SEDIMENT TASK FORCE RECOMMENDATIONS

Publication 221 *June 2002*

SUSQUEHANNA RIVER BASIN COMMISSION
SEDIMENT TASK FORCE

SUSQUEHANNA RIVER BASIN COMMISSION
SEDIMENT TASK FORCE MEMBERS

Richard Batiuk, *Chesapeake Bay Program Office, U.S. Environmental Protection Agency*
Alternate—**Charles Rhodes**, *U.S. Environmental Protection Agency, Region 3*

Thomas W. Beauduy, *Sediment Task Force Chair*
Chesapeake Bay Commission/Susquehanna River Basin Commission

Daniel M. Bierly, *U.S. Army Corps of Engineers, Baltimore District*

Karl Brown, *Executive Secretary, Pa. State Conservation Commission*
Alternate— **John Pari,** *Bureau of Plant Industry, Pa. Department of Agriculture*

Robert E. Edwards, *Water Quality Division, Susquehanna River Basin Commission*
[Representing CBP-Implement. - Monitoring Subcommittee]
Alternate—**Andrew D. Dehoff**, *Water Management Division, Susquehanna River Basin Commission*

Thomas R. Embich, *Consultant to Susquehanna River Basin Commission*

Scott J. Foti, *N.Y. State Dept. of Environmental Conservation*
Alternate—***Frank Estabrooks**, *N.Y. State Dept. of Environmental Conservation*
Alternate—**Jeffrey Myers**, *N.Y. State Dept. of Environmental Conservation*

Jerry Griswold, Ph.D., *USDA Natural Resources Conservation Service, Chesapeake Bay Program Office*
Alternate—**Alan Wood**, *USDA-Natural Resources Conservation Service*

Jeffrey Halka, *Md. Geological Survey*
Alternate—**Darlene Wells**, *Md. Geological Survey*

Marshall J. Kaiser, *Safe Harbor Water Power Co.*
Alternate—**Orin L. O'Donel**, *Safe Harbor Water Power Co.*

Michael J. Langland, *U.S. Geological Survey*
Alternate—**Lloyd Reed**, *U.S. Geological Survey*

Kenn Pattison, *Office of the Chesapeake Bay Watershed, Pa. Dept. of Environmental Protection*
Alternate—**Donald Fiesta**, *Bureau of Watershed Management, Pa. Dept. of Environmental Protection*

L. Kenneth Pensyl, *Nonpoint Source Program, Water Management Administration, Md. Dept. of the Environment*
Alternate—**Visty P. Dalal,** *Md. Dept. of the Environment*

N. Christian Porse, *PPL Corp.*

Thomas Simpson, Ph.D., *University of Maryland, [Representing CBP Nutrient Subcommittee]*

Ronald K. Smith, *Susquehanna Electric Company, Conowingo Hydro Station*
Alternate—**Donald W. Baldwin**, *Susquehanna Electric Company*

Paul O. Swartz, *Exec. Director, Susquehanna River Basin Commission*

Alan Taylor, Ph.D., *Consultant, Chesapeake Research Consortium [Representing CBP-STAC]*
Alternate—**Jaclin Schweigart**, *STAC Staff, Chesapeake Research Consortium*

Richard A. Weismiller, Ph.D., *Dept. of Natural Resource, Sciences and Landscape Architecture, University of Maryland [Representing CBP-STAC]*
Alternate—***M. Grant Gross**, *Exec. Sec.-STAC, Chesapeake Research Consortium*
Alternate—***Caryn Boscoe**, *STAC Coordinator, Chesapeake Research Consortium*

*Served partial term.

CONTENTS

ILLUSTRATIONS

INTRODUCTION

The issue of sediment buildup behind the dams on the lower reaches of the Susquehanna River, and more particularly the loss of sediment storage capacity behind those dams, is now drawing considerable attention. There is heightened concern about the issue because of the implications it raises with respect to nutrient and sediment loads to the Chesapeake Bay, and with the management of sediments generally throughout the Susquehanna River Basin.

Earlier studies released in 1995 by the U.S. Geological Survey (USGS) and the Susquehanna River Basin Commission (SRBC) indicate that the dams have historically acted as a sediment (and associated nutrient) trap, thus reducing the amount of sediments and nutrients reaching the Bay. As of 1990, the total amount of sediment trapped by the dams was estimated at 259 million tons. The USGS estimated average trap efficiency for the dams as high as 70 percent for sediments and upwards of 40 percent for phosphorus.

As the dams reach a steady-state, or equilibrium (i.e., when they reach their maximum sediment storage capacity), they no longer influence the ultimate fate of sediments transported by the Susquehanna. Of the three lower dams, two (Holtwood and Safe Harbor) are considered to be effectively at steady-state, and Conowingo is anticipated to reach that status between 2015 and 2025. The net effect of reaching a steady-state is increased loads of sediments and nutrients to the Bay equal to the amount currently being trapped.

Given the implications for Bay restoration efforts and sediment management throughout the river basin, the Chesapeake Bay Commission, through its Pennsylvania Delegation, provided grant funding to the SRBC to organize and chair a multiagency task force to review the technical aspects of the issue and make management recommendations to policy makers at the state, regional, and national level.

The Sediment Task Force was organized in July 1999 by the SRBC, with the following charge: (1) undertake a review of existing studies related to Susquehanna sediment transport and storage; (2) evaluate and make recommendations on management options to address the issue; (3) conduct a symposium to bring experts and policy makers together; and (4) recommend continued areas of study, research, or demonstration.

