SOIL EROSION, SEDIMENTATION AND WATER QUALITY IN THE GREAT LAKES REGION

A report to the
USDA - Soil Conservation Service

from the

Great Lakes Commission

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I. INTRODUCTION

This report has been prepared by the staff of the Great Lakes Commission to fulfill the requirements of a Joint Venture Agreement entered into with the U.S. Department of Agriculture - Soil Conservation Service Michigan Office in June of 1987.

The purpose of this effort was to present information on Great Lakes water quality impacts as they relate to soil erosion and sedimentation control efforts in the Great Lakes region. Particular emphasis was to be given to quantifying, where possible, the off-site water related costs and damages associated with sedimentation. This interest stemmed from discussion of the importance of off-site impacts by the Great Lakes Commission's Soil Erosion and Sedimentation Task Force and an acknowledgment on the part of the Commission and the SCS of the importance of documenting these impacts to support the need for establishing a basin-wide program to protect and improve water quality through erosion and sedimentation control. It also reflects the national commitment of the SCS to address water quality issues as a second top priority to the implementation of the 1985 Food Security Act.

This paper reflects a thorough review of literature addressing nonpoint water quality issues associated with erosion and sedimentation, as well as efforts to document the off-site costs and impacts of sedimentation. It describes qualitatively these impacts and presents them in the context of current erosion and sedimentation control programs designed to mitigate these impacts. The paper adds little to the quantitative information on off-site water related impacts of sedimentation in the Great Lakes. This is due to the scarcity of quantitative information, particularly Great Lakes specific information, and the magnitude of the effort necessary to obtain this information which is beyond the scope of this paper.

It does, however, provide a good starting point for continuing the effort of quantifying off-site impacts and builds a strong case for the need to establish a special Great Lakes Basin Program to protect and improve water quality through erosion and sedimentation control.

It also presents a series of conclusions and recommendations regarding the off-site issue and possible future activities and involvement for the SCS, Great Lakes Commission or other appropriate groups to consider.

Some of these recommendations are:

- The need to continue working toward the development of a Great Lakes Basin Program to protect and improve water quality;

- The need for a dedicated intermediate term commitment to support the quantification of off-site impacts associated with sedimentation; and

- The need to establish a clearinghouse to disseminate and exchange information on completed and ongoing research and demonstration projects relating to erosion, sedimentation and water quality in the Great Lakes.

II. BACKGROUND

Soil erosion and sedimentation are serious problems in the Great Lakes Basin. Erosion, the detachment of soil particles by the actions of water, wind and other factors, diminishes the productivity of the land resource base. Sedimentation, the deposition of the material, fills harbors, streams and lakes and degrades water quality. Combined, erosion and sedimentation adversely affect recreation and fish and wildlife habitat and cause federal, state and local governments to incur tremendous costs through increased dredging, ditch and stream channel maintenance and damages to water treatment and conveyance facilities.

Nationally, the amount of soil loss due to erosion is tremendous. The National Resources Inventory (NRI) conducted by the U.S. Department of Agriculture (USDA) in 1977 estimated the annual water-caused erosion from non-federal land at 6.42 billion tons. This is equivalent to about 30 tons of soil per person nationwide or an average of more than 200 tons lost every second. Based on estimates from the 1982 NRI, the eight Great Lake States lose more than 900 million tons of soil each year through erosion. This is the equivalent of 12 tons per person in the eight states or enough material to fill 53 million standard dump trucks.

Erosion and sedimentation are natural processes that can be accelerated or slowed by human intervention, but never stopped entirely. As long as the natural environment is altered, erosion and sedimentation will take place. The challenge for resource managers is to minimize erosion and control sedimentation to maintain and improve the productivity and quality of our land and water resources.

The Great Lakes Basin, as an important agricultural region, is not immune to the consequences of soil erosion and sedimentation. The costs of this erosion and the subsequent sedimentation are great. It has long been recognized that the agricultural sector pays for the on-site costs of soil erosion in the form of lost topsoil and nutrients, and reduced crop productivity. Sedimentation, however, exacts a heavy monetary toll on the nation's system of public works as well as the environment. There are off-site costs that can be attributed to sediment damage, including the need for increased dredging, the loss of wildlife habitat, additional water treatment and the maintenance of stream channels and roadside ditches. Nationally, these off-site costs of erosion have been estimated to be more than $6 billion annually (Clark II, 1985).

Sources of Erosion

Land use strongly influences the amount of erosion that occurs. Table 1 shows the estimated annual erosion in the Great Lakes States by source and state.

Cropland. Nationally, cropland is the largest source of erosion. Cropland is also the largest source of erosion in the Great Lakes States although much of the region's cropland lies outside the Basin.

When examining the impact of the different land uses on the rates of erosion, it is extremely revealing to note where the erosion is taking place within a land use. It is typical for a relatively small percentage of land to contribute the majority of the soil erosion. For example, 106 million acres of cropland in the eight Great Lakes states contribute a total of 607 million tons of eroded soil, but all of it does not erode at the same rate. Cropland considered to be highly erodible in these states contributes about 79 percent of the eroded soil, while representing only about 41 percent of the total cropland area. In fact, about 54 percent of soil eroded from cropland can be attributed to the 18 percent of the cropland with the most severe erosion. More revealing is the fact that the cropland within the Great Lakes Basin is for the most part not classified as highly erodible.

Pastureland and Forest Land. The same trends can be seen in the pastureland and the forest land. The majority of erosion occurs on a small percentage of pastureland and forest acres. With the forest land, it should be noted that the bulk of the erosion is occurring in areas with grazing or timber harvesting activities. Forest lands, however, usually contribute small amounts of eroded material relative to their surface area.

Other Rural Lands. The most severe erosion on "other rural lands," including farmsteads, strip mines, quarries and pits, also occurs in pockets. In some of the states, particularly those with large mining industries like Illinois, Indiana, Pennsylvania and Ohio, the erosion on the other rural lands is a major source of soil erosion in the state. However, the majority of the highly erodible other rural lands, such as strip mines, lie outside the Great Lakes Basin.

Urban Erosion. Streambanks, gullies, roads, and construction from urban areas contribute significant amounts of eroded material relative to their surface area. Although the erosion from urban areas is not included as a separate category in the 1982 NRI, up to 90 percent of the soil erosion in urban areas is attributable to land disturbing practices such as construction activities. Therefore, on a unit area basis the impact of urban erosion is extremely significant. Many water quality experts believe that urban area erosion and sedimentation have more serious, prolonged effects on local water quality in streams, reservoirs, lakes and harbors than sediment from rural areas.

