# The Role of Pollution Prevention in Reducing Nutrient Enrichment of Chesapeake Bay

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## Introduction

This case study explores the use of pollution prevention strategies in a large, multi-jurisdictional effort to reduce nutrient enrichment in Chesapeake Bay. Nutrient enrichment has increased chlorophyll production and reduced dissolved oxygen levels below those that can maintain a healthy ecosystem. The resulting loss of submerged aquatic vegetation threatens many commercially and recreationally important species, such as blue crabs, oysters, and juvenile fish.

The "pollution prevention" approach to environmental protection was ushered in by the Pollution Prevention Act of 1990. The U.S. Environmental Protection Agency (EPA) defines pollution prevention as "source reduction" and "other practices that reduce or eliminate the creation of pollutants through (1) increased efficiency in the use of raw materials, energy, water, or other resources or (2) protection of natural resources by conservation."[1] Unlike traditional approaches to "control" pollution through end-of-pipe and clean-up strategies, pollution prevention strategies are applied throughout production, distribution, and consumption processes to reduce the substances that cause pollution.[2]

We begin with an introduction to the nutrient enrichment problems and describe the Chesapeake Bay Agreement, a federal and multi-state effort to reduce pollution in the Bay and its tributaries. The case study then discusses some of the strategies underway to show that pollution prevention strategies are an active part of the nutrient reduction activities underway in Maryland, Pennsylvania, Virginia, and the District of Columbia. Much remains to be done to fully integrate the pollution prevention approach into solving this complex, regional problem.

## A System Under Stress

Chesapeake Bay is the largest estuary in the United States and one of the most productive in the world. It spans 2,300 square miles, with more than 4,400 miles of shoreline. The long, shallow basin averages only 27 feet deep but holds 18 trillion gallons of water.[3] Freshwater comes from more than 50 major tributaries to the north and west with a 64,000 square mile watershed; this combines in the Bay with an equal volume of Atlantic salt water from the south. (See **Figure 1**.) The watershed extends into six states and three geographic provinces from Southern Virginia to New York and from the DelMarVa Peninsula on the Bay's Eastern Shore to the Appalachian foothills of West Virginia and western Pennsylvania.[4] Seven major rivers contribute about 90% of the Bay's freshwater: the Susquehanna (which contributes 50% of the water), the Patuxent, the Potomac, the Rappahannock, the York, the James, and the Choptank.

More than 40% of the original forests and wetlands have been converted to urban and agricultural lands, and wetland loss continues to occur at a rate of eight acres per day.[5] Population in the watershed has exploded, with much of the development occurring on Bay and riverfront property, clearing natural forest buffers that once protected the Bay from sediment and storm water runoff. In 1950, 8.4 million people occupied the watershed; in 1990, 14.7 million lived there, and projections for 2020 suggest a population of 17.4 million.[6]

Submerged aquatic vegetation (SAV) serves as a habitat for juvenile fish and crabs and is a source of primary productivity in the food web. SAV declined sharply between 1965 and 1980 as a result of increased algae growth and sedimentation and has only begun to recover.[7] Most of the Bay's fisheries suffer from exposure to multiple stressors, such as over-fishing,