The Task Force met for 18 months before organizing a Sediment Symposium, which it held in December 2000. The Symposium, coupled with the ongoing deliberations of the Task Force, have provided a forum for bringing together expertise on the following issues:

1. The state of our knowledge with regard to sediment loads in the basin and their sources, including historical information;

2. The implications of that loading data and the lower Susquehanna reservoir capacity issue on Bay Program goals *(We are indebted to the Scientific and Technical*

Advisory Committee of the Chesapeake Bay Program for having conducted a special workshop in March 2000 examining potential Bay impacts.);

3. The efficacy of various management technologies or practices;

4. An analysis of various riverine, upland, and reservoir management options for controlling basin sediment loads;

5. The applicability or implications of Susquehanna River Basin sediment management issues to other river basins in the Bay watershed and their resulting cumulative impact on Bay restoration efforts; and

6. Evaluation of current sediment monitoring and assessment level of effort and recommendation of appropriate refinements to provide the most useful information to evaluate demonstration projects and guide long-term sediment management efforts.

This report sets forth a series of recommendations developed by the Task Force for riverine, upland, and reservoir management options in the basin.

Riverine management recommendations are focused on stream restoration and stabilization, riparian buffers, and natural and constructed wetlands. As is the case with the upland recommendations, emphasis is placed on the use of BMPs and natural systems to slow the speed of water runoff, thus limiting its erosive effects. Since energy builds as water moves downstream toward the Bay, equal attention must be paid to streambeds and floodways as is paid to flow originating from land sources.

Upland recommendations address agricultural, forest, mining and urban lands, as well as transportation systems. To date, most BMPs have focused on nutrient pollution, particularly those on agricultural lands. BMPs will have to be expanded to address both nutrients and sediments, and existing practices must be evaluated to determine their effectiveness in controlling both. For urban lands, recommendations are made for promoting innovative, environmentally-sensitive site design measures, ground-water recharge, improved water quality, stream channel protection, and enhanced watershed management of stormwater and floodways.

First, a feasibility study is recommended to determine if dredging the reservoirs is a viable option to maintain or reduce the volume of sediment currently trapped behind the dams. Other alternatives, including sediment bypassing, sediment fixing, and modified dam operations, were considered, but dismissed. The Commission is now working to secure the necessary Congressional support to allow the U.S. Army Corps of Engineers to begin such a study.

In anticipation of this feasibility study and with funding support provided by the Chesapeake Bay Commission and the Commonwealth of Pennsylvania, the SRBC also began a study in cooperation with USGS, Maryland Geological Survey, and the University of Maryland to characterize the sediment stored behind the dams. The study, intended to determine the physical, biological, and chemical composition, will help to establish if the accumulated sediment can be put to beneficial use if dredging proves to be a viable option. A final report is anticipated in 2002.

Regardless of whether dredging to extend the life of sediment storage capacity is undertaken, the Task Force also concluded that reducing sediment loading throughout the basin is critical. It presents a series of recommendations for riverine and upland management, designed to improve BMPs along the rivers and in the basin in order to reduce the sediment flow.

At a more generic level, the Task Force recommends enhancement of sediment monitoring and modeling to facilitate smarter and more comprehensive management decision-making. While a certain level of monitoring data is maintained, and while the current Bay watershed model can be useful in informing management decisions, the data are at a scale too general to provide the specific policy-relevant information needed to make sound management decisions.

These recommendations are offered to provide guidance to policymakers in the Susquehanna River Basin on the issue of sediment management. They also may serve as a foundation for management options elsewhere throughout the Chesapeake Bay Watershed.

RIVERINE MANAGEMENT RECOMMENDATIONS

Category A: Stream Restoration and Stabilization

Recommendations: A key component to a Riverine Management Plan is to restore, stabilize, and protect the Susquehanna River Basin stream systems. As part of that management plan, it is important to provide the necessary funding and appropriate technical guidance in order to restore or stabilize impaired stream systems within the basin. When benefits and risks allow, natural stream design methods should be used to restore riparian corridors. The following are specific recommendations regarding stream restoration:

1. Continue to fund stream restoration pilot projects across the state through the existing Growing Greener Program.
2. Develop "Guidelines for Stream Restoration and Stream Assessment" (e.g., stream restoration toolbox).
3. As Part of the NPDES Phase II implementation strategies, include conditions in the municipal stormwater permits for retrofitting degraded stream systems.
4. Promote and conduct education and outreach workshops on stream restoration.
5. Coordinate, identify, and implement stream restoration strategies through Pa. DEP's Watershed Programs, and related programs of federal and state jurisdictions within the Susquehanna watershed.
6. Stream restoration techniques and strategies should be incorporated into all existing land development programs (e.g. agricultural, new development, redevelopment, state and federal construction projects, etc.).

An example of a natural stream restoration strategy is Montgomery County's Stream Protection Strategy (Md.) (http://www.co.mo.md.us/dep/Watershed/csps/csps.html). Also, an example of guidance material is MDE's Waterway Construction Manual (http://www.mde.state.md.us/wetlands/guide/toc.pdf).

Importance: A significant source of sediment is from eroding stream banks and the degradation of stream channels exacerbated by increased run-off from developed uplands. By stabilizing stream channels through restoration techniques (e.g., root wads, imbricated rip-rap, brush bundles, planting or not mowing stream buffers, etc.) as well as controlling the runoff for a specific storm event (e.g., managing runoff for the more frequent storm events to stay within bank full conditions, normally 1 to 1.5 year storm event), we will assist in the control of eroding stream channels. By controlling stream bank erosion, we will be moving towards delisting impaired stream segments and achieving Federal Clean Water Act requirements, Chesapeake Bay Agreement Goals, and improving the overall quality of Susquehanna River Basin stream system.