TABLE 1

ESTIMATED ANNUAL EROSION IN GREAT LAKES STATES, BY SOURCE AND STATE
(millions of tons)

State	Cropland	Pastureland	Forest Land	Other Rural	Streambanks	Gullies	Roads	Construction	Total of All Sources
Illinois	172.4	9.4	12.7	6.3	16.5	4.7	0.9	0.9	223.7
Indiana	84.7	5.5	2.8	14.9	15.1	0.7	0.2	0.9	124.7
Michigan	36.3	1.2	2.3	3.0	2.2	0.2	1.0	0.5	46.6
Minnesota	147.8	1.5	2.5	1.8	6.0	5.9	1.9	2.2	169.4
New York	17.4	1.7	1.8	3.0	11.9	2.4	6.1	1.1	45.3
Ohio	49.4	7.8	11.5	20.4	12.1	2.1	1.8	3.0	108.1
Pennsylvania	31.2	3.3	11.9	37.8	7.4	1.2	2.9	3.1	98.8
Wisconsin	67.4	3.2	5.5	3.0	2.6	2.3	1.1	1.3	86.3
Total	606.5	33.6	50.9	90.0	73.8	19.3	15.8	13.0	902.9

Source: 1982 National Resources Inventory. USDA-SCS.

In the Great Lakes States, urban nonpoint pollution sources contribute significantly to the total pollutant loadings to lakes and streams. Construction activities and stormwater overflows, especially, can be major factors in the transport of sediment. High public costs of dredging, ditch and channel maintenance and sediment removal from ponds and reservoirs make it increasingly necessary to control erosion from urban sources.

III. SEDIMENTATION AND WATER QUALITY ISSUES

Sedimentation is directly related to the problem of nonpoint source pollution. Nonpoint sources of pollutants are diffuse and not as easily controlled as point sources. Nonpoint sources include run-off from agricultural and urban areas and are responsible for at least half of all water pollution.

Although nonpoint sources of pollution are responsible for such water contaminants as pesticides, PCB's, heavy metals, and phosphorus and other nutrients, the pollutant contributed in greatest volume is sediment (Chesters, 1985).

Sediment is both a pollutant and a carrier of other pollutants. With a drainage area of over 200,000 square miles, the Great Lakes Basin is a natural sink for sediment and the nutrients, pesticides, and heavy metals that bind themselves to it. Lake Erie, for example, has eight large tributaries which flow through rural and highly urbanized areas before reaching the lake. Estimates of the amount of soil that reaches a water body from agricultural lands range from 25 to 40 percent of the total that has eroded. In urban areas, this percentage is much higher due to a drainage network of stormwater sewers and large amounts of paved surfaces. All this suggests that practices which cause soil erosion on the land have far reaching impacts on the water quality of the Great Lakes.

Sediment affects the quality of the water in a number of ways. Its concentration in a water body is usually presented as total suspended solids, which is a measure of the turbidity of the water. Sediment has an aesthetic impact, affecting the recreational use of water, and a physical impact, affecting fish and wildlife habitats. The actual cost of reduced water quality due to sedimentation is difficult to calculate and will be explored further in section IV.

Nutrients and Toxics Associated with Sediment

Nitrogen and phosphorus are nutrients typically associated with soil erosion. In the Great Lakes, phosphorus has received much attention because of its recognized impacts on water quality, particularly in Lake Erie. The 1972 Great Lakes Water Quality Agreement between Canada and the United States established load reduction allocations and compliance schedules for phosphorus. In 1983, Canada and the U.S. proposed phosphorus load reduction plans to address the continuing problems in parts of Lake Huron, Lake Erie and Lake Ontario. In the 1987 Report on Great Lakes Water Quality to the International Joint Commission, the Great Lakes Water Quality Board suggested that current programs would need to be accelerated to achieve the targets.

Management programs have focused mainly on the control of phosphorus to mitigate the effects of nutrients on water quality. Nitrogen, another conventional pollutant, has been considered less of a problem since it is water soluble. However, with increasing use of fertilizers, more emphasis on controlling nitrogen is being considered because of its capacity to contaminant drinking water supplies.

Soil erosion also involves the transport of toxic pollutants from the land to water. In some cases, toxic pollutants are washed into streams, rivers, or storm sewers without attachment to particulate matter. In other cases, the pollutants are transported with the sediment. Areas where the sediment are deposited are often the areas with the most activity, in terms of shipping, recreation and public access. Many of the bays and harbors require dredging to maintain navigation, or construction of recreational facilities.

These and other erosion related impacts cost society more than six billion dollars (Clark II, 1985) as well as resulting in sometimes irreversible environmental damages.

per year?

IV. REVIEW OF IMPACTS OF EROSION AND SEDIMENTATION

A. On-site Impacts

Although this report focuses on the water quality impacts of soil erosion, there are important on-site, economic impacts as well. On-site impacts are damages that occur at the site of erosion. On-site damages of soil erosion, particularly in agriculture, have long been recognized and are usually expressed in terms of reduced soil productivity. This section will concentrate on agricultural erosion since this is the major source of soil erosion nationally, and because some cost estimates are available.

On-site damages of agricultural erosion include the loss of topsoil, reduced soil productivity and the loss of expensive chemical fertilizers and pesticides.

Loss of Topsoil

The loss of topsoil is a severe consequence of soil erosion. In a recent study in Indiana, the loss of 84 million tons of soil was equated to losing the plowlayer (top 7 inches) on 85 million acres. This is equivalent to a loss in property value of about $50 million (Governor's Soil Resource Study Commission, 1984).

The loss of the fertile topsoil results in lost soil productivity often requiring increased use of agricultural chemicals. As this happens, an increasing dependence on these chemicals can result. Increased chemical use has been found in at least one study to result in a decrease in soil polysaccharides which act as a soil glue for good soil structure. According to the study, the presence of polysaccharides was, for the most part, responsible for six more inches of topsoil on an organically farmed field in Oregon than on an adjacent, chemically farmed field (Tonge, 1987).

Reduced Productivity

The extent to which soil erosion reduces productivity is a function of many factors, including the severity of existing eroded conditions, active erosion and deposition during the crop season, the properties of the soil and the adaptive capabilities of the crop. The fact that soil erosion reduces crop productivity has long been recognized. Erosion not only results in the loss of critical topsoil, but its "most serious and ubiquitous long-term consequence . . . appears to be reduction in the amount of water in the root zone and increased susceptibility to drought (Walker, 1986)."

