ECONOMIC ANALYSES OF NUTRIENT AND SEDIMENT REDUCTION ACTIONS TO RESTORE CHESAPEAKE BAY WATER QUALITY

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Executive Summary

In developing revised water quality criteria, designated uses, and boundaries for those uses to protect living resources in the Chesapeake Bay and its tidal waters, the Environment Protection Agency's (EPA) Chesapeake Bay Program Office provided to Bay jurisdictions information for development of water quality standards for dissolved oxygen, clarity, and chlorophyll *a* in its guidance document *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability* (*Technical Support Document*) (U.S. EPA Chesapeake Bay Program. 2003.). Part of the jurisdictions' water quality standards development process may be to conduct use attainability analyses (UAAs). The information contained in the *Technical Support Document* is to assist states in development of their individual UAAs, and serve as a basis for state-specific documents that will be initiated after the revised criteria for the Chesapeake Bay are finalized by EPA.

This document supplements the *Technical Support Document* by presenting economic analyses performed by the Chesapeake Bay Program related to controls to meet the revised criteria and uses. Part I of the *Economic Analyses* provides estimates of the total annual cost of achieving the three levels of controls based on the costs of best management practices (BMPs) to remove nitrogen and phosphorus loads to the Chesapeake Bay. This cost information includes total capital cost requirements, and to the extent that information could be compiled, estimates of how these costs may be shared between the public and private sectors. Part II describes economic modeling of the potential impacts of these control costs in the Bay region. Part III documents a screening-level analysis of potential impacts, also based on the costs of the tier scenarios. Although this information may be useful to states in developing their own UAAs, the Bay Program did not use these analyses to delineate boundaries for the new refined designated uses.

SUMMARY OF ESTIMATED COSTS

The Chesapeake Bay Program's estimated costs of the tier scenarios reflect the costs of BMPs to remove nitrogen and phosphorus; these BMPs also remove sediment to some extent and, therefore, capture a portion of sediment removal costs. Costs for publicly owned treatment works (POTWs) and industrial sources are based on facility-provided estimates; the Bay Program's Nutrient Reduction Technology (NRT) Task Force developed a methodology to estimate the costs of achieving the tier-specific effluent concentrations when facilities did not provide estimates.

Costs for urban, agriculture, forestry, and onsite system BMPs are based on the units (e.g., acres) of BMP implementation in each tier scenario, and BMP-specific estimates of capital and operation and maintenance (O&M) costs. The Chesapeake Bay Program performed an extensive literature search that included documents provided or prepared by Chesapeake Bay Program workgroups and stakeholders (e.g., tributary strategy reports), academic journals, studies by University Extension offices, the U.S. Department of Agriculture, the U.S. EPA, and others to estimate such costs. In addition, to estimate the costs for the onsite system denitrification BMP, the Chesapeake Bay Program collected data from manufacturers of onsite system denitrification technology. Of the available data on cost estimates, the Chesapeake Bay Program prioritized well-documented sources and studies in or near the Chesapeake Bay watershed. In general, the Chesapeake Bay Program used a simple average of the estimated costs from appropriate sources.

The costs to implement the tier scenarios include capital costs to install controls and annual O&M costs. Part I provides details of the methods and results of the cost analyses, including estimates of the total annual cost of achieving the tier scenarios, total capital cost requirements, and, to the extent that information is available, estimates of how costs may be shared between the public and private sectors. The total annual costs shown here include annualized capital costs for control technologies or BMPs that require initial capital expenditures and annual O&M expenditures, regardless of whether costs accrue to private-sector businesses and households or public entities that provide funding through cost-share programs. The estimates represent the annual costs at full implementation of the tier scenarios. Therefore, actual annual costs in the years prior to meeting the full implementation goals will likely be lower.

Total capital costs represent total initial expenditures for all source controls. Capital costs indicate overall financing requirements to achieve the level of control or degree of BMP implementation specified for each tier. The costs, however, will not be incurred in any single year. Instead, they will be spread over many years though gradual implementation.

The distinction between private and public cost estimates is based on cost-share assumptions developed using current cost-share information for the agricultural and POTW sectors to project the share of future costs accruing to the public sector. The cost share assumptions vary according to individual state programs. There are no cost-share assumptions for urban BMPs although retrofit BMPs for developed areas may receive financial support from federal and state sources. They may also benefit greatly from "piggy back" opportunities that reduce incremental BMP costs to a fraction of the unit costs because BMPs can be added more cost-effectively to planned infrastructure upgrades, repairs, or investments.