Implementation: Stream restoration and/or stabilization should be implemented through all existing and future programs, and proper guidance material should be developed that includes an education and outreach component to ensure its success. Funding of pilot projects should continue through programs such as the Pa. DEP Growing Greener Program and the Pa. Dirt & Gravel Roads Pollution Prevention Program. State and federal agencies should be role models and assist in the development and implementation of proper stream restoration techniques using natural materials.

Expected Outcome and Benefit: Stream restoration is but one component to a riverine management plan that will reduce the amount of sediment pollution, an improved stream habitat, and create a healthier Susquehanna River Basin stream system and Chesapeake Bay.

Category B: Sediment Trapping Structures

Recommendation: Conduct a basinwide assessment of sediment trapping capability of multiple use water impoundment structures.

Importance: Determine whether water impoundment structures have a direct or indirect impact on sediment load being delivered to the main Susquehanna River system. Water impoundment structures should include those built through Public Law 566 projects, U.S. Army Corps of Engineer projects and similar public and private multiple use impoundments.

Implementation: Such an assessment should include state and federal surveys akin to the Pennsylvania Department of Environmental Protection, Division of Dam Safety database of dams and structures that was developed in the 1990s. The design capacity of each structure should be determined to find if some, or all, of the capacity has been filled with sediment.

Expected Outcome and Benefit: The expected outcome would be a comprehensive database of multiple use dams and structures in the Susquehanna River Basin, and an evaluation of their relative value in sediment trapping and flow control.

Category C: Sediment Transport Assessments

Recommendations: In order to assess the instability of stream channels and evaluate riverine management options, one must understand changes in river channel characteristics, and also understand those characteristics with respect to the activities occurring within the entire watershed. Upland and riverine sources of sediment and processes need to be evaluated as an interrelated system. Enhanced sediment monitoring that effectively supports modeling and research needs to characterize sediment source, sediment transport rate, and watershed sediment yield (delivery). <u>The following enhanced sediment-monitoring design recommendations are made for characterizing sediment transport and delivery in the Susquehanna River Basin, through the lower Susquehanna reservoirs, and the Chesapeake Bay. These monitoring enhancements should complement related watershed modeling improvements</u>.

1. Monitor at a scale that provides adequate spatial coverage of diverse physiographic/land cover watershed types.

2. Assess sediment delivery from overland sources.
3. Assess sediment storage and remobilization from stream banks and channels.
4. Characterize sand, silt, and clay fractions in monitoring system design.
5. Use or develop a sediment budget process/method that partitions the sediment yield at the watershed outlet into the sediment sources by particle size.
6. Determine sediment residence time by source.
7. Collect data for watershed models that emphasize channel processes and suspended-sediment delivery.
8. Document select field parameters/indicators that influence stream state (e.g., sediment supply, flow regime, bank erodibility, etc.) in terms of existing unstable condition to that of a potential stable condition as a means for riverine management and sediment control.
9. Add storm event sampling for suspended sediment and particle size fractions at existing state water quality networks.
10. Review existing models for applicability of sediment erosion, suspension, transport, deposition, and resuspension processes and identify types of models needed where none exist.

Importance: Erosion of sediment and delivery to off-site locations affects streams, reservoirs, and estuaries. We need to understand how the distribution of sediment sources and sediment particle sizes within a watershed relate to the sediment yield from the watershed. Also, sediment lag time, or residence time, needs to be clearly understood because the sediment reaching the mouth of a watershed is the summation of different lag times from different sources. Understanding these relationships is critical for the functionality of best management practices (BMPs) and restoration efforts for sediment control, especially if various BMPs are implemented and sediment yields do not change.

On a national scale, several studies indicate that, of the total amount eroded off the uplands in natural watersheds, only a small percentage (10-20 percent) is delivered to rivers and estuaries, while the remaining percentage (80-90 percent) is being stored somewhere between erosion sites and the rivers and estuaries. Unstable stream channels can erode the riparian zone, remobilize stored sediment, and increase sediment yields. Sediment yield from a watershed is limited by the conveyance capacity of the streams and flood plains. When this capacity is exceeded by sediment supply, storage of sediment occurs. If the sediment supply drops below the conveyance capacity, then there must be net loss of storage. The desired stream channel condition is where the stream, over the long-term, is not degrading due to over scouring or aggrading due to increased deposition.

Implementation: Specific recommendations should be added to current monitoring programs. Evaluate existing multiagency monitoring networks that can implement specific recommendations through a multijurisdictional coordinating committee, such as, the Chesapeake Bay Program Non-Tidal Water Quality Workgroup and the Sediment Workgroup. Other recommendations may require a special study or a specifically-focused investigation.

Expected Outcome and Benefit: The observed suspended-sediment load at current monitoring network stations is the result of both erosive processes that generate sediment, and transport and storage processes that mobilize sediment. Information on sediment budgets, lag times, and stream stability will help identify where sediment yields from different watersheds are dominated by erosion from overland sources or dominated by remobilization of stream corridor source areas. Use of specific parameters/indicators on upland and riverine conditions will help track changes in the sediment erosion, transport, delivery, and yield cycle due to watershed activities, e.g., development, restoration, BMP implementation. This information is critical for restoration efforts and sediment management. For example, if sediment delivery is not significant from stream corridor areas, widespread implementation of traditional upland BMPs to control soil loss should have a rapid measurable effect in reduced sediment load. However, if the observed sediment load is from storage areas along the stream corridor, the downstream benefits may be slow to appear.

Category D: Stream Bank/Channel Stability Assessment

Recommendation: Do basinwide, uniform monitoring of stream channel stability and stream bank conditions.