Numerous studies, dating as far back as 1949 and spanning the country, including the Midwest, have found reductions in cotton, corn, soybean and oat yields ranging from 5 to 40 percent as a result of varying rates of soil erosion (Duda, 1985; Governor's Soil Resources Study Commission, 1984). The

Governor's Commission report estimated that Indiana farmers lose $115 million each year in income from erosion induced productivity losses. It further reported that erosion resulted in the increase of production costs by as much as $3.61 per acre in 1971. A more complete summary of these studies was included in the Final Report of the Soil Erosion and Sedimentation Task Force to the Great Lakes Commission (Great Lakes Commission, 1987)

Although erosion results in lost productivity, total crop production has been on the rise due to the great advances in agricultural technology. Technological advances in the areas of hybrid seeds, fertilizers and pesticides have served to offset the negative consequences of soil erosion. Upon analysis, however, researchers have determined that these advances are not a substitute for sound soil conservation practices (Walker, 1986). These technologies do little to improve the adverse impacts of erosion on soil integrity, topsoil depths or the retention of water. Used in conjunction with sound soil conservation practices, technology can enhance yields on deep soils. In fact, future yield-enhancing technologies depend on conservation practices to maintain adequate soil conditions.

Loss of Nutrients and Pesticides

Excessive amounts of chemical fertilizers and pesticides are used to replace the productivity lost due to eroded soils (Duda, 1985). The monetary value of the nitrogen, phosphorus and potassium that is lost with soil erosion was estimated to be $4.40 per ton of eroded soil by the USDA in 1977 (Duda, 1985). Five dollars per ton is the current USDA rule of thumb. In another estimate, the value of nutrients in 84 million tons of soil eroded from cropland in Indiana in 1982 was "conservatively estimated to be around $400 million", or $4.76 per ton (Governor's Soil Resources Study Commission, 1984). Using the current estimate of $5.00 per ton, the value of lost nutrients for the eight Great Lakes states are indicated in Table 2.

Depending on the rate of erosion, the value of lost nutrients can be tremendously large for the individual farmer as well. Take for example an average sized farm of 200 acres. If soil is eroding between 4 tons and 10 tons per acre per year, farmers can lose between $4000 and $10,000 worth of nutrients, respectively.

Although dollar values are not available, a number of studies have shown that conventional farming practices result in greater total pesticide losses than practices involving conservation measures (Mostaghimi, 1987; Duda, 1985). These losses are attributable to the resulting greater soil erosion which carries the pesticides away.

TABLE 2

VALUE OF NUTRIENTS LOST ANNUALLY IN ERODED CROPLAND SOIL IN GREAT LAKES STATES

State	Amount of Cropland Erosion (millions of tons)	Value of Nutrients (millions of dollars)
Illinois	172.4	862.2
Indiana	84.7	423.4
Michigan	36.3	181.5
Minnesota	147.8	738.8
New York	17.4	87.1
Ohio	49.4	246.9
Pennsylvania	31.2	155.9
Wisconsin	67.4	337.0
Total	606.5*	3,032.6*

* State estimates may not add to this figure due to rounding.

Discussion

Much of the information presented in this section is for each of the Great Lakes states as a whole rather than for the in-basin portions of the states. This is principally due to the fact that little information is available for only the basin portions of the states.

Major agricultural states like Illinois, Indiana and Minnesota have relatively little agricultural land (percentage-wise) within the Basin. In addition, the land-use activities within the Basin areas of these states differ greatly from the areas outside the Basin.

There is also no discussion of K values (the soil erodibility factor) in this section, only a brief mention of the significance of highly erodible lands for areas within the Basin. In general, the Basin has deep soils that are eroding at low rates of T (the tolerable soil loss factor) or less. This affects the ability for in-basin farmers to participate in the Conservation Reserve Program (CRP) which takes highly erodible land out of production (see section V). However, recent additions to the eligibility criteria for the CRP have addressed water quality concerns.

While areas within the Basin may not be highly erodible they are causing water quality problems as a result of their close proximity to streams, harbors and the Great Lakes themselves. This underscores the deficiency in current control programs that focus primarily on erosion rather than on sedimentation and the effects on water quality as well.

B. Off-site Impacts

Introduction

There are several water-related impacts of soil erosion and sedimentation that occur off-site from where the erosion takes place. These include impacts on fish and wildlife, recreational activities, dredging and public work facilities. The rates at which eroded soils are delivered to water bodies and ultimately cause off-site impacts, however, is very difficult to determine. Estimates of sedimentation on a regional basis, such as in the Great Lake States, are often imprecise. Estimating the value of off-site impacts are even more complicated and uncertain. When costs cannot be quantified, qualitative descriptions of impacts are often valuable as they can draw attention to the problem and identify future research needs.

Fish and Wildlife

Sedimentation adversely affects wildlife, fish and other aquatic organisms by altering the biological and physical environments that support them. The magnitude of the problem, as it relates to the nation's fisheries, is great. The National Fishery Survey conducted by EPA and the U.S. Fish and Wildlife Service found that fish communities in 81 percent of the nation's waters are not as productive as they could be because of impaired water quality (LaRoe, 1986). They further determined that the main cause of poor water quality was nonpoint source pollution, of which agricultural run-off was the primary contributor.

Sediment adversely affects fish and wildlife by settling on stream and lake bottoms, impacting invertebrates and fish that use gravel beds to deposit their eggs. This alters available food supplies for aquatic wildlife.

As sediment settles, streams become shallower and wider. This causes water temperatures to rise as the sun warms the water more efficiently. This can adversely affect fish species such as trout that cannot tolerate warm water temperatures. Other fish species can lose habitat as well, as sediment fills depressions or "holes" that act as holding areas.

Soil erosion and sedimentation also adversely affect fish and wildlife by increasing the turbidity of the water. Increased water turbidity has a number of impacts. First, it hinders the penetration of sunlight, inhibiting photosynthesis and the production of dissolved oxygen as well as phytoplankton. Second, highly turbid waters inhibit the mixing of dissolved oxygen by altering water temperatures. Increased turbidity also decreases the visibility of fish and other aquatic organisms. This impairs their ability to feed properly. Many invertebrates are unable to feed in highly turbid waters because sediment clogs their feeding mechanisms. Sediment can also clog the gills of fish causing physical damages that can lead to a greater susceptibility to disease.

Finally, sedimentation also adversely impacts fish and wildlife as it transports attached nutrients and toxic chemicals into waterways. Nutrients, such as phosphorus, contribute to the eutrophication or over-enrichment of the water. This leads to an increase in algal growth which depletes the level of dissolved oxygen in the water resulting in changes in animal and plant specie compositions as well as possible fish kills. Fish species more resistant to these types of environmental changes are the less desirable types, such as carp and catfish.