Exhibit ES-1 provides a summary of cumulative costs for each tier. These are costs beyond what has already been expended up to the year 2000 (and already funded POTW upgrades). It is important to note that some portion of Tier 2 and 3 costs will be incurred regardless of tier implementation because of baseline requirements that are not fully captured in the Tier 1 scenario (e.g., livestock BMPs required in a recent federal rule). Finally, the costs include those paid by businesses and households in the watershed as well as costs paid through federal and state cost-share programs.

Exhibit ES-1 also shows the implied average annual costs for each of the projected 6.3 million households by 2010, if all costs were paid by households living in the watershed (in reality, household costs will vary by location and household type, and a substantial share will be paid by federal and state sources). These annual costs are small compared to median household incomes in the watershed. The median estimate for the counties in the watershed is $49,300. This estimate is in 2001 dollars and reflects incomes in the 2000 Census of Population. Average median incomes across the states range from $37,800 for the basin counties in New York to $58,300 for the basin counties in Maryland.

Exhibit ES-1: Summary of Total Annual Cumulative Costs (in 2001 dollars)

Cost Category	Tier 1 (cost of current programs funded to 2010)[1]	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1+ Tier 2 + Tier 3)
Total Annual Costs ($millions)[2]	$198	$555	$1,139
Implied Cost per Household Before Cost Share[3] ($)	$31	$88	$181
Implied Cost per Household After Cost Share[3] ($)	$24	$59	$130
Implied Household Cost Before Cost Share as Percent of MHI in Watershed ($49,300)	0.1%	0.2%	0.4%
Implied Household Cost After Cost Share as Percent of MHI in Watershed ($49,300)	0.0%	0.1%	0.3%
Federal and State Funding Share (%)	25%	33%	28%

MHI = median household income

1. POTW NRT upgrades already funded or completed are not included in Tier 1.
2. Includes costs paid by federal and state cost-share programs.
3. Actual household costs will vary by location and type of household (e.g., urban or farm) and will be reduced by the federal and state funding shares. The impact analysis addresses these distributional effects.

Federal and state cost-share programs provide financial support for nutrient controls. Based on current practices, these programs could provide up to $49 million of annual Tier 1 costs (or 25%), $186 million of annual Tier 2 costs (or 33%), and $317 million of annual Tier 3 costs (or 28%). The total cost-share contribution increases from Tier 1 to Tier 2 because agricultural costs increase relative to other sectors, and most agricultural BMPs are covered by cost-share programs. The total cost-share contribution declines from Tier 2 to Tier 3 as urban costs, for which federal and state funding is possible but not included, increasingly dominate total costs. Average cost per household will also decrease if actual implementation of controls is more cost effective than the tier scenarios.

A breakdown of costs by state in **Exhibit ES-2** show that three states—Maryland, Pennsylvania, and Virginia—account for almost 90% of costs across all three tier scenarios. Maryland has the largest share of annual Tier 1 costs, followed by Virginia and Pennsylvania. However, Virginia has the highest share of Tier 2 and Tier 3 costs, followed by Pennsylvania and Maryland. Maryland's shift from highest baseline costs to third highest Tier 2 and Tier 3 costs illustrates its aggressive level of implementation already employed or planned.

Exhibit ES-2: Summary of Total Annual Cumulative Costs by Jurisdiction[1]
(millions of 2001 dollars)

Jurisdiction	Tier 1 (cost of current programs funded to 2010)[2]	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)
Delaware	$3	$8	$13
District of Columbia	$9	$16	$34
Maryland	$63	$121	$262
New York	$7	$31	$66
Pennsylvania	$51	$167	$320
Virginia	$57	$192	$407
West Virginia	$7	$19	$37
Total	$198	$555	$1,139

Detail may not add to total due to rounding.
1. Includes costs paid by federal and state cost-share programs.
2. POTW NRT upgrades already funded or completed are not included.

The cumulative cost estimates shown in Exhibits ES-1 and ES-2 do not reflect the incremental costs of implementing controls beyond Tier 1 levels (or baseline levels that are essentially what would happen anyway). The incremental costs for Tiers 2 and 3 can be derived by subtracting the Tier 1 costs from the cumulative Tier 2 and 3 costs, respectively.