Importance: Most often we define sources as those various land use areas contributing to the overland erosion and runoff process and sediment delivery to streams. However, the riparian zone (stream banks, stream channel, and flood plain) may be a significant and direct sediment source to the stream network in a watershed. This occurs when the natural stream channel equilibrium and stability are compromised, resulting in either net aggradation or net degradation over time. One of the conclusions from the SRBC Sediment Symposium was the need to better understand the condition of the riparian zone as a source of sediment in order to better manage or target BMPs.

There are over 31,000 stream miles in the Susquehanna River Basin, or over 62,000 miles of stream banks when one considers both sides of the stream. An assessment of these many miles is a monumental task that would require an enormous amount of resources, in terms of money, manpower, and time. One approach to do stream monitoring is to utilize trained volunteer monitors. In Pennsylvania, some watershed organizations are already doing some form of stream water quality monitoring with volunteers. Many citizen monitors want their data to be utilized by environmental and water resource agencies. However, because streams in the Susquehanna River Basin drain diverse physiographic areas and land uses, testing methods may not be comparable among watersheds and probably lack the specific indicators needed for a basinwide evaluation. Along with an understanding of how these diverse conditions react to and place different stresses on the stream network, assessment criteria and quality assurance also are important considerations.

Implementation: As an example, Pennsylvania has established the Citizens Volunteer Monitoring Program, guided by the Pa. DEP. Several organizations, including Environmental Alliance for Senior Involvement (EASI), Pennsylvania Organization for Watersheds and Rivers (POWR) and independent watershed groups, are coordinated as a network of volunteer watershed monitors. Such an organization, basinwide, would need to:

1. Identify groups that are currently monitoring and evaluate potential monitoring activities.
2. Promote and coordinate training and quality assurance protocols for sediment data/information collection by connecting technical assistance from service providers to the volunteer monitoring group.
3. Act as a clearinghouse to integrate volunteer-generated data into one database.
4. Coordinate with existing riparian efforts and programs.
5. Promote the use of volunteer data by local, state, and federal agencies to effectuate improved environmental quality and encourage others to continue the effort in areas needing assessments.

This coordinating agency would need to work with a group whose members would include scientists and technicians experienced with sediment monitoring and sediment-related issues. This technical workgroup would:

1. Identify a process to develop the needed criteria or indicators. This would include evaluating existing rating systems.
2. Develop an assessment tool that is simple to apply and consistent in methodology.
3. Provide technical assistance to volunteer groups identified by the coordinating organization.
4. Provide guidance on data management needs to integrate the criteria or indicators into a database system and linkage to a geographic information system.

Conceptually, the organizational infrastructure to move this concept forward already exists in parts of the Susquehanna River Basin. Many watershed groups exist and new groups are forming throughout the Susquehanna River Basin. The Pennsylvania Stream Team (a multiagency advisory committee) and POWR could take on a significant coordinating role. Technical workgroups such as the CBP Nutrient Subcommittee's Sediment Workgroup and the Monitoring Subcommittee's Nontidal Tributary Workgroup could provide the assistance to POWR and watershed groups with data use and amalgamation of the database. Select members from the Sediment Task Force also could serve in this capacity.

Expected Outcome and Benefit: A comprehensive and detailed database of riparian conditions within the Susquehanna River Basin is the direct result of the implementation of the recommendation. The dataset would include a series of indicators/parameters that describe riparian conditions and are also tied spatially to a geographic information system.

This data set could be used to develop a more targeted stream restoration strategy and provide an important dataset to other agencies tracking implementation of riparian buffers. Because this approach provides a consistent methodology for data compilation and assessment throughout the basin among watershed groups, riparian conditions could be revisited and evaluated for change.

Category E: Riparian Buffers

Recommendations:

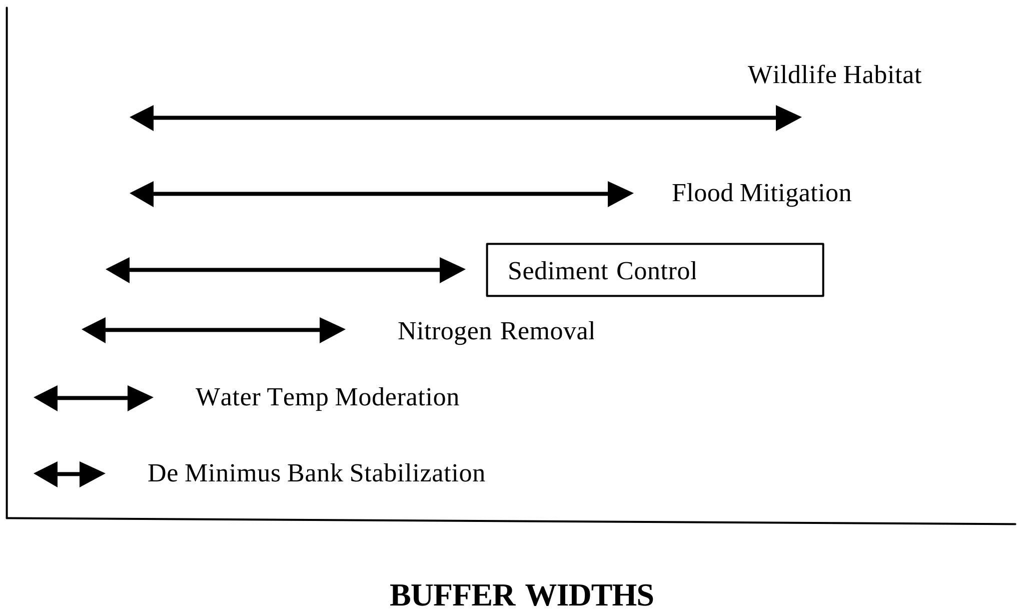
1. Increase buffer width, where possible, to maximize sediment retention and to mitigate flow during high flow episodes.
2. Significantly increase the number of stream miles with riparian zones beyond the 2,010 miles targeted in the Chesapeake Bay 2000 agreement.
3. Build riparian buffers for long-term effect. Incorporate woody plants into buffer zones, in addition to, or instead of, herbaceous types. **NOTE**: Most effective buffers contain a mixture of vegetation, most importantly including woody plants and need 10-20 years to mature and become most effective.
4. Achieve continuity and integration of buffers into natural landscape in addition to optimizing buffer width.
5. Make buffer layout and design for sediment control a sustainable system.

