio can be defined as the concentration of a substance in the sediment compared to the concentration of the substance <u>in situ</u> in the soil. Enrichment ratios are typically greater than unity. Factors affecting the enrichment ratio include soil, kind of erosion, and character of the runoff.

Sediment affects the use of water in many ways. Suspended solids reduce the amount of sunlight available to aquatic plants, cover fish spawning areas and food supplies, and clog the gills of fish. This reduces fish, shellfish, and plant populations and decreases the overall productivity of lakes or streams. Turbidity interferes with feeding habits of fish. Recreation potential is limited because of the decreased fish population and the water's unappealing, turbid appearance. Turbid water reduces visibility, thus it is less safe for swimming.

Sediment fills farm drainage ditches, road ditches, culverts, and stream channels and shortens the economic life of reservoirs and farm ponds. It can plug water filters, erode power turbines and sprinkler nozzles, and damage pumping equipment. Maintenance costs are increased and additional treatment may be necessary before the water can be used for drinking or industrial purposes.

Sediment does not always have a detrimental effect, however. Its presence can contribute to streambank and channel stability. It can be beneficial as it may reduce dissolved inorganic phosphorus concentrations in surface waters. The clay-organic complexes in sediment act as scavengers as a result of their ability to adsorb some chemicals in runoff waters.

Chemicals such as some pesticides, phosphorus, and ammonium are transported with sediment in an adsorbed state. The toxicity of a pesticide does not necessarily decrease because of its adsorption to sediment, but its association with the sediment will normally cause much of it to settle out in the receiving water. However, the toxicity of some insecticides, such as toxaphene, decreases faster under anaerobic conditions, and adsorbed insecticides have a greater opportunity for exposure to anaerobic conditions. Changes in the aquatic environment, such as a lower concentration in the overlying waters or the development of anaerobic conditions in the bottom sediments, can cause these chemicals to be released from the sediment. Adsorbed phosphorus transported by the sediment may not be immediately available for aquatic plant growth but does serve as a long-term contributor to eutrophication.

ANIMAL WASTES

Animal wastes and manure are terms that are often used interchangeably. They include the fecal and urinary defecation of livestock and poultry, process water (such as from a milking parlor), and the feed, bedding, litter, and soil with which they become intermixed. Animal wastes can contribute nutrients, organic materials, and pathogens to receiving waters.

Manure will be more easily removed in runoff when applied to the soil surface than when incorporated in the soil. Spreading manure on frozen ground or snow can result in high concentrations of nutrients being transported from the field during rainfall or snowmelt. The problems associated with nitrogen and phosphorus also apply to animal wastes. If sufficient manure is applied to meet the nitrogen needs of a crop, phosphorus will generally be in excess. The soil generally has the capacity to adsorb any phosphorus leached from manure applied on land. However nitrates are asily leached through soil into subsurface drains and into the ground water.

The demand for oxygen exerted by carbonaceous materials (individually or in combination with nitrogen) can deplete dissolved oxygen supplies in water, resulting in anoxic or anaerobic conditions. When the decomposition process becomes anaerobic, methane, amines, and sulfide are produced. The water acquires an unpleasant odor, taste, and appearance and becomes unfit for drinking, and for fishing and other recreational purposes.

Animal diseases can be transmitted to humans through contact with animal feces, but manure that has been incorporated is rarely a public health problem. The bacteria present in manure, including possible pathogens, are filtered by the soil and rarely infiltrate more than a few centimeters into the soil profile. Groundwater contamination is usually not a problem if manure is incorporated. Runoff from fields receiving manure will contain extremely high numbers of bacteria if the manure has not been incorporated or the bacteria have not been subject to stress.

Conditions which cause a rapid dieoff of bacteria are low soil moisture, low pH, high temperatures, and direct solar radiation. Manure storage generally promotes dieoff, although pathogens can remain dormant at certain temperatures. Composting the wastes is quite effective in decreasing the number of pathogens.

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* Text adapted from Water Quality Field Guide, USDA, Soil Conservation Service, 1983 (Publication Pending).

SUPPORTING DOCUMENTS RECOMMENDED FOR ADDITIONAL READING*

1. EVALUATION OF NONPOINT SOURCE CONTROL REMEDIAL PROGRAMS - ONTARIO by Mr. D. R. Cressman, Ecologistics Limited, Waterloo, Ontario.

2. EVALUATION OF NON-POINT REMEDIAL PROGRAMS - U.S. SIDE by Mr. Lance Marston, Harbridge House, Inc., Washington, D.C.

3. AGRICULTURAL NON-POINT SOURCE TECHNOLOGY by Mr. A. W. Bos, London, Ontario.

4. EVALUATION OF URBAN NON-POINT REMEDIAL MEASURES by Mr. Eugene D. Driscoll, E. D. Driscoll and Associates, Oakland, New Jersey.

5. PRIORITY MANAGEMENT AREAS IDENTIFICATION by Mr. Donald R. Urban, U.S. Department of Agriculture, Washington, D.C. and Dr. Greg J. Wall, Agriculture Canada, Guelph, Ontario.

6. TRANSPORT AND TRANSFORMATIONS OF POINT AND NONPOINT SOURCE PHOSPHORUS by Dr. Mark P. Brown, New York State Department of Environmental Conservation, Albany, New York.

7. PHOSPHORUS BIOAVAILABILITY by Dr. William C. Sonzogni, University of Wisconsin, Madison, Wisconsin.

8. STATUS AND EVALUATION OF PESTICIDE IMPACTS ON THE WATER QUALITY OF THE GREAT LAKES by Mr. Jerry L. Wager, Ohio EPA, Columbus, Ohio.

9. WIND EROSION AS A SOURCE OF WATER POLLUTION by Mr. Bruna Guera, National Oceanic and Atmospheric Administration, Ann Arbor, Michigan, and Dr. William C. Sonzogni, University of Wisconsin, Madison, Wisconsin.

10. TOOLS FOR EVALUATION OF REMEDIAL MEASURES by Mr. J. E. O'Neill, Ontario Ministry of the Environment, Toronto, Ontario and Dr. Stephen M. Yaksich, U.S. Army Corps of Engineers, Buffalo, New York.

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*Copies of the above-listed documents are available upon request from the International Joint Commission, Great Lakes Regional Office, 100 Ouellette Avenue, 8th Floor, Windsor, Ontario, N9A 6T3.

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