Corresponding total capital costs are $1.4 billion for Tier 1, $3.6 billion for Tier 2, and $8.0 billion for Tier 3. These estimates include anticipated federal and state cost shares. These costs will be incurred slowly over time as controls are gradually implemented. Nevertheless, comparing them to annual economic statistics provides crucial perspective because—despite their magnitude—they are small compared to total annual personal income, which in 1999 was $574 billion in the watershed counties and $1.4 trillion in the basin states (BEA, 2001; in 2001 dollars the values become $610 billion and $1.5 trillion, respectively).

State-level capital costs shown in **Exhibit ES-3** also include the portion that will be funded through federal and state cost-share programs as well as costs that will be paid by households in the watershed. The distribution of capital costs follows the same pattern as annual costs in Exhibit ES-2. Maryland, Pennsylvania, and Virginia account for approximately 90% of watershed costs across all tier scenarios. Maryland costs are highest in Tier 1, followed by Virginia and Pennsylvania. Tier 2 and Tier 3 capital costs in Virginia are highest, followed by Pennsylvania and Maryland.

Exhibit ES-3: Summary of Total Cumulative Capital Costs

Jurisdiction	Total Capital Cost (millions of 2001 dollars)[1]			Annual Total Personal Income in Watershed for 1999 (millions of 2001 dollars)[3]
	Tier 1 (cost of current programs funded to 2010)[2]	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)	
Delaware	$21	$36	$60	$24,600
District of Columbia	$133	$170	$368	$21,600
Maryland	$592	$860	$2,069	$178,800
New York	$20	$175	$405	$47,400
Pennsylvania	$258	$899	$1,940	$134,700
Virginia	$382	$1,387	$2,901	$197,400
West Virginia	$35	$116	$232	$5,600
Total	$1,442	$3,644	$7,975	$610,000

Detail may not add to totals because of rounding.

1. Includes capital costs paid by federal and state cost-share programs.
2. POTW NRT upgrades already funded or completed are not included in Tier 1.
3. Total personal income in 1999 (BEA, 2001) in the counties located partially or wholly in the watershed. Values have been inflated to 2001 dollars using the Consumer Price Index.

For comparison purposes, Exhibit ES-3 also provides the 1999 estimates of total annual personal income for the watershed counties. In each jurisdiction, total capital costs for Tier 1 equal less than 0.7% of regional income. Thus, even if all capital costs were paid in a single year, instead of being spread over 10 to 20 years through gradual implementation and financing, they would be small compared to local economic activity. Total capital costs for Tier 2 equal less than 1% of regional income in each jurisdiction except West Virginia, where costs are 2.1% of income. Tier 3 capital costs equal less than 1% of income for Delaware and New York, less than 1.5% of income in Maryland, Pennsylvania and Virginia, less than 2% in the District of Columbia, and less than 5% in West Virginia.

These costs do not include the costs of onsite waste management systems (OSWMS; e.g., septic systems) in new homes. The rationale is that the additional expense associated with denitrification will be absorbed in the cost of a new home and the impact would, therefore, be limited to tradeoffs in what a homeowner can buy for the same price (e.g., changes in other materials or features in the home).

COSTS BY SECTOR

Exhibit ES-4 shows the breakdown of total annual costs and total capital costs by sector. In both instances, costs include those paid by the affected sectors and those that will be paid for by federal and state cost-share programs. State-level breakdowns are shown in the sector-specific sections below.

Exhibit ES-4: Total Annual and Capital Costs by Sector[1]
(millions of 2001 dollars)

Sector	Total Annual Cumulative Cost			Total Capital Cumulative Cost		
	Tier 1 (cost of current programs funded to 2010)[2]	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)	Tier 1 (cost of current programs funded to 2010)[2]	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)
POTW	$53	$148	$286	$655	$1,615	$3,087
Industrial Sources	$0	$8	$15	$0	$51	$98
Agriculture	$61	$226	$376	$312	$850	$1,490
Forestry	$23	$27	$31	$0	$0	$0
Urban	$60	$146	$418	$475	$1,128	$3,233
OSWMS	$0	$0	$13	$0	$0	$68
Total	$198	$555	$1,139	$1,442	$3,644	$7,975

Detail may not add to total because of rounding.
1. Includes costs paid by federal and state cost-share programs.
2. POTW NRT upgrades already funded or completed are not included in Tier 1.

With respect to annual costs, the agriculture sector accounts for the highest share of Tier 1 costs, followed by urban and POTW costs. In Tier 2, agricultural costs dominate total costs (41%) followed by POTW costs (27%), but the urban sector has the highest cost share in Tier 3 (37%) followed by agricultural costs (33%).