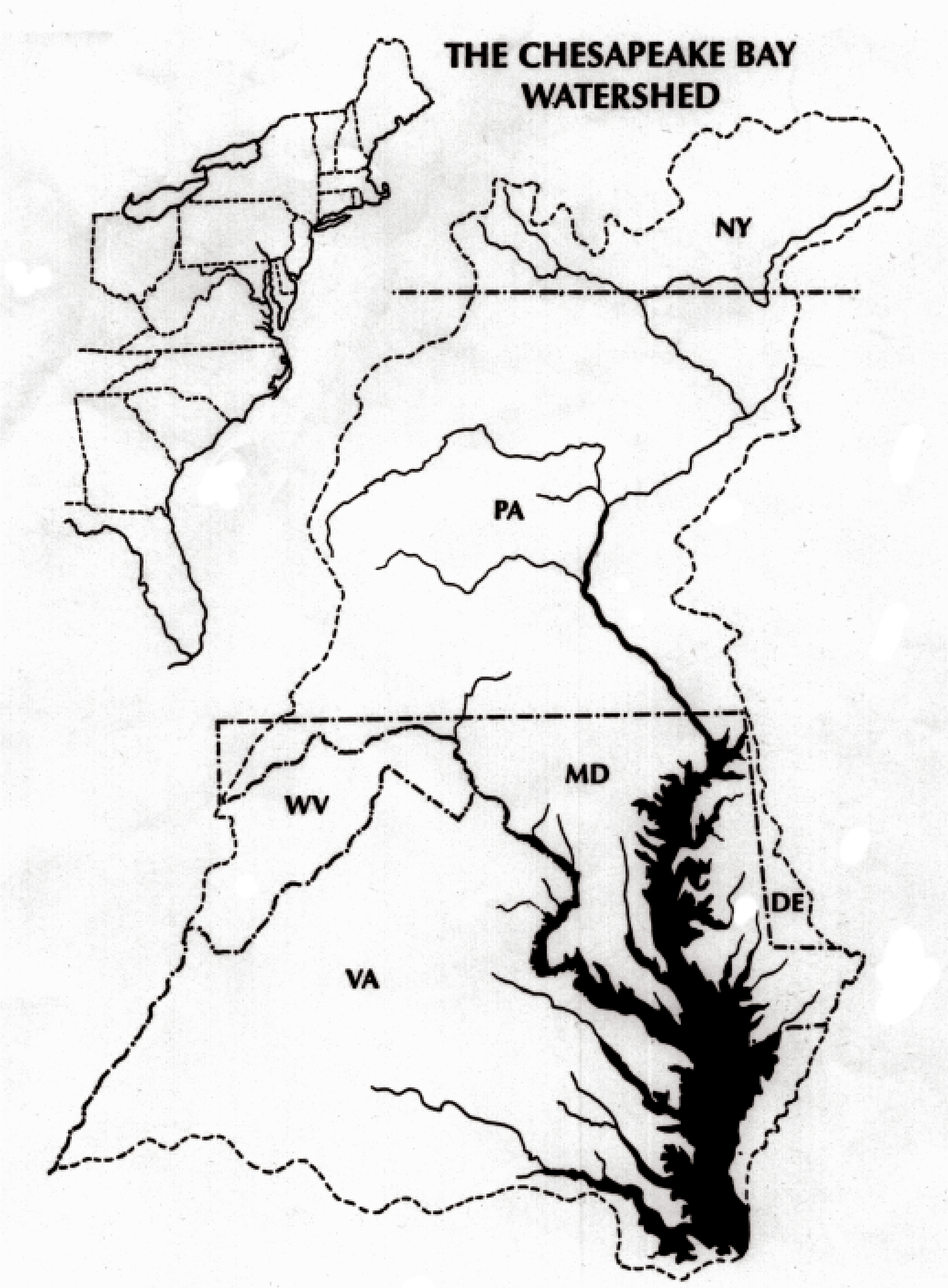


**FIGURE 1**

anoxic conditions caused by nutrient enrichment, habitat loss, and toxic contamination. A number of commercially and recreationally important species, such as the American shad, have been driven to the point of extinction and have been the subject of expensive restocking efforts. Pollution that continues from multiple sources throughout the watershed threatens the health and genetic vitality of the populations and their habitats that remain.[8]

The greatest human impact on the Bay is nutrient enrichment or eutrophication, specifically phosphorus and nitrogen enrichment.[9] While moderate quantities of nutrients are a key stimulator of healthy levels of phytoplankton (microscopic algae that are a primary food source in the ecosystem), excess levels of nitrogen and phosphorus over-fertilize the Bay. Excessive algae can deplete oxygen from the water, block sunlight needed by Bay grasses, and cause the overall health and aesthetic quality of the ecosystem to decline (see **Figure 2**). Agriculture and household fertilizer runoff, air pollution, acid rain, sewage and industrial outfalls, deforestation, and urban development all contribute to this nutrient increase, as indicated in **Figure 3**.

An EPA study which examined nutrient enrichment in the Bay concluded that the amount of water in the main part of the Bay that had low or no dissolved oxygen in 1980 was fifteen times greater than in 1950.[10] The upper reaches of almost all Bay tributaries were highly enriched in nutrients. In most parts of the Bay, water quality degraded between 1950 and 1980, contributing to the declines in SAV. Those declines were spatially correlated with the areas of highest nutrient concentrations, mostly in the upper Bay and near western shore tributaries.

Formal recognition of the decline and the need for intervention did not occur until 1975, when the U.S. Congress authorized the EPA to create the Chesapeake Bay Program. Congress ordered the Program to conduct a five-year study of the Bay's water quality and resources and to develop management strategies to preserve the Bay's quality.[11] Prior research had documented pollution's effects on the Bay but did not adequately address whether losses of fish and Bay grasses were (1) cyclic or permanent and (2) due to background or anthropogenic causes. Furthermore, the scale of Chesapeake Bay called for a comprehensive regional management approach to reduce pollution throughout the watershed.