Toxic contaminants from such sources as pesticides and industrial residues are consumed by organisms such as mussels and some plants. As other species feed on these contaminated organisms, the often long-lived chemicals accumulate in their fatty tissues. As they move up the food chain, these chemicals become more concentrated and potentially more dangerous. Depending on the contaminant and the species, chemical exposure can result in problems as serious as mutations or even death.

It is very difficult to quantify the extent of the economic costs of soil erosion on fish and wildlife. Many of the species affected do not have a readily determined value as defined by economic markets. The physical impacts of erosion are not fully understood in all cases, let alone a valuation for affected species. Yet, it is important to gain a better understanding of the full range of the costs of soil erosion that society is paying.

Some attempts at estimating costs have been made. Minnesota has developed values for many game and nongame species for use in levying fines for illegal kills. Some standard economic valuation tools include measuring the expenditures related to an activity, such as fishing and hunting license fees, or the willingness to pay technique. A new approach is to survey peoples' willingness to sell their rights to, for instance, never catch a fish again.

These methods are an important beginning, but there are shortcomings, such as determining the economic impact on the less obvious, but crucial organisms at the bottom of the food chain. These shortcomings should always be made explicit and efforts should continue to include them in cost valuations.

Recreation

Waterways provide many recreational opportunities including boating, swimming, fishing, waterfowl hunting and often serve to compliment other activities such as camping, hiking and picnicking.

Sedimentation can adversely affect boating activities in several ways. Boat propellers, rudders and keels will more easily run aground as more sediment deposits form. Turbid water also hides underwater hazards to boats. Although turbidity is not likely to be solely responsible, 930 vessels ran aground or hit fixed objects in 1971, resulting in approximately 100 deaths nationwide (Clark II, 1985). Suspended sediment as well as excessive algal growth can damage boat motors and machinery. Finally, a number of cases exist where whole lakes or areas of lakes were rendered inaccessible to boats because sedimentation made them too shallow (Clark II, 1985; American Farmland Trust, 1986).

Swimmers face similar dangers from sedimentation as do boaters. Turbid water and excessive algae obscure submerged hazards, increasing the chances of swimming and diving accidents. In the event of a drowning, reduced visibility in the water makes it more difficult to rescue a victim.

Turbid or eutrophic water bodies also detract from the aesthetic appeal of such related recreational activities as camping, hiking and picnicking as well as boating and swimming. Finally, fishing and waterfowl hunting are also negatively impacted by sedimentation. As mentioned above in the section on Fish and Wildlife, sediment can reduce gamefish populations (and other organisms the fish depend on) through displacement, disease and death. Turbid waters further decrease the success of fishing by making it more difficult for gamefish to see fishing lures or baits. Waterfowl that depend on fish or that dive for their food will also be harmed by sedimentation. Waterfowl hunting will be further impacted by sedimentation as wetlands that support duck populations may fill in at faster than normal rates. As mentioned earlier, toxic contaminants that are carried by sediment will not only affect the health of game species but also all animals that feed on them, including humans.

It is "extremely difficult" to estimate the costs of sedimentation on recreation (Russell, 1986). Standard cost estimation techniques, such as travel cost methods, often lack all the necessary data. Because of this data gap problem, Russell goes so far as to conclude in his paper that it "is impossible . . . to estimate the recreation benefits of soil erosion control," and that programs to control it "cannot be justified in any substantial way by recreation benefits alone" (Russell, 1986). He does suggest, however, that valuation methods turn toward intrinsic benefits. This can be accomplished by contingent valuations, or direct surveys of peoples' willingness to pay for clean water. Finally, Russell suggest that costs of soil erosion be calculated beyond any one aspect of its impacts, like recreational costs, alone.

Dredging

The costs of remediation of impacts on water quality attributable to sedimentation are difficult to estimate. Costs which can be calculated are those incurred to dredge, or dig the sediment out of the Great Lakes, streams and harbors.

Excessive sedimentation can result in the need for more frequent dredging to maintain channel and harbor depths for navigation and to prevent flooding.

Dredging expenditures result from both the removal and disposal operations. In many areas, dredged material is contaminated with toxic pollutants and must be disposed of on land or in specially designed, confined disposal facilities. As a result, disposal costs can often exceed the cost of dredging (American Farmland Trust, 1986).

Dredging as an activity can impact the environment, adversely affecting fish habitat and benthic communities, and causing increased turbidity by the resuspension of sediments to the water column. If these sediments are contaminated they can raise the levels of synthetic organics, heavy metals and other chemicals in the water column. Policy questions remain over whether to dredge certain areas or leave the contaminated sediments in place.

The U.S. Army Corps of Engineers is responsible for dredging activities associated with the federally authorized commercial and recreational harbors on the Great Lakes. The Corps spent over $33 million in FY 1985 to dredge nearly 9 million cubic yards of material from Great Lakes recreational and commercial harbors. Costs associated with dredging non-federally authorized recreational harbors are incurred by state or local entities or by private interests.

Total dredging expenditures underestimate the costs of sedimentation to navigation and recreation since limited funds and scheduling problems prevent officials from undertaking all desired dredging projects, and because dredging does not take into account other impacts associated with sediment.

Also, the percentage of sediment from upland areas contributing to the need for increased dredging as opposed to the percentage of material from streambanks and shoreline sources varies from harbor to harbor. However, if sediment loadings could be reduced by say, one-quarter, through the implementation of erosion control practices on upland areas, the cost savings from reduced dredging requirements could be millions of dollars per year which would more than offset the costs incurred to control the erosion.

To illustrate, approximately $4 million per year is spent year to dredge the Cuyahoga and Cleveland harbors in Lake Erie. A 1982 SCS study on the Cuyahoga River found that 587 acres upstream from Cleveland contributed 11 percent of the sediments that must be dredged each year from the river and harbor. The study further found that it costs $440,000 each year to dredge the sediments from just those 587 acres. The study went on to say that a program to control that erosion would cost approximately $1.6 million ($2,800 per acre). Put another way, the money spent for four years of maintenance dredging would offset the costs of controlling erosion on the 587 acres (Lake Carriers' Association, 1987).

Roadside and Agricultural Drainage Ditches

The deposition of sediment in roadside and agricultural drainage ditches limits the ability of these facilities to efficiently convey water. As sediment fills these ditches, and plants take root, local governments and farmers incur the costs of clearing these conveyances. Other costs of ditch sedimentation can include the increased probability of flooding as well as delays in planting crops due to saturated fields.