Importance: Effective riparian buffers help to dissipate energy from sheet runoff and over bank flow, which can result in sediment removal. Other benefits include flood mitigation, nutrient removal, bank stabilization, and reduced variability in water temperature.

Implementation: Agencies currently involved with riparian buffer programs include the U.S. Fish & Wildlife Service, National Resources Conservation Service, Pa. Game Commission, Trout Unlimited, and USEPA-Chesapeake Bay Program, to name a few. Any state, federal, or local group that deals with stream restoration, fish, or animal habitat improvement can help to establish or restore riparian buffers as part of their projects.

Expected Outcomes: A significant reduction in suspended sediment and total suspended solids in the water can be realized with best management of land areas adjacent to streams (riparian zones). Figure 1 shows relative riparian buffer widths to accomplish specific functions of these buffers.

Figure 1. Relative Buffer Widths



Category F: Natural and Reconstructed Wetlands

Recommendations:

1. Significantly increase the wetland acreage (especially in the flood plains) in the Susquehanna River Basin.
2. Continue "no net loss" of wetlands philosophy, but modify to "with no net loss" of function and value, also.
3. Design and integrate both riparian buffers and wetlands (including wetlands with buffers) in flood plains for optimum sediment control benefit.

- Most effective design incorporates continuity of all wetland and buffer features into the landscape
- Control flow through meander and/or detention before it reaches the stream
- Incorporate as many sediment control tools into the landscape as reasonable

Importance: Natural and reconstructed wetlands provide flood control, energy dissipation of flow resulting in deposition of sediments, removal of nutrients, ground-water recharge, wildlife habitat, and sometimes, aquatic recreation areas. **NOTE**: Most wetlands of the Susquehanna River Basin are Palustrine (3 types)

- Emergent wetland (marshes most commonly found along lakes and rivers)
- Shrub wetlands
- Forested wetlands (half of all wetlands this type)

Leading causes of destruction—agriculture and pond construction

Implementation: Those state and federal agencies that have jurisdiction over wetlands should be involved with implementation of these recommendations.

Expected Outcome and Benefit: According to USGS, wetlands can reduce flood peaks up to 80 percent. Flow in a river is inversely related to the area of wetlands in the watershed. Examples of the benefits from various sources: a 95-acre wetland retained 50-80 percent of the inflow sediment load in a Wisconsin study. In a paired study in New Jersey, wetland destruction caused 6 ft of bank erosion/yr in the impacted basin, while no change occurred in the "control" basin. Wetland destruction and conversion to agricultural land caused a tripling in sediment concentrations in the Illinois River. Water purification of wetlands from one swamp in South Carolina is estimated to be worth $5 million/yr. California estimates value of water purification of wetlands statewide in 1992 to be approximately $3 billion/year.

If the above facts and project successes are part of a broad education focus by the respective agencies and educational institutions from elementary through professional levels, the additional benefit and impact derived by the implementation of these and related recommendations will be significant.

UPLAND MANAGEMENT RECOMMENDATIONS

Category A: Agriculture Uplands

Recommendations: Reduce field soil loss and retain field losses at the edge of field before delivery to stream systems. The following are specific recommendations regarding agricultural upland sediment management:

1. Promote clean water practices as an additional component to practices that consider maintaining soil productivity.
2. Evaluate existing soil loss tolerances on water quality responses.
3. Provide better information on "sediment delivery" to edge of field
4. Encourage partnerships through volunteer watershed organizations.
5. Demonstrate clean water practices through education and outreach workshops (e.g., Steve Groff farm in Pennsylvania).
6. Emphasize agricultural management plans that address enhanced nutrient and sediment management.
7. Enlist all farmland, in highly erodable soil regions, into conservation management practices.

Importance: There is a great deal of experience with agricultural sediment control practices. Much of this works to maintain soil productivity and is not always related to water quality impacts. As a result, practices that limit erosion to "soil loss tolerances" (usually 3-5 tons/acre/year) may, or may not, provide adequate water quality protection. There is a need to develop conservation management plans on farmland in highly erodable soil areas. Funding to promote this enlistment, or to create incentives to enlist, need to be considered.

The task group recommends that existing and new practices be considered both for maintaining soil productivity and as clean water practices (the minimization of soil and nutrient loss to receiving streams). It may be that more rigorous conservation practice application is needed to achieve clean water reductions than to maintain soil productivity. The task group recommends that future practice implementation be planned to accomplish both maintenance of soil productivity and clean water objectives, such as CREP. The greater the participation of farmland in these BMPs, the greater the prevention of soil loss, particularly, on highly erodible soils.

Implementation: The objective of agricultural programs designed to reduce sediment is to encourage landowners to change their behavior with respect to land management. Sound land management practices generally can have a direct positive impact on sediment reduction through the implementation of BMPs. Conversely, poor land management practices can have a detrimental impact. Encouraging or forcing landowners to implement sound land management practices can be accomplished through two general approaches, voluntary and regulatory.

Landowners generally favor the voluntary approach because of inherent flexibility. However, as a last resort, a regulatory approach may be needed to accomplish critical water quality goals.