**FIGURE 2**

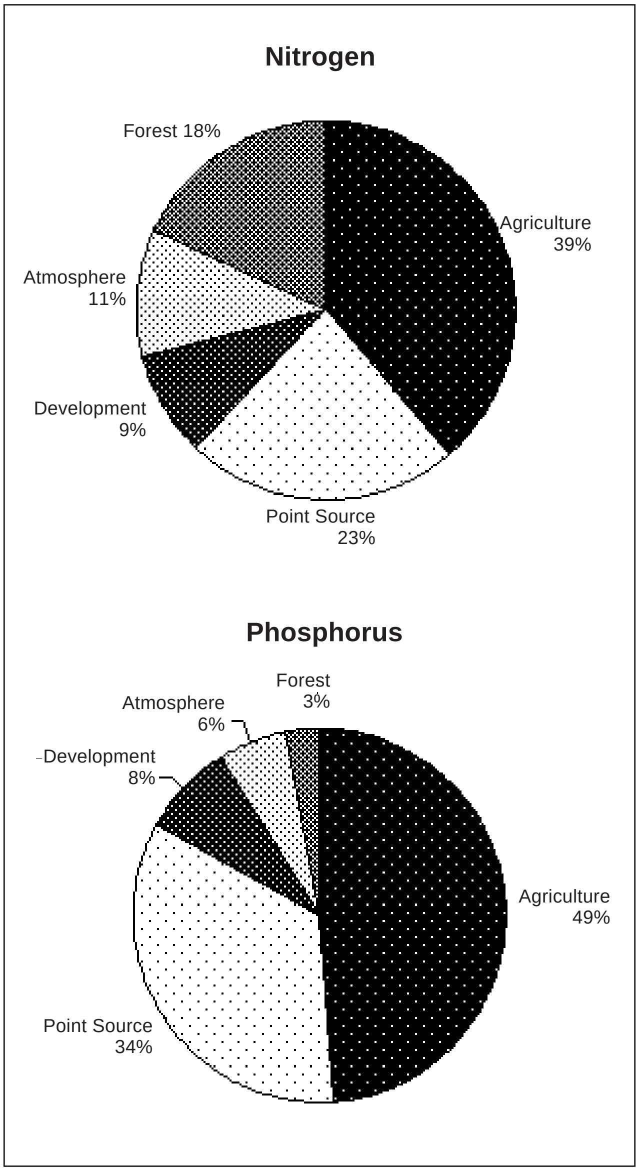


**FIGURE 3:
OVERALL WATERSHED NUTRIENT SOURCES**

In 1983, EPA's five-year study concluded that the Bay had "increasing pollution burdens and declines in desired resources."[12] The study provided a framework for action and encouraged the watershed states and the federal government to work closely to reduce pollution into the Bay. Specific recommendations focused on the establishment of long-term research and monitoring programs to support preservation and restoration efforts, and the development of a region-wide plan to reduce point and nonpoint source nutrient and toxic inputs to the Bay.

## *The Chesapeake Bay Agreement — A Unique Example of Inter-jurisdictional Cooperation (1983)*

The EPA report became the foundation for an unprecedented voluntary effort between the federal government, the District of Columbia and the states most significantly impacting Bay water quality: Maryland, Virginia, and Pennsylvania. The Chesapeake Bay Agreement, signed December 9, 1983, acknowledged the need for a cooperative approach "to fully address the extent, complexity and sources of pollutants entering the Bay." It proposed the the signatories share responsibility "for management decisions and resources regarding the high-priority issues of the Chesapeake Bay."[13]

This first voluntary agreement did not set specific pollution-reduction goals. It did establish an executive decision-making council to coordinate the development of management plans and address technical matters. The Executive Council consisted of cabinet-level designees of the governors of the states and the mayor of the District of Columbia, as well as the EPA Region 3 Administrator, and was supported by the Chesapeake Bay Program liaison office.[14] While this new arrangement succeeded in fostering cooperation among the parties, the Council itself acknowledged its need for more specific goals and priorities. In 1987, the Council amended the Agreement to add more specifics to its strategy. The new agreement stated that

> the improvement and maintenance of water quality are the single most critical elements in the overall restoration and protection of the Chesapeake Bay. Foremost, we must improve or maintain dissolved oxygen concentrations in the Bay and its tributaries through a continued and expanded commitment to the reduction of nutrients from both point and non-point sources.[15]

Specifically, the parties committed to design (by 1988) and execute (by 2000) a basin-wide strategy to reduce the controllable nitrogen and phosphorus entering Chesapeake Bay by 40%.

Mathematical models enabled managers and scientists to examine nutrient reduction options ranging from "no action" to "restoration of pre-European settlement conditions." They selected the 40% goals based on what scientists determined would be necessary to achieve significant improvement in Bay health, plus what was achievable given population growth projections and the limits of technology.[16]

The goals have been controversial. Scientists and managers have criticized them as failing to target the worst polluting tributaries in the watershed for greater nutrient reduction and also for not considering the physical dynamics of the Bay, which show that nutrients entering from the northern tributaries have a much bigger impact on Bay health than inputs from the south.[17]

Further criticism focuses on the importance of the dynamic state of the estuarine environment, the different roles phosphorus and nitrogen play within the Bay, and their relative importance to fresher versus saltier regions of the Bay. Research by Cerco[18] demonstrates that phosphorus is the limiting nutrient in the northern, freshwater region of the Bay, while nitrogen is limiting in the saltier southern portion. Because the salinity regime shifts seasonally, the locations in the Bay where nitrogen or phosphorus is the limiting factor also shift. Despite these criticisms, the managers appear to have little interest in revising the general 40%-reduction strategies.

Because nutrient reduction goals are uniform across all tributaries, so is federal funding. Pennsylvania has raised concerns that while the Susquehanna River contributes more than 50% of the nutrient problems in the Bay, it is not proportionally funded to reduce 50% of nutrient loads. Pennsylvania's Nutrient Reduction Strategy[19] suggests that a partial solution may be to allow nutrient reduction shortfalls to be traded among signatories, thus achieving the most cost-effective solutions. Trading involves identifying where reduction goals can be exceeded more cost-effectively in some tributaries than others, then trading excess reduction in one tributary for the shortfall in another.[20] Pennsylvania is considering trading phosphorus-reduction shortfalls between the Susquehanna and its other major tributary, the Potomac. It also observes that, with additional institutional, political, and economic arrangements, intrastate trading could benefit the signatories and save significant costs in the Potomac Basin, which crosses through the borders of all four signatories.[21]