Estimates of the costs of cleaning agricultural drainage ditches were made recently in a study of six agricultural counties in Ohio that lie within the Great Lakes' Basin (Forster and Abrahim, 1985). Results showed that 8 percent of the estimated annual gross soil erosion in the counties' watersheds was deposited in drainage ditches. The costs of removing this sediment was determined to be approximately $.45/acre/year (1979 dollars). When considered in the aggregate, removal costs can be substantial. Forster and Abrahim extrapolated their results to all ditches in Ohio and found sediment removal costs to be nearly $1 million. In Indiana, researchers found that continued ditch maintenance after initial ditch cleaning added substantially more to removal costs (Governor's Soil Resources Study Commission, 1984).

Care must be taken in using these particular cost figures on a wider scale. The need for ditch cleaning and maintenance is a function of soil erodibility, the physical characteristics of the drainage area, climatic conditions of a particular area and individual land use practices. Costs in one region may very well be quite different than actual costs in other areas. However, it is clear that roadside and drainage ditch cleaning and maintenance costs will be a significant factor in determining the overall off-site costs of sedimentation.

Public Works and Industrial Water Use

Excessive sedimentation adversely impacts water treatment and storage facilities as well as industrial operations. Water used for public drinking supplies as well as for some commercial consumer products must undergo treatment before use. Excessive sediment in these water supplies necessitates increased expenditures on chemicals for treatment, filters and sludge disposal. Suspended sediment will also increase pumping costs as water volume is increased, as well as likely increasing maintenance costs from additional wear and tear on pump machinery.

Nitrogen, as a pollutant, has a major effect on public drinking water supplies. Several major tributaries of Lake Erie have been affected by high nitrate concentrations in the Spring, during years when water run-off from fields is high. Nationally, groundwater monitoring in agricultural areas is also showing high concentrations of nitrates, as well as soluble herbicides and pesticides. Current soil conservation practices are not as effective in controlling nitrogen because it is soluble and therefore does not attach to the soil as phosphorus does.

Filtration equipment must be cleaned more frequently and operated for greater lengths of time to remove excessive amounts of sediment. In some instances, filtration capacity may even need to be increased.

The amount of sludge, a by-product of water treatment facilities, is related to the amount of sediment carried by the water entering the plant. As sediment levels increase, the costs of removing and disposing of additional sludge increases. In one case, plant officials in Michigan felt that the greatest costs associated with sedimentation were the expenditures to remove increased levels of sludge (American Farmland Trust, 1986). Sludge disposal is complicated by the presence of toxic contaminants, which often necessitates disposal in specially designed facilities, further adding to costs.

Water storage facilities, including settling basins in treatment facilities as well as supply reservoirs, can incur additional expenses due to sedimentation. Any excess sediment which settles out of the water will decrease the capacity of the holding facility. While sedimentation is not a major problem for most reservoirs in the Great Lakes, there are many cases, including some in midwestern states, where reservoirs have filled with sediment at alarming rates (Clark II, 1985).

Finally, sedimentation can add to the costs of many industrial operations. High levels of algae resulting from nutrient loadings can clog industrial water in-takes leading to increased maintenance costs as well as lost operating revenues. In the case of power plants that have experienced this problem, the downtime has resulted in the additional expense of the facility having to purchase more expensive electricity from outside sources.

<u>Discussion</u>

To reiterate, there is a lack of quantitative information on the impacts of sedimentation on water quality in the Great Lakes. The task of obtaining this information is complicated by the need to link the damages from sedimentation to the specific sources. Even when costs are explicit, there may still be difficulties in isolating the impacts from sedimentation.

In one study, however, the USDA concluded that the off-site benefits per ton of erosion reduced was the highest for the Lakes States and Northeast regions which comprise the majority of the Great Lakes States (USDA, Ribaudo, 1986a). Ribaudo's explanation is that the higher damages per ton of erosion are due to the demand for higher water quality by in-stream and withdrawal users in these regions.

Ribaudo was unable to quantify all sediment related impacts due to many of the reasons already mentioned. Efforts must continue, however, to account for all costs. The wise use of limited program dollars is at stake. There are a multitude of programs competing for public funds, some of which become available after damages have already occurred. Dollars spent for remediation could possibly be better spent in the prevention of soil erosion.

V. OVERVIEW OF CURRENT FEDERAL PROGRAMS

The federal government has long recognized the impacts of soil erosion and water pollution. The importance of these problems can be seen in the multitude of programs designed to address them. However, major federal programs tend not to have as their primary focus the control of erosion to reduce off-site impacts on water quality. Major programs typically focus either on on-site agricultural productivity or water quality enhancement through sedimentation control but not both.

In this section, federal programs were analyzed because of the important lead role that federal agencies have played in providing support and assistance to states and landowners in controlling erosion and sedimentation. Also, federal programs are designed to address problems on a national and regional level, and can often provide special assistance to particular areas of concern. State programs in the Great Lakes region do exist and play an important role in addressing these problems. State programs were summarized in the Great Lakes Commission's Soil Erosion and Sedimentation in the Great Lakes Region: Final Report of the Soil Erosion and Sedimentation Task Force to the Great Lakes Commission (Great Lakes Commission, 1987). The reader is referred to this report for additional information.

A. Current Federal Agricultural Programs

The major federal agricultural conservation programs are principally concerned with maintaining the productivity of the soil on-site. By controlling erosion they do have the added effect of minimizing off-site impacts on water quality. However, since these programs often lack specific water quality goals, many of the water quality benefits are residual and not well documented.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is one of the provisions under the Conservation Title, of the Food Security Act of 1985. The program encourages farmers to stop producing crops on highly erodible cropland for ten years and plant grass or trees on the land to minimize erosion.

The Agricultural Stabilization and Conservation Service (ASCS) administers 10 year contracts between USDA and landowners. Landowners must enter into a contract before 1990 to be eligible for the program.

Eligible landowners voluntarily enter the program by placing a bid with the USDA for the annual rental payment they would be willing to accept for that land. The federal government will pay accepted landowners an annual rental fee up to $50,000 as well as one-half the cost of planting the vegetative cover crop. The conservation plan to convert the land must be approved by the local conservation district.

Land eligible for the program is determined in large part by the SCS's land capability class system and the tolerable soil loss measure or "T". The land capability class system uses Roman Numerals I through VIII to indicate progressively greater limits on the agricultural use of land. The term "T" is defined as the maximum amount of soil loss per acre per year "that will permit a high level of crop productivity to be sustained economically and indefinitely" (Crosson and Brubaker, 1982). Depending on particular soil conditions, T values range between 1 to 5 tons of soil per acre per year.