Programs: The following list briefly describes various types of programs designed to reduce sediment getting into water sources and causing environmental damage:

Watershed Approach: A watershed approach encourages landowners to cooperatively and collectively work to solve problems existing in a particular watershed. The watershed approach demonstrates to landowners how actions in one part of the watershed can have profound impacts in other parts of the watershed.

Education Programs: Educational programs are designed to educate citizens and landowners about the benefits of conservation. Educational programs, for youth through adult, should cover topics such as sound land management principles, land management for profitability, conservation ethics, and economic benefits of protecting the resource base.

Financial Incentive Programs: Financial incentive programs provide landowners with an opportunity to defray real costs of installing BMPs.

Cost-Share Programs: A public or private entity shares the initial installation cost with the landowners. This process implements practices that society deems important or an organization views as being in the best interest of its membership.

Tax Incentive Programs: One type of tax incentive involves an annual income tax or property tax reduction (where these are allowed by law), based on a landowner's implementation of sound land management practices. It may have a time limit, or it could become a permanent incentive, based upon the period the landowner maintains the practice.

A second type of tax incentive is a one-time tax break or credit for installation of a best management practice.

Regulatory Programs: Regulatory programs are generally the least favored among landowners. There is a natural resistance to being required to implement land management practices. Most regulatory programs are originated from government agencies given the responsibility to protect the natural resources of the nation or a state. Implementation is effective, but often costly, and requires continuous maintenance to remain effective. Subdivision and zoning ordinances by local governments also are regulatory, and restrict land uses on environmentally sensitive areas.

Technical Assistance Programs: Technical assistance is available to landowners through both the public and private sector. Local, state, and federal agencies and sometimes not-for-profit organizations provide technical assistance to landowners for education about programs, and for planning, designing and installation supervision of BMPs.

Expected Outcome and Benefit: Reducing sediment loss provides cost savings to the agricultural community, provides healthier streams, and thus, recreational opportunities. In addition, decreased channel maintenance costs are incurred due to reduced sediment loads and debris. Actual costs are dependent upon the specific soils, types of crops, and slopes adjacent to the stream. The most erodible soils in the Susquehanna River Basin are in the southern portion, where the Piedmont soils types exist, and therefore, improved "clean water" practices in that zone will be most effective.

Category B: Urban Uplands

Recommendations: The key objective to urban upland sediment management is to minimize disturbance, stabilize as soon as possible, provide adequate erosion and sediment control measures for active construction projects, and maintain predevelopment runoff characteristics. The following are specific recommendations regarding urban upland sediment management:

1. Promote innovative environmentally-sensitive site design measures, ground-water recharge, improved water quality, stream channel protection, and enhance existing watershed management programs to ensure better-coordinated and enforced stormwater water quality and floodway management.
2. Evaluate existing regulatory programs and voluntary efforts and make recommendation to improve these sediment management programs (e.g., additional resources, etc.).
3. Provide additional education and outreach to the development and building community, environmental community, local planners, engineers, plan reviewers, inspectors and the general public regarding erosion and sediment control, stormwater management, retrofitting existing development, stream restoration, pollution prevention, etc.
4. Encourage local, state, and federal demonstration projects that lead by example.
5. Demonstrate new construction techniques that provided environmentally-sensitive design (e.g., rain gardens, disconnection of roof and no roof runoff, enhanced buffers, natural conservation, reducing impervious surfaces, narrower roadways, grass channels, use of nonstructural BMPs, innovative stormwater management structures, phasing of erosion and sediment control plan, accelerated stabilization, minimize earth disturbance, etc.).
6. Development of watershed management plans that provide enhanced water quality treatment, ground-water recharge, channel protection, and flood protection.
7. Design stormwater BMPs to maximize the settling of sediment particles (e.g., adopting a performance standard of 80 percent removal of TSS).

Importance: Development activities can cause adverse impacts on the physical, chemical, and biological integrity of both terrestrial and aquatic ecosystems. Impacts can be caused by activities such as clearing vegetation, mass grading, removing and compacting soils, and extensive use of impervious surfaces (such as buildings, parking lots, and roadways). These activities significantly alter a watershed's hydrology by reducing runoff storage capacity; reducing the volume of ground-water recharge; and increasing runoff volumes, velocities, discharge frequencies and the magnitude of flows. In urbanized areas, these hydrologic changes manifest themselves as flashy streams (higher storm peak discharges and lower dry weather base flows), increased flooding, more frequent runoff events, higher annual pollutant loads, increased stream erosion and sedimentation, disruptions of instream habitat, and loss of aquatic biota. Furthermore, the magnitudes of these impacts are cumulative, increasing as more land is developed and watersheds become more impervious.

Erosion and sediment control during land-disturbing activities is an essential element to ensuring sediment-laden runoff is minimized. Accelerated stabilization, phase construction plans that address initial stage to final stage of construction, adequate design, inspection and enforcement tools, are key elements during land disturbing activities. Stormwater management, historically, has been designed to provide peak discharge and flood control for after development conditions. The new focus is to improve water quality, increase ground-water discharge, and provide stream channel protection, as well as flood and extreme flood control.

Implementation: Increase awareness and promote environmentally-sensitive designs that rely on more nonstructural BMPs (BMPs such as rain gardens, disconnected roof and no roof runoff, sheet flow, vegetative filters and channels, open section roadways, vegetated buffers, etc). Improvement in urban BMPs (which are a combination of structural and nonstructural measures) by ensuring that the BMPs are designed as part of an environmentally-sensitive site design and maximize the settling of sediment particles (e.g., performance standard of 80 percent TSS removal and 40 percent phosphorous removal).