As an intermediate step, the parties agreed to re-evaluate this 40% objective, in view of research and modeling, by December 1991.[22] Following this review, the Executive Council amended the Agreement in 1992. The Council acknowledged an improvement in water quality as a result of nutrient reduction, reaffirmed the 40% reduction goals, and committed to intensified efforts, including the development and implementation of tributary strategies for each of the major rivers by August 1993.[23]

## *The Role of Pollution Prevention Under the Agreement*

### The Chesapeake Bay Agreement and Pollution Prevention

The nutrient reduction goals of the Chesapeake Bay Agreement (hereafter "Agreement") provide an opportunity to examine pollution prevention's role in solving a regional-scale problem of national importance. Pollution prevention ranks waste management options in a pyramid hierarchy, with anticipatory activities such as waste reduction/pollution prevention at the top and (in descending order of desirability) reactive methods such as external waste recycling and reuse, waste treatment, controlled disposal, and uncontrolled release. This hierarchy emphasizes that preventive actions influence the potential causes of pollution, while reactive strategies follow once the pollution occurs.[24]

The Agreement does not specify guidelines for how states and intrastate authorities should meet reduction goals beyond the broad charge to develop tributary strategies, nor does it make specific references to pollution prevention or source reduction. Nevertheless, signatories have moved steadily away from the uncontrolled release and treatment strategies at the bottom of the pollution prevention pyramid to higher-order efforts to reduce nutrient inputs at their sources.

For instance, the Agreement specifically charges signatories to incorporate public participation into the strategies' development, review, and implementation. It also requires signatories to explore improved technologies for nutrient reduction and to promote cost-effectiveness.[25] As a result, states have undertaken a mix of voluntary, incentive-based measures as well as legislative mandates in their efforts to meet the reduction goals. These measures vary in their levels of effort and degrees of success from state-to-state and from tributary-to-tributary. Throughout the watershed, however, states consistently have focused on reducing inputs from the largest sources of nutrient enrichment: agriculture, deforestation, wastewater outfalls, urban runoff, and atmospheric deposition.

Source reduction strategies include banning the use of phosphates in household detergents, creating special zoning areas to control coastal development, and establishing riparian buffers that reforest river and stream banks. Nutrient management practices on farms and biological nutrient removal at sewage treatment plants have also become core nutrient-reduction strategies under the Agreement. While nutrient management and best management practices on farms rank high on the pollution prevention pyramid, sewage treatment plants rank lower. However, the new technology of biological nutrient removal provides a cost-effective method for reducing nitrogen loads, which have lagged behind phosphorus reductions. The following sections describe specific examples of these five measures.

## Banning Phosphate Detergents

One of the first significant pollution prevention actions under the Agreement was the banning of household use of phosphate detergents in Maryland and Virginia (1985) and Pennsylvania and D.C. (1989). The impact on phosphorus levels in Bay tributaries was instant and measurable: almost as soon as the laws were enacted, states experienced a 30–50% reduction in phosphorous pollution from sewage treatment plants. Achieving such reductions by changing plant technology would have cost hundreds of millions of dollars.[26] The phosphate bans were especially easy to enact because, at the time of the legislation, manufacturers were supplying phosphate-free detergents to some areas of the Great Lakes watersheds, where bans already existed. In the history of the Agreement, the phosphorous detergent bans remain the most obvious and effective source-reduction strategy.

## Reducing Agricultural Sources: Pennsylvania's Susquehanna River Watershed Approach

The largest of the Chesapeake tributaries, the Susquehanna is also the largest contributor of nutrients. In 1985, the year the base loads for reduction were established, it carried an estimated 116.2 million lbs. of nitrogen and 5.9 million lbs. of phosphorus into the Bay. More than 21,000 farms cover 7,000 square miles — 35% of the watershed. Since joining the Agreement, Pennsylvania's efforts toward nutrient reduction have focused largely on the establishment of Best Management Practices (BMPs) on the most polluting farms in the Susquehanna watershed.[27] Pennsylvania's total load from all sources in 1985 was 124.8 million lbs. of nitrogen and 6.8 million lbs. of phosphorus.[28] Reducing its controllable 1985 nutrient levels by 40% translates into a reduction of 19.8 million lbs. of nitrogen and 2.5 million lbs. of phosphorus. Under Pennsylvania's strategy, agriculture is responsible for reducting more than 85% of nitrogen and 62% of phosphorus. By 1995, the state had reduced 21% of its nitrogen goal and 49% of its phosphorus goal.[29]

Pennsylvania does not border Chesapeake Bay, so it doesn't gain the same tourism, commercial fishing, recreation, and amenity benefits as Maryland and Virginia do from Bay improvement. Pennsylvania's incentive to participate is a "good neighbor" policy, along with the recognition that nutrient reduction can do as much good for Pennsylvania's polluted streams, lakes, and rivers as it can for the Bay. State officials emphasize that the improvement of water quality throughout Pennsylvania's Susquehanna watershed is as important a benefit of state revenue expenditures under the Agreement as what goes on downstream.[30]

Pennsylvania's efforts rank high on the pollution prevention pyramid, because farm nutrient management and other agricultural BMPs reduce nutrients entering streams and rivers:

- Nutrient management matches the amount of nutrients applied to crop needs.
- Stream bank fencing keeps livestock from polluting stream beds.
- Crop rotations make use of natural nutrient cycles within the soil.
- Manure storage ensures that land applications do not exceed soil assimilative capacity.