To be eligible for the CRP, land must meet one of the following criteria: cropland in land capability classes II through V (land suited for cropland if soil conservation practices are used) eroding at three T or greater; cropland in classes VI through VIII (land limited in use for cultivation); cropland eroding at two T and subject to gully erosion; or, cropland within 99 feet of a perennial stream. The goal of the program is to take 40 million acres of cropland out of production.

Highly Erodible Land Conservation

The Highly Erodible Land Conservation Compliance provision is also contained in the Conservation Title of the Food Security Act of 1985. Unlike the CRP's incentives to control erosion, this provision acts as a deterrent and becomes effective January 1, 1990. Under this provision, a landowner wishing to continue farming on highly erodible soil must have a conservation plan approved by the local conservation district by 1990 and have it implemented by 1995. If the landowner fails to do this he will lose eligibility for certain USDA agricultural incentive programs such as price and income supports, crop insurance, Farmers Home Administration loans and other programs which disperse commodity-related payments.

The "Sodbuster" element of the conservation title states that if a landowner plants annually tilled crops on highly erodible land that was not planted during the period 1981 to 1985 he or she is subject to the terms stated above.

The "Swampbuster" element of the conservation title also covers naturally occurring wetlands that are converted to cropland after the signing of the enacting legislation, December 23, 1985.

Since approximately 80 percent of the nation's farmers participate in USDA programs, these regulations have great potential in gaining the implementation of soil conservation practices in the Great Lakes Basin as well as the rest of the nation.

The Agricultural Conservation Program

The Agricultural Conservation Program (ACP) was established under the Soil Conservation and Domestic Allotment Act of 1935 and subsequently amended in 1973, 1977 and 1979. The ASCS is responsible for administering the program.

The ACP is the principal program through which the USDA provides farmers and ranchers with the financial and technical assistance to implement soil and water conservation practices.

Landowners apply for program benefits by petitioning ASCS for the cost-sharing assistance necessary to implement the conservation practices. The ASCS may provide each landowner up to $3500 annually. The money is distributed by local ASCS committees. Technical assistance is provided by the SCS.

Assistance under ACP is used primarily for such practices as establishing terraces, grass waterways and structures as well as for implementing minimum and no-till farming practices. These practices are not specifically targeted for improving water quality although they often have that benefit.

Conservation Technical Assistance Program

The Conservation Technical Assistance Program (CTA) was also established under the Soil Conservation and Domestic Allotment Act of 1935. Its function is to provide the technical assistance for preparing and implementing soil conservation plans. The program is administered by the SCS and assistance is provided through the nationwide system of soil conservation districts.

Assistance is available for many purposes such as interpreting soil surveys, conducting site investigations as well as designing and installing erosion and sedimentation control practices.

Soil and Water Resource Conservation Act of 1977

The Soil and Water Resource Conservation Act of 1977 mandates USDA to appraise soil and water resource conditions and trends every five years. The Secretary of Agriculture, in cooperation with other federal, state and local agencies, is required to develop and periodically update a program for conserving and protecting these resources. The first appraisal was completed in 1980.

B. Current Federal Nonpoint Source Water Quality Programs

The major federal nonpoint source water pollution control programs have as a main goal the improvement of water quality. They can often be applied to agriculturally related water pollution problems but are designed to reduce nonpoint source pollution in a broad-based manner. However, programs that establish standards for nutrient loadings for instance, often serve as an impetus for controlling soil loss from upland areas.

Water Quality Act of 1987 - Clean Lakes Program

The Clean Lakes Program was amended under the Water Quality Act of 1987. The program authorizes grants to states of up to $30 million each year to implement approved methods to control pollution entering lakes and restore their quality.

To qualify for grants, states must submit a biennial report beginning in April, 1988 on the water quality of their lakes. The report should include, among other things, the identification and classification of eutrophic lakes, the extent of point and nonpoint source loadings and the descriptions of procedures to control pollution sources and methods of restoring water quality.

The program also authorizes $40 million to conduct a water quality demonstration program to, among other things, develop pollution control technologies especially for nonpoint sources and for the removal and disposal of contaminated lake sediments.

Water Quality Act of 1987 - Nonpoint Source Management Program

The Nonpoint Source Management Program was also established under the Water Quality Act of 1987. The program requires states to prepare an assessment report to identify categories of nonpoint sources of pollution and describe their programs for controlling these sources.

Each state is also responsible for preparing a nonpoint source management program. The management program should include best management practices to reduce loadings from categories identified in the assessment report, methods to implement the program, an implementation schedule and the certification that the state's laws provide the necessary authority for program implementation. The Act authorizes $400 million in fiscal years 1988-1991 to be used as grants to the states for implementing their nonpoint source management program. No funds have been appropriated to date, however.

If a state has not submitted an assessment report by July, 1989, the EPA will. If a state does not submit a management program, a local organization with the authority to manage nonpoint sources of pollution may, with the state's approval, request technical support from the EPA to prepare the management program. The organization will receive the same state funds as long as the program is approved.

Great Lakes Program - Clean Water Act of 1972

The Great Lakes Program was enacted with the Clean Water Act in 1972. Its purpose is to fund demonstration projects in the Great Lakes Basin to study nonpoint source pollution problems as well as methods to control them. Projects use the resources of local governments as well as various federal agencies to implement the program's goals and objectives.

In 1981, the Great Lakes National Program Office began a demonstration project in the Western Basin of Lake Erie basin in Ohio, Indiana and Michigan to accelerate the adoption of agricultural conservation practices with the goal of reducing phosphorus loadings to the lake. County soil and water conservation districts together with the SCS and the ASCS of the U.S. Department of Agriculture cooperated in a multi-agency effort to provide conservation tillage equipment and technical assistance to participating farmers. Funding for the demonstration was ended in 1985 with officials calling the efforts a success. Ohio farmers participating in the program for instance, adopted conservation tillage practices at a rate that was two-and-a-half times higher than other farmers in the state. Researchers concluded that the demonstration program was responsible for a "significant portion" of the estimated 1.9 million tons of soil and nearly 900 tons of phosphorus saved in the participating counties during 1981 to 1985 (U.S. EPA, 1987a).

The Great Lakes National Program Office is focusing current demonstration project funds on areas with in-place, contaminated sediments. This will aid in the effort to improve water quality in the Great Lakes, but demonstration projects are still necessary to combat the source of the problem, namely agricultural soil erosion.

Rural Clean Water Program of 1979

The Rural Clean Water Program was enacted by Congress in 1979. Through the USDA, the program provides long-term technical and financial assistance to agricultural landowners who have a land-use related, identifiable water quality problem. The program encourages the use of best management practices to control the levels of sediment, chemicals and livestock wastes entering water bodies. Only 21 project areas across the country were approved for funding under this program.