The task group identified the following recommendations for urban land use:

Soil loss prevention: Enhanced and maintained erosion and sediment control through accelerated stabilization (e.g., immediate, 24-, 48-, or 72-hour vegetative cover for difficult areas or steep slopes, 7- and 14-day rule, etc.); phased erosion and sediment control plans that provide increased protection from the initial stage through the final stage of construction; increased education and outreach for plan reviewer, designer, developers, inspectors, general public; better enforcement tools (e.g., stop work orders, administrative penalties, adequate staffing, etc.); and demonstration and increased monitoring of innovative practices (e.g., super silt fence, deflogulation materials, certain geotextile materials, etc.).

Ground-water recharge: Promoting ground-water recharge for all soil types when proposing new development projects (http://mde.state.md.us; a new stormwater management approach). Encouraging sheet flow and the use of rain gardens; green roofs or roof gardens, rain barrels; disconnecting your roof and no roof runoff through the use of vegetative filters, drywells or French drains; and minimizing compaction of soil and reduce the amount of initial disturbance by maintaining natural conservation areas or reforestation of cleared areas. Also, pretreat the development's runoff prior to discharge to a natural wetland area or the waters of the state.

Water quality: Improve and provide water quality treatment of stormwater runoff. Treat 90 percent of annual runoff (approximately 1 inch of rainfall over the impervious area).

Stream channel protection: Protecting channels from excessive erosion caused by increased flow at, or near, the bank full level. Provided by 24-(12 in Use III/IV) hour extended detention of the post-developed one-year design storm.

Over bank flood protection and extreme flood protection: Protecting infrastructure from flooding caused by increases in peak discharges due to development. Utilizing our flood plains as sediment trapping devices.

Expected Outcome and Benefit: Environmentally-sensitive designs through enhanced landscaping techniques and disconnection of roof and no-roof runoff, improved ground-water recharge for maintaining and improving stream base flow, improved water quality, better stream channel protection, less erosion from construction sites, less cost (e.g., less infrastructure required, less storm drains and pipes to convey water, more natural or vegetative measures). Overall, less sediment-laden runoff during construction, and reduced runoff after construction, that results in improved water quality for our streams, Susquehanna River, and the Chesapeake Bay.

Category C: Transportation Systems

Recommendations: The focus of transportation system sediment management is to minimize sediment and road maintenance additives in roadway, railway and highway construction runoff. The following are specific recommendations regarding transportation upland sediment management:

1. Identify and promote a program of "clean water practices" for highway/railway construction and maintenance.
2. Evaluate current edge of right-of-way soil grading practices and stormwater management catch basins designs to reduce sediment discharge.
3. Provide training programs for all roadway/railway construction contractors and government employees responsible for maintenance work; such as within the "Dirt & Gravel Roads Pollution Prevention" program, focused on sediment and stormwater BMPs.
4. Encourage innovative use of right-of-way easement areas for ground-water infiltration and sediment reduction.

5. Demonstrate new technology and practices to reduce siltation and sediment from railway, highway, and roadway construction and maintenance activities.
6. Develop better liaison programs between conservation agencies and transportation construction, maintenance contractors, agencies and all levels of government to build a "clean water practices" work ethic.

Importance: Because of the tens of thousands of miles of roads and railways traversing the Susquehanna River Basin, road building, railway maintenance, and road/highway maintenance activities impact each stream. If a focused sediment/siltation reduction work ethic is impressed upon the transportation management-related segment of government, significant sediment reduction could be realized in a short period.

Implementation: Improve erosion and sediment control during construction and repair and maintenance.

Enhance stormwater management using landscape-based practices and infiltration techniques.

Improve ditch management and maintenance (minimize exposed soil, provide vegetative or protective cover to as great an extent possible).

Make stormwater and erosion control measures appropriate to road system types, dirt roads, subdivision roads, secondary roads, primary and highway systems, and railways.

Expected Outcome and Benefit: The expected outcome and benefits are cleaner flowing waters near transportation corridors after storms, less debris management required of catch-basins, better long-term cost efficiency of roadway maintenance, and improved ground-water recharge adjacent to impervious road surfaces. Many conservation practices are not costly to implement, but the training and recognition of the value of implementing such practices makes them successful.

Category D: Forestry Uplands

Recommendations: The main objective to forestry upland sediment management is to manage the forest soil as a unique ecosystem with great potential for reducing erosion when it is healthy. The following are specific recommendations regarding forestry upland sediment management:

1. Identify and promote a healthy forest soil management program where foresting is taking place.
2. Evaluate techniques to enhance energy dissipation in forested areas that mimic the healthy undisturbed forest ecosystem.
3. Provide forest preservation and restoration programs, and grazer management programs to protect the forest from overgrazing, particularly, white-tailed deer.

4. Encourage forest plot enlistment in such programs as Clean and Green, and Ag-preservation and the purchase of development rights by conservancies, where appropriate.
5. Demonstrate and research the BMPs for forest harvesting to provide for the least impact upon a healthy forest ecosystem during harvesting. Consider the Dirt & Gravel Roads program as a model approach.
6. Develop, expand, and use the Continuous Forest Inventory to better focus on the private forestlands in the basin.

Importance: Based on extensive research, a healthy forest ecosystem has the best water retention, erosion control and sediment control characteristics of any land use in the Susquehanna River Basin. Wherever this type of ecosystem can be protected, restored, or mimicked, sediment control will be maximized.

Implementation:

1. Implement and maintain forest-harvesting BMPs
2. Encourage forest expansion, restoration or preservation.
3. Fund the training and out-reach programs to enlist private forest plot owners in conservation programs, to train forest harvesters in BMPs, and to preserve or restore healthy forests within the Susquehanna River Basin.

Expected Outcome and Benefit: The greater the amount of forested area in the Susquehanna River Basin, the greater the sediment holding capacity of undeveloped upland areas**.** Since the hardwood forests of the northeastern states provide a significant economic resource for the United States and the world, it is logical to protect and enhance the sustainable harvesting of these great forest resources.