Economic analysis of nonpoint agriculture reduction practices rank nutrient management and crop rotations as the most cost-effective approaches.[31] Manure pits, on the other hand, are expensive to build and, while controlling the amount and timing of nutrients entering the watershed, are not as efficient as other source-reduction strategies. The Pennsylvania Department of Environmental Protection has undertaken a major economic analysis of conservation practices, so it can develop future plans to direct limited funds into the strategies that generate the best results.[32]

Despite the transfer of state control from the two-term Democratic administration of Governor William Casey to Republican Governor Tom Ridge in 1994, the commitment to nutrient management remains strong. In a November 1995 speech, Ridge boasted that plans for increased voluntary and regulatory nutrient management activities have moved steadily forward.[33]

The broad and bipartisan political support for the state's program may stem from the nature of its grassroots implementation. From the signing of the first Agreement in 1983, Pennsylvania held public meetings in affected counties and formed advisory groups. People from agriculture, livestock and dairy operations, academia, business, and local government attended.

Because Pennsylvania expected that farmers would resist mandatory regulations, it adopted a voluntary approach, working through local conservation districts and environmental groups to offer farmers generous incentives for participating. Farmers who volunteer to install conservation practices receive government support of 80%, up to $30,000. In return, farmers must pay the balance and agree to maintain established structures and practices. More farms per county usually want to participate than there are funds available to implement.[34]

The $30,000 ceiling makes the incentive payment less attractive to animal producers needing manure pits. Pennsylvania raises large numbers of dairy cattle, swine, and poultry.[35] In response, Pennsylvania's voluntary approach is changing. The 1993 Nutrient Management Act requires that farms with the highest concentrations of animals per acre implement BMPs.[36] The Act shifts some of the state's pollution prevention activities from a voluntary to a mandatory framework, in recognition that nitrogen reduction has lagged behind that for phosphorus. A broad coalition of farming and environmental organizations support the Act, and the Chesapeake Bay Foundation considers it a national model and a landmark piece of legislation.[37]

The draft regulations under the Nutrient Management Act mandate BMPs on farms where the animal density is at least two thousand pounds of live weight per acre. Through incentive-based activities, the Act encourages implementation of BMPs on less dense operations.[38] The BMPs include (1) nutrient application procedures that limit nitrogen, (2) utilization of excess manure, (3) barnyard manure management, and (4) stormwater runoff controls. The state projects tha,t between 1995 and 2000, mandatory plans will be implemented on 2,089 farms or 10% of the state's farms. Voluntary plans will be implemented on another 2,089 farms for a total of 380,000 acres. Officials estimate the total cost of this implementation at more than $15.5 million. By early 1996, the regulations were still in draft stage awaiting public comment and it was not clear when the program would begin.

## Resource Protection and Source Reduction: Forest Buffers on the Watershed

Forests provide a natural biological filter system to the watersheds in the Chesapeake region. Tree roots stabilize the shoreline, reducing erosion; they also absorb nutrients that otherwise might run off the land. Leaves, limbs and roots store these nutrients. Significant levels of denitrification occur on the forest floor, when bacteria convert nitrate to nitrogen gas, which is released into the air.

Forests now cover 24.5 million acres or 60% of the Bay watershed.[39] In 1990, the U.S. Forest Service assigned a Forestry Program coordinator to the Chesapeake Bay Program to assist EPA in forest restoration strategies.[40] In 1994, the Chesapeake Bay Commission adopted a resolution supporting the development of a riparian forest buffer policy. A final recommendation for a riparian forest buffer policy is pending.[41]

In 1991, the U.S. Forest Service, the Pennsylvania Department of Environmental Resources, the Maryland Department of Natural Resources, and the U.S. Fish and Wildlife Service drafted guidelines for Riparian Forest Buffers.[42] These guidelines divide the forest buffer into three zones: Zone 1, with woody vegetation adjacent to the stream bank; Zone 2, of forest located upslope from Zone 1; and Zone 3, a herbaceous filter area upslope from Zone 2. These three zones act as a natural filter from surface runoff.[43]

In 1991, Maryland enacted the Forest Conservation Act, requiring permits and a forest conservation plan for site planning on areas 40,000 $ft^2$ or greater.[44] Maryland's Critical Area Act and Virginia's Chesapeake Preservation Act protect the riparian forests within a 100-ft buffer zone around the Bay shoreline. Although Pennsylvania does not have land bordering the Bay, its land managers require forest preservation on state lands, protecting their streams.[45]

Although some forest conservation practices are mandatory, others are incentive-based. For example, Maryland's Buffer Incentive Program offers payment of $300 per acre to maintain a minimum 50-ft. forested buffer.[46] All three signatory states have some type of preferential tax assessment program for land kept as open space or private wooded areas.