The program is administered by the ASCS with the SCS coordinating all technical assistance. Agricultural land owners and operators voluntarily enter the program by preparing a conservation plan with the aid of the SCS. If the plan is approved, the farmer enters into a 3 to 10 year contract with the local county ASC committee to implement the plan. Federal cost share payments for each best management practice are available from the county ASC committee and are limited to 75 percent of the cost of each practice and to $50,000 per landowner over the life of the project.

VI. SPECIAL PROGRAMS / CURRENT AND PROSPECTIVE

In addressing the issues of erosion, sedimentation or water quality, the following programs were selected for presentation because they achieve special recognition for a region to address a critical problem. While the Great Plains Conservation Program and the Chesapeake Bay Program were not designed to specifically or exclusively address water quality improvement through erosion and sedimentation control, they are innovative in their approaches to problem solving and have been successful in achieving their goals. They also provide good background for discussion of the need to achieve special recognition for the Great Lakes through the establishment of a Great Lakes Basin Program.

Great Plains Conservation Program

The Great Plains Conservation Program was authorized in 1956 by public law 84-1021. It is designed specifically for the Great Plains region of the country, encompassing 518 counties in 10 states from Montana south to Texas. The goal of the program is to "conserve, protect, develop, and utilize the soil and water resources of the Great Plains region" (USDA, 1987).

The program was not specifically designed with the goal of improving water quality. Its focus is on conserving soil, but will reduce sedimentation as a secondary benefit. It is instructional though, to study the program's method of providing services and obtaining results through a structure that provides economic incentives and technical support.

The federal government provides private land users in the region with technical and financial assistance necessary to accomplish the program's objectives. Farmers and ranchers voluntarily enter the program by submitting a conservation plan for their land. SCS personnel usually assist in the drafting of the plan. Plans are designed with attention to climatic factors of the region and consist of schedules of changes in farming practices and land uses, or the use of structural measures that are deemed necessary to conserve soil and water. Since the region is primarily grassland, most projects are designed to protect rangeland and pastureland, as opposed to cropland, with a system of conservation practices that insure long-term productivity.

The plan emphasizes the contract method of cost sharing between the landowner and the federal government. The contract commits the landowner to carrying out the conservation plan. Upon the signing of the contract, the USDA will share part of the cost of the plan, up to $35,000 per contract. In the past, the federal government has paid approximately 44 percent of all the plan's costs, averaging payments of $10,500 per contract. Progress on contracts is assessed annually by SCS staff and individual contracts are modified if necessary.

In the last decade, the program's annual budget has been approximately $20 million. The money has been appropriated to the USDA and administered by the SCS. Conservation plans are implemented as the government provides cost sharing assistance to the individual land user, as specified in the contract. Contracts may be entered into until 1991 and are for period of 3 to 10 years.

Chesapeake Bay Program

The Chesapeake Bay Program was established in 1983 with the signing of the Chesapeake Bay Agreement by the U.S. EPA and the four jurisdictions of Maryland, Virginia, Pennsylvania, and the District of Columbia. The Agreement resulted from an exhaustive, 7 year EPA study of the Chesapeake Bay that was completed earlier in 1983. The study documented the degradation of the bay and concluded that nonpoint sources of toxics and nutrients were principally responsible. As a result, the goal of the Agreement was to coordinate the efforts of an array of federal and state agencies to control nonpoint source pollution and continue monitoring the state of the bay. Six other federal agencies, including the SCS, joined the signatories of the agreement within the year.

A principal feature of the program is the institutional structure that was developed to coordinate the distribution of funds for projects and the activities of the four jurisdictions. An Executive Council consisting of representatives of the signatories of the Agreement oversees a committee responsible for the implementation of the various pollution control programs, as well as five subcommittees including a nonpoint source and a technical advisory subcommittee. A new EPA office, the Chesapeake Bay Liaison Office, was established to help with coordination by providing the jurisdictions with administrative and analytical support. Also, over 150 monitoring stations were established around the Chesapeake Bay and its tributaries to gather baseline data and support a computerized watershed model of the bay.

Federal funds, most recently from the 1987 reauthorization of the Clean Water Act, provide $10 million per year in program grants and $3 million for fiscal years 1987-1990 for the EPA's Chesapeake Bay Liaison Office.

The grants are specified for either new, long-term programs or for projects that are a part of a comprehensive nonpoint source program specific to a particular river basin. These funds can be used for either structural or non-structural control programs. Each of the 3 states receive 30 percent of these grants and the District of Columbia receives the remaining 10 percent. There is a 100 percent matching requirement of each jurisdiction. At least 75 percent of the funds must be spent on nonpoint source pollution control efforts.

The four jurisdictions also receive a variety of other support from various federal agencies. Soil and water conservation districts supply public information materials and technical assistance. The SCS trains technical field personnel and provides technical support for the various other federal cost-sharing conservation programs. Resources of other federal agencies such as the ASCS and the Cooperative Extension Service are also employed to control the nonpoint source pollution entering the bay.

The four jurisdictions carry out their own control programs, and due to their differing nonpoint source problems, laws and agency resources, specific programs vary. However, most programs begin by identifying the critical geographic areas to focus on and which cost-effective management practices, or Best Management Practices (BMP), to use.

BMPs are used to address both agricultural and urban nonpoint source pollution. Agricultural BMPs address such things as tillage practices, the use of fertilizers and methods of controlling animal wastes.

Unlike agricultural BMPs, some urban nonpoint source BMPs are enforced through regulations. All four jurisdictions issue permits to builders at construction sites to enforce practices to minimize sedimentation. Other urban BMPs include the use of porous pavement and infiltration trenches to limit stormwater overflows.

The Chesapeake Bay Program's control of nonpoint source pollution including sediment, its dedicated source of federal funds and its regional focus is akin to what is needed to improve water quality in the Great Lakes. A side-by-side comparison of the Lake Erie Basin and the Chesapeake Bay even reveals that the problem of sedimentation and its resulting damages appears to be greater in the Great Lakes (see Table 3). While the Chesapeake Bay drains an area three times the size of the Lake Erie Basin, the Lake Erie Basin supports a larger proportion of intensive row crop agriculture and a higher population density. As a result, the tributaries of Lake Erie receive more than six times the amount of sediment and fives times the amount of phosphorus than Chesapeake Bay tributaries receive (Baker, 1987).

TABLE 3

COMPARISON OF THE LAKE ERIE AND CHESAPEAKE BAY BASIN

Parameter	Lake Erie	Chesapeake Bay
Population	14,000,000	14,000,000
Land Area (miles^2)	35,406	103,023
River Sediment Loads (metric tons/yr)	6,531,000	3,005,800
River Phosphorus Loads (metric tons/yr)	8400	4659
River Nitrogen Loads	111,670	77,584

Source: Baker, 1987. Lake Erie Agro-Ecosystem Program: Sediment, Nutrient, and Pesticide Export Studies, Draft Report.