Category E: Mining Uplands

Recommendations: The focus of mining upland sediment management is to minimize the impacts that abandoned mine land (AML) has on receiving streams, and therefore, the Bay. Abandoned mine land contributes sediment and uncontrolled acid mine drainage to receiving streams. Pennsylvania alone has over 250,000 acres of surface coal AML. Pennsylvania is currently reclaiming 800 to 1,000 acres of AML each year. The surface coal mining industry is reclaiming 3 to 5 times that area as part of normal mining BMPs. At this rate, it will take at least 50 years to address this problem.

1. Promote the identification and implementation of acid mine drainage abatement technology.
2. Petition for a multiyear appropriation of the federal Title IV AML (Abandoned Mine Lands) Trust Fund for states with approved long-term reclamation management plans.

3. Encourage the identification of all existing funding sources and develop new sources for financing acid mine drainage restoration projects, including:

   - Streamline and integrate the federal and state process for obtaining funding for restoration work, such as restoration of the Rural Abandoned Mine Program (RAMP)
   - Enact legislation to establish a mine drainage cleanup fund

4. In Pennsylvania, remining has removed or buffered pollution loading of acid discharge in nearly 98 percent of the sites given permits for remining. We must establish and implement an effective program that encourages the remining of abandoned mine lands:

   - Reduce unnecessary regulatory barriers to remining, for example, obligatory perpetual treatment of preexisting discharges even when operator mined in accordance with permit provisions. We should develop other incentives that reduce the risk and constraints associated with remining.
   - Support research efforts and demonstration projects to promote the science of AML reclamation, and provide additional technical personnel to implement the reclamation programs, particularly in design and construction
   - Enact legislation that creates remining tax credits that can be applied against an operator's total state and federal tax liability.

Importance: Abandoned mine land (coal, noncoal, metal, and nonmetal) all contribute sediment to receiving streams. Many of these AMLs also contribute other pollutants, including heavy metals and metal oxides that result in coatings on streambeds. It will be difficult to meet 2010 goals without enhancing programs that address this problem.

Implementation:

- Meet or exceed revegetation requirements.
- Encourage reforestation of AMLs, and perimeter areas.
- Adequately fund the programs that can most effectively implement the recommendations.

Expected Outcome and Benefit: Expected outcome and benefit: reclaiming AML at a faster rate will reduce sediment loading; reduce pollutant loading; and establish 250,000 acres of usable land, most of which are within the Susquehanna River Basin.

RESERVOIR MANAGEMENT RECOMMENDATIONS

The Sediment Task Force and the SRBC generally support a preliminary impact study of dredging in the interest of maintaining or reducing the volume of sediment currently trapped behind the lower Susquehanna River dams. The study would determine if maintaining the sediment-trapping capability of the dams by dredging is technically and logistically feasible, economically viable and environmentally acceptable. The work of the Task Force and the continued input of the Task Force members will provide a solid foundation for future study efforts. The SRBC will continue to work with appropriate elected officials to have such a study authorized and appropriated for the U.S. Army Corps of Engineers.

The Task Force also considered various other in-reservoir alternatives. As with the dredging option, the primary goal of any in-reservoir option is to preserve the reservoir's ability to trap sediment as it is carried down the Susquehanna River and, if possible, to reduce the volume of sediment that is available for transport during high-flow episodic events. The alternatives that were considered include sediment bypassing, sediment fixing, and modified dam operations.

Sediment bypassing is an option that is practiced in many reservoirs throughout the world to maintain water storage capacity behind dams. The primary goal of this method is to pass sediments through the dams during less critical (that is base, or nonstorm, flow) periods so that the reservoirs maintain storage capacity for high-sediment transport storm events. This lessens the amount of sediment passed during these storm events. It is during the larger storm events that most of the negative impacts of sediment are inflicted upon the Bay ecosystem. This method, however, would not greatly mitigate the effects of catastrophic storm events. That is, events during which the flow is sufficient to scour the in situ material and cause the net transport of sediment past the dams to be greater than the sediment load that the river carries into the dams. Furthermore, this option would result in a base load condition that exceeds the current base load into the Bay. It is unknown at this time if the current load is acceptable, though it is generally assumed that it is not. Since this option would be counter to the currently accepted goal of reducing the sediment input to the Bay, this option was dropped from consideration.

Sediment-fixing implies the capping of sediments such that their continued transport is impeded even during high-flow events. Capping is considered an appropriate method to control contamination. Usually, capping is accomplished by placing clean dredged material over contaminated material so that the contaminated sediment is rendered harmless to nearby benthic communities. Sometimes this capping, or stabilization, is used in conjunction with treatment of the material being capped. This process would do little to mitigate scouring events, as described above. Also, this option does not change the amount of sediment passing through the system, nor does it add capacity to the reservoirs. Since it is not believed that the sediments within the reservoir are contaminated, this option is not appropriate. The Task Force considered the option of hardening the material such that it could not be scoured, but it was unclear as to how this would be done or what it would cost. Furthermore, this would not address the primary concern over the lack of available sediment capacity in the reservoirs. These options were not considered further.

The option of modifying the operation of the dams also was considered. Dam operations are currently established for the purpose of electricity generation, within the constraints and requirements of the Federal Energy Regulatory Commission (FERC) and applicable state and environmental laws. To require the dam operators to modify standard operation may unduly impact their primary purpose. The dams were not established as sediment traps, though this ancillary effect has been very beneficial over time. Furthermore, it is unclear if modified operation could accomplish anything in the interest of sediment control other than as a form of bypassing, as discussed previously. Since the potential benefits of modified dam operations seem limited, at best, this option was dropped from consideration.