## The Blue Plains Treatment Plant: An Experiment in Biological Nutrient Reduction

Sewage and stormwater runoff are the two of the major urban sources of nutrients entering Chesapeake Bay tributaries. Wastewater treatment plants remove nitrogen and phosphorus at the ends of their pipelines, rather than reducing them at the source. This means that wastewater treatment plants do not prevent pollution. However, a new technique, Biological Nutrient Removal (BNR), may ultimately play a large role in nitrogen reduction. BNR is particularly useful in achieving nitrogen reduction goals, which have lagged under the Agreement. BNR retrofits existing nitrification tanks to create anoxic zones for denitrification. Bacteria break down nitrogen-containing ammonia from raw wastewater and convert it into nitrogen gas, removing it more substantially than traditional methods.[47]

One of the largest sewage treatment plants with BNR is the Blue Plains Plant on the Potomac River. The plant processes sewage from Maryland, Virginia, and the District of Columbia. Since 1985, the Blue Plains Inter-Municipal Agreement (IMA) has governed the waste treatment arrangement and allocates funds from each of the regional partners to the plant.[48] Under the IMA, the District of Columbia has the lead in managing and improving the plant.

Since the early 1980s, the District of Columbia studied various nitrogen removal mechanisms for Blue Plains.[49] IMA considered three nutrient-reduction strategies for Blue Plains. Two of the options are effective at nitrogen removal but are prohibitively expensive. The preferred option, three-Stage BNR (3ST BNR), would enable the District to achieve 40% reduction. However, full-scale implementation of BNR technology will not occur until after the end of the two-year pilot study (June 1995–97). In the study, while half of the treatment plant implements BNR, the D.C. Department of Public Works evaluates BNR effectiveness in reducing overall nitrogen into the Potomac.[50] In 1985, the department estimated total nitrogen at 15.46 mg/l. After implementing 3ST BNR, the nitrogen concentration should decrease to 7.5 mg/l.[51]

Despite the mix of nutrient reduction and prevention alternatives that the three signatory states are implementing, only D.C. expects to meet its 40% reduction goals for both nitrogen and phosphorus. That is because the District is a geographically small, densely populated urban area whose nutrient enrichment impacts on the Chesapeake ecosystem are largely from sewage and stormwater. The Blue Plains plant alone contributes 95% of the District's nitrogen and 53% of its phosphorus loads.[52]

One of the main problems the District faces in controlling wastewater flow is the original setup of the sewer system. About one third of the city has the old combined sewer system that carries both rainwater and sewage. During dry weather, the flow moves toward Blue Plains for treatment before entering the Potomac River.[53] However, heavy rainfall causes inflow to exceed the plant's capacity, discharging raw sewage into the river. The combined sewer overflows contribute 2% of the nitrogen and 31% of the phosphorus.[54] Re-routing the current system would be prohibitively expensive. Instead, the District has adopted its Combined Sewer Overflow Abatement Program (CSO).

The District has invested about $32.6 million into this program.[55] The CSO Abatement Program emphasizes temporary storage and creation of facilities to partially separate combined sewer flows. The Program is an important complement to the Blue Plains Treatment Plant. The Blue Plains WWTP upgrade will account for 99% reduction in nitrogen, yet the phosphorus load will still be 10,000 pounds per year over the cap. Control of combined sewer overflows will reduce phosphorus by 11,000 pounds per year.[56]

Both Maryland and Virginia have also implemented BNR. Maryland created a voluntary program, except that it requires BNR for WWTPs plants with a flow of at least 0.5 million gallons per day (MGD).[57] Virginia's all-voluntary approach to BNR has fitted two plants in the Potomac Basin with BNR.[58] Nine of 26 facilities with ammonia limits in their permits are also considering BNR.[59] Because BNR technology is expensive to construct and operate, Pennsylvania has not implemented it in its current Nutrient Management Plan.[60] However, Pennsylvania studies show that installion of BNR at three treatment plants in the Susquehanna Basin and one in the Potomac would decrease nitrogen inputs by 2.14 million pounds per year and phosphorus by 69,000 pounds per year.[61]

Maryland's combined mandatory/voluntary BNR approach is the most ambitious of the three states. The particular jurisdiction responsible can implement BNR by entering into an agreement with the Maryland Department of the Environment and constructing a facility to maintain seasonal nitrogen concentration of 8 mg/l from April to October and maximize nitrogen removal for the rest of the year.[62] Currently, there are 17 WWTPs in Maryland that remove nitrogen, eight of which are within the Patuxent watershed. BNR will reduce Maryland's contribution of nitrogen to the Potomac by 48%.[63] While 47 plants in Maryland require upgrading to meet the year 2000 reduction goal, current funding will only permit upgrading 24 plants.[64]

## *Growth Management for Pollution Prevention*

Growth management is an important and perhaps essential nutrient reduction strategy. Population growth is the fundamental cause of increased nutrient loadings to the Bay. Growth in the Chesapeake Bay region is not uniform, as more people settle in the suburban counties around the region's cities.[65] During the last 40 years, cropland, forest areas, and pastures have been converted to residential and urban lands. Furthermore, agriculture has shifted from labor-intensive activities to capital-intensive ones.[66] Intensified use of land requires more fertilizers, resulting in more nitrogen and phosphorus going into the Bay. Between 1970 and 1980, the rate at which land was developed exceeded the population growth rate. Increased development means greater urban nonpoint source loads and greater sewage flows.