Based on the above comparison, it is clear that dedicated long-term funding is needed to develop and support a special erosion and sedimentation control effort that emphasizes the protection and improvement of Great Lakes water quality.

Great Lakes Basin Program

At its 1988 semi-annual meeting, the Soil Erosion and Sedimentation Task Force of the Great Lakes Commission presented its recommendation to the full Commission regarding the need to establish a Great Lakes Basin Program to protect and improve Great Lakes water quality through erosion and sedimentation control.

The objectives of the program are:

- To achieve special legislative recognition for the water quality problems associated with erosion, sedimentation and the delivery of nutrients and toxic contaminants to the Great Lakes.

- To provide dedicated, reliable long-term funding for erosion and sedimentation control programs in the Great Lakes Basin.

- To better coordinate efforts, roles and initiatives between federal, state and local soil conservation and pollution control agencies and groups in the Great Lakes Basin.

- To recognize sediment as an important pollutant, its role in the transport of chemicals and to improve the linkage between erosion control and water quality programs.

- o To support the development and implementation of urban and rural nonpoint source management programs and sediment components of Remedial Action Plans under terms of the U.S.-Canada Great Lakes Water Quality Agreement.

- o To build coalitions and networks to support a Great Lakes Basin Program and to share information and educate groups and individuals with similar interests and goals.

- o To protect and enhance the region's water quality for the benefit of all economic and environmental interests.

The Proposed Great Lakes Basin Program would include five principal elements:

- o Program Grants and Technical Assistance.
- o Financial Assistance and Demonstration Grants.
- o Demonstrations and Special Projects.
- o Evaluation/Monitoring.
- o Education/Information.

Under the program, a federal lead agency (or agencies) would be designated to implement and coordinate the specific program areas in conjunction with the states. The U.S. Environmental Protection Agency and the SCS would have important roles, with enabling legislation designating a lead agency. This legislation would mandate interagency agreements among and between various federal agencies, including the U.S. Environmental Protection Agency; SCS; Cooperative Extension Service; ASCS and the Agricultural Research Service. A single line agency within each of the eight Great Lakes States would be designated as the grant administrator.

The Great Lakes Basin Program is envisioned as a ten-year commitment, with funding for the first year at $10 million, second year funding at $15 million, and subsequent years at $25 million.

Funds appropriated for the start-up phase of the program (years 1 and 2) will be used primarily, but not exclusively, to:

- o help the states in developing program plans to implement the Great Lakes Basin Program;

- o begin implementation of those portions of the state nonpoint source management programs that relate to erosion and sedimentation;

- o set up evaluation/monitoring programs so that baseline data can be gathered; and

- o identify erosion control/water quality research needs that can be addressed through the various aspects of the program in years two through ten.

Funds appropriated for the implementation phase of the Program (years 3 to 10) will be used to address all five Program elements.

There will be a state cost-sharing requirement of not less than 25 percent for any of the principal elements, with the built-in flexibility to include financing mechanisms such as revolving loan funds for certain aspects of the program. This does not preclude higher matching requirements for certain aspects of the programs such as demonstration grants.

VII. Conclusions and Recommendations

Conclusions

In a 1986 study titled Reducing Soil Erosion: Off-site Benefits the Economic Research Service of the USDA attempted to quantify the off-site damages of erosion. While not precisely directed at the Great Lakes, the USDA researchers found that two regions, the Lakes States and the Northeast will receive the greatest benefits per ton of soil erosion reduced as a result of their greater demand for high water quality (USDA, Ribaudo, 1986a).

The purpose of this paper has been to give an overview of soil erosion and sedimentation issues in the Great Lakes. A second goal, stressing the importance of sediment as a pollutant, its role in the transport of chemicals and its impact on the environment, was to alert the reader to the fact that information in this area is lacking but critical to the development of nonpoint source management programs.

Historically, erosion control programs have emphasized the on-site benefits of sustained soil productivity rather than the off-site impacts of soil erosion on water quality. For the Great Lakes, it is extremely important to improve the linkage between erosion control and water quality programs, and to develop soil erosion and sedimentation control programs that lock in water quality priorities.

There are several reasons why this needs to occur:
1) Excessive sedimentation in the Great Lakes Basin results in significant economic losses and extensive water related impacts, yet information on sedimentation and sediment loadings and water quality impacts to the Great Lakes, particularly from upland areas, is lacking.

2) The role that sediment plays as a transporter of other pollutants has not been well quantified and is not completely understood. The complex nature of nonpoint source pollution makes quantifying the impacts from any one source extremely difficult. There is general agreement that off-site water related damages from sedimentation are widespread but the overall effects of sedimentation to water quality degradation need to be considered in relation to the transport of chemicals, urban stormwater runoff and agricultural practices.

3) The eligibility of agricultural areas within the Great Lakes Basin to be included in the Conservation Reserve Program under the Food Security Act has been restricted due to the program's past focus on highly erodible lands.

Recommendations

Several principal recommendations suggested by the preceding discussion include:

1) The Great Lakes Commission, the SCS and the U.S. Environmental Protection Agency working with the Commission's Soil Erosion and Sedimentation Task Force should continue their efforts to develop and establish a Great Lakes Basin Program to protect and improve Great Lakes water quality through erosion and sedimentation control. Efforts should continue on program design, with necessary advocacy and outreach to establish broad-based Congressional and constituent support. Program design efforts should include special attention to the quantification of off-site impacts of Great Lakes soil erosion and sedimentation.

2) An extensive evaluation of off-site costs and impacts associated with sedimentation in the Great Lakes should be undertaken by appropriate agencies; perhaps a cooperative approach involving the Great Lakes Commission, the EPA and the SCS. This should include the effects of sedimentation on such aspects as; fish and wildlife resources, recreation, dredging, and the system of industrial and public works. Federal, state, regional, local and private entities should be contacted for information on all counties in the Great Lakes Basin, where available. Alternately, a site-specific study or demonstration program could be undertaken to develop a model, applicable to other areas to assess off-site impacts.

3) A thorough review of current, federally-funded Great Lakes programs is needed to identify specific opportunities to better link soil conservation and water quality goals. In addition to support for a new Great Lakes Basin Program, as called for above, revisions to existing programs provide a complementary approach. Once identified, the Great Lakes Commission and other Great Lakes interests can work with the Great Lakes Congressional Delegation to support such opportunities.

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