Maryland recognized the need for growth management before the Agreement and in response to the 1983 EPA Chesapeake Bay study.[67] Governor Hughs appointed an interdepartmental task force to draft legislation that would become the Chesapeake Bay Critical Area Law of 1984. Under the Law, local governments must submit maps and zoning plans designating the critical area in their jurisdiction. If necessary, the jurisdiction may amend or create new regulations, zoning ordinances, and provisions for enforcement.[68] The Critical Area Act, as mandated by the state, requires counties to restrict development within 1,000 feet of Bay and tributary tidal waters and to place a 100-ft. buffer along the shoreline. Strict development control also restricts density to one house per 20 acres. Sixty local governments fall within the Critical Area.[69] For agricultural land, the buffer must be at least 25 ft. and have natural vegetation.[70] Farms within the critical area must implement BMPs and maintain water quality plans and soil conservation.[71]

To further accommodate for Maryland's increasing population, the state passed the Economic Growth, Resource Protection and Planning Act in 1992. This law, overseen by the Economic Growth, Resource Protection, and Planning Commission within the Maryland Office of Planning, complies with the 1987 Chesapeake Bay Agreement. The Planning Act requires local governments to amend growth and development plans by 1997 so that water quality and restoration goals will continue in the future.[72] The Planning Act requires counties to adopt the Sensitive Areas Element that protects "stream buffers, floodplains, endangered species, and other areas that need to be protected from development," by July 1, 1997. Because the Act does not specifically state the extent of the protection, each county has the discretion to determine its own standards. However, the Growth Commission reviews the local government plans every six years.[73]

Although not mandatory like the Critical Area Act, Maryland's Program Open Space also incorporates strategic growth development. The program funds state and local governments to purchase community open space.[74] The funds used to buy parks, forests, and wildlife management areas prevent pollution by supporting "friendly" land uses.

Other states have been less ambitious in managing growth. In response to EPA's 1983 Bay Study and the 1987 Chesapeake Bay Agreement, signatory state leaders made a commitment to address population growth while improving Bay water quality. Under the 1987 Agreement, the population growth and development goal is to "[p]lan for and manage the adverse environmental effects of human population growth and land development in the Chesapeake Bay watershed."[75] To support this goal, Maryland, Pennsylvania, Virginia, and the District of Columbia are to provide local governments with financial and technical management assistance, avoid and mitigate adverse impacts of growth, and identify local government restoration and protection programs.[76] This Population Growth and Development Commitment was partially fulfilled by the 2020 Panel in 1988. This 12 -member panel reported anticipated growth and related trends through the year 2020. Throughout 1988, the 2020 Panel and interested observers met regularly to receive public comments and recommendations on growth and development.

Even though the Agreement requires consideration of population growth management, growth control is not a priority in Pennsylvania's strategy, which addresses more the impact of animal populations than humans. Virginia has enacted the Chesapeake Bay Preservation Act which, like Maryland's Critical Areas Act, maintains a 100-ft. tide shoreline.[77] However, this buffer is the extent of Virginia's growth management. Of the Agreement's signatories, only Maryland has enacted development control legislation.

## Obstacles for Bay Cleanup and Pollution Prevention

The Chesapeake Bay Agreement is unprecedented in its jurisdictional scope and in its largely voluntary nature. Success of the Agreement depends on political will and the consistency between the interests of each state and those of the group. Pollution prevention, like other environmental protection efforts, relies on political initiative for its force.

The Virginia example is illustrative. The Potomac Basin contributes most of Virginia's phosphorus and nitrogen loadings into the Bay, and the state has spent the majority of its time and resources developing the Virginia Potomac River Basin Tributary Nutrient Reduction Strategy, released in August 1995. The purpose of this draft nutrient reduction strategy is

> to present a framework and plan for how [the state] will close the gap on meeting [its] 40% nutrient reduction goal for the Potomac River basin.[78]

Several proposed nutrient reduction tactics would reduce the amount of point and non-point nutrients polluting the Chesapeake Bay watershed. Virginia's approach includes several agricultural BMPs, as well as enhanced BNR at WWTPs in the Potomac Basin. Most of these proposed measures are voluntary.[79]

While officials have stated that Virginia plans to be a presence in the Bay cleanup, the late start has essentially guaranteed that the nutrient reduction goal set for the year 2000 will not be met.[80] Projections suggest that Virginia will reduce total phosphorus inputs from the Potomac Basin by 32.3%, leaving a 7.7% nutrient gap; nitrogen reduction is expected to be 7.2%, leaving a 32.8% nutrient gap.[81] These gaps are a cause of concern for many, including the EPA. On April 7, 1994, the Director of the EPA's Chesapeake Bay Program Office wrote to the Virginia Secretary of Natural Resources that nearly $1.2 million of a $2.8 million EPA matching grant would be withheld unless "satisfactory progress" was shown by May 1 of that year.[82] Secretary Dunlop responded by developing a comprehensive schedule for the current Potomac Basin Draft Strategy.

Officials must address several problem areas before the goals of the Agreement can become a reality. Lacking are: (1) a state "authority figure" for implementing the proposed nutrient reduction, (2) explanation on how state officials would implement BMPs practices on the local level, and (3) a state plan on funding mechanisms.[83]

The Chesapeake Bay Foundation (CBF) is the largest nonprofit organization working to protect and restore the Bay. Jean Watts, a CBF staff scientist, stated in a Foundation review of the Potomac Basin Draft Strategy that she "does not believe that the [local governments] will spontaneously come together to design and implement effective strategies without some direct state coordination and funding."[84] Virginia has developed a strategy for using localized nutrient reduction initiatives without considering how those initiatives would be funded and without coordinating the proposed nutrient reduction activities across the region. Both oversights must be addressed in the final strategy report if Virginia hopes to advance in its nutrient reduction goals.

## Conclusions

Each of the parties has implemented, or at least planned, several nutrient-reduction strategies in order to meet the goals established in the Chesapeake Bay Agreement. Agricultural BMPs, wastewater BNR upgrades, land-use planning, riparian buffer strips, and bans on phosphate detergents are some of the most important nutrient-reduction strategies, and officials have taken a mixed voluntary/mandatory approach to implementing these measures. In deciding to adopt voluntary measures as a large component of the program, officials are broadly delegating responsibility for environmental policy across the different levels of government and to local communities and individuals. The Agreement stresses public involvement at all stages of activities and, in fact, the many agencies and organizations involved in implementing the Agreement have all developed strong public outreach campaigns.[85] In addition, each signatory to the Agreement has had to work collaboratively to identify the roles that the federal, state, and local authorities must play for their nutrient reduction strategies to be successful in the Bay watershed.

Nevertheless, voluntary, incentive-based strategies such as pollution prevention could be applied more broadly under the Agreement if more strongly endorsed and funded by government leaders. Funding is a limiting factor, as are institutional dynamics such as those in Virginia, but all funding for pollution prevention plans does not need to originate from traditional government programs. Under the leadership of the Chesapeake Executive Council, the states could apply many creative financing mechanisms . Perhaps the most important task for state officials is resolution of the issue of insufficient funding, and the states must complete this before the terms of the Agreement can be met.

The state nutrient reduction strategies wisely allow political and economic flexibility for individual watershed efforts in the protection and restoration of the Bay. Maintenance costs for reduction techniques, such as streambank fencing and fertilizer management BMPs, are less expensive for the user than the more traditional clean up strategies. However, the largely voluntary nature of these programs needs to be cost-effective and manageable for those using them. Farmers who have implemented BMPs have done so not only to help reduce nutrient loading into the Bay, but also out of their own economic interest.

The Chesapeake Bay Agreement was to be re-evaluated in 1997. Officials could consider restructuring the program to adopt a more formal pollution prevention approach. The Chesapeake Executive Council could adopt a resolution encouraging pollution prevention measures throughout the Bay watershed. Successful examples of pollution prevention practices used in the watershed could be used to encourage further state management planning and also encourage the involvement of New York, West Virginia, and Delaware, states that currently do not participate in the Agreement.

While state nutrient-reduction efforts have resulted in progress towards cleaning up the Bay, continued efforts should focus more on the source-reduction aspect of the pollution prevention paradigm. Officials need to address funding shortfalls and develop further cost-share incentives or other new funding initiatives that would help increase states' source-reduction practices. State encouragement of voluntary pollution prevention programs must remain an important component of the tributary strategies, but citizen acceptance and participation will largely determine the success of the pollution prevention initiatives.

The application of pollution prevention measures within this regional program demonstrates the value of source reduction. States can overcome funding limitations and government complacency through a dedicated, long-term effort that illustrates the soundness of this source-reduction approach. If officials can work together to implement a regional pollution prevention approach to the nutrient loading problems that exist in the watershed, they will meet the nutrient reduction goals established in the Agreement.

## *Endnotes*


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## *Discussion Questions*

1. Funding for state nutrient management activities is provided half by the federal government through EPA grants to the states and half from state revenues.

   a) Considering the relative economic benefits of cleaner Chesapeake Bay water to each of the states who participate in the Agreement, is it equitable to expect each state to contribute a 50% share of the cleanup costs from its own coffers?

   b) Should the limited EPA funds be concentrated on areas that have the most impact on water quality problems?

   c) Should EPA prioritize its funding directions to reward source reduction over cleanup activities?

   d) If this approach were taken, which state could stand to gain the most EPA support?

   e) What would the others need to do to become more competitive?

2. Pennsylvania's voluntary program to implement BMPs on Susquehanna watershed farms is under–funded and cannot keep up with the demand from farmers willing to participate. This is one key reason why Pennsylvania will not meet the Agreement's 40% phosphorus and nitrogen reduction goals by 2000. Currently, the state is reviewing its BMPs to determine which are the most economically efficient and to reorganize its program to focus on the strategies that will reduce the most nutrients for the least cost. In light of this reorganization, discuss how the various BMPs rank in a P2 hierarchy and whether the reorganization for economic efficiency will likely result in a greater emphasis on those BMPs that rank higher. Because farmers are expected to fund the maintenance of BMPs after installation, consider the maintenance costs of source reduction activities vs. the more reactive methods of pollution control.

3. Should individual states enact nitrogen limitation regulations on their own, or should they wait for possible regional or national EPA regulations on nitrogen inputs?

4. How does the fact that this an executive agreement (rather than legislation) make implementing P2 strategies more difficult ?

5. Should the use of "Bad Actor" [WILL STUDENTS KNOW WHAT THIS MEANS?] laws be used as an incentive to implement BMP and BNR practices on the individual state level? What about on the regional level?

6. How can states maintain the nutrient reduction cap while taking growth management into account? Can other states benefit from Maryland's Critical Areas Act by implementing similar approaches?

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