The distribution of capital costs across sectors differs significantly also. POTW costs account for the largest share of capital costs in Tier 1 (45%) and Tier 2 (44%), followed by urban and agricultural costs. In Tier 3, urban costs account for the largest share (41%) followed by POTW and agricultural costs. Urban costs in Tier 3 go up significantly due to the amount of storm water retrofits, which increase from 5% in Tier 2 to 20% in Tier 3.

POTW and Industrial Source Costs

Costs for NRT among POTW and industrial sources include capital expenditures and annual O&M costs. There are no industrial control costs in Tier 1 because industrial Tier 1 actions are assumed to be those already in place or planned. In Tiers 2 and 3, POTW control costs account for more than 90% of annual NRT costs. Total annual costs of $156 million for Tier 2 include $148 million for POTWs and $8 million for industrial facilities. Similarly, annual Tier 3 costs of $301 million include $286 million for POTWs and $15 million for industrial facilities.

Costs for POTW controls in Tier 1 reflect NRT projects planned for 2010 that are not yet funded. This includes NRT planned for 154 out of the 304 significant POTWs in the Bay watershed; effluent concentrations for these facilities in 2010 should be 8 mg/l total nitrogen (TN). (Chesapeake Bay Program, 2002). Tier 1 POTW costs include costs for D.C. combined sewer overflows (CSOs) (capital cost of $130 million).

Tier 2 reflects costs to implement NRT in the remaining 150 POTWs and assumes, in general, TN and total phosphorus (TP) effluent concentrations of 8 mg/l and 1 mg/l, respectively. The technologies to achieve this level of reduction include extended aeration trains and denitrification zones for nitrogen removal and chemical addition systems for phosphorus removal systems. Tier 3 reflects costs of technologies necessary to implement NRT in all of the POTWs to effluent concentrations of 5 mg/l TN and 0.5 mg/l TP. The technologies to achieve this level of reduction include the addition of a secondary anoxic zone plus methanol addition, and additional clarification tankage for nitrogen removal and additional chemicals for phosphorus removal. (Note that limits of technology for point sources for nutrient removal are considered to be 3 and 0.1 mg/l TN and TP, respectively.) The technologies to achieve this level of reduction include deep bed denitrification for nitrogen removal and microfiltration for phosphorus removal.

Exhibit ES-5 shows annual POTW costs by tier scenario and jurisdiction. Similar to annual costs for all sectors, these results show that the largest share of Tier 1 costs occur in Maryland and the largest share of Tier 2 and Tier 3 costs occur in Virginia. These results show how planned (Tier 1) NRT implementation costs vary across these states. Maryland is planning expenditures of $29.5 million annually under Tier 1, which accounts for 81% of cumulative costs under Tier 2 and 35% of cumulative costs under Tier 3. In contrast, Pennsylvania's Tier 1 costs are $6.5 million, which accounts for 20% of cumulative Tier 2 costs and 11% of cumulative Tier 3 costs. Virginia's Tier 1 costs are $8.7 million, which equals 15% of cumulative Tier 2 costs and 9% of Tier 3 costs.

Total capital costs for POTWs and industrial dischargers are $0.7 billion for Tier 1, $1.7 billion for Tier 2, and $3.2 billion for Tier 3. This includes costs paid by households in the watershed as well as costs paid by federal and state cost-share programs. Similar to annual costs, POTWs accounts for more than 90% of these costs in each tier. The distribution of capital costs across states also mimics the distribution of annual costs shown in Exhibit ES-5.

Exhibit ES-6 provides a summary of total annual costs, including those paid by farmers and those paid by cost-share programs. Based on current implementation shares, the cost-share programs would account for approximately 75% of annual costs in Tiers 2 and 3; farmers would incur the remaining 25% of annual costs. Cost-share programs account for a smaller share of annual Tier 1 costs (60%) because BMPs with lower cost-shares such as animal waste management systems account for a larger portion of annual costs.

Exhibit ES-5: Summary of Total Annual Cumulative POTW Costs[1] (millions of 2001 dollars)

Jurisdiction	Tier 1 (cost of current programs funded to 2010)[2]	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)
Delaware	$0.2	$0.6	$0.8
District of Columbia	$8.3	$14.1	$25.7
Maryland	$29.5	$36.2	$85.2
New York	$0.0	$6.2	$10.2
Pennsylvania	$6.5	$31.8	$60.0
Virginia	$8.7	$57.9	$101.3
West Virginia	$0.0	$1.7	$2.4
Total	$53.1	$148.3	$285.5

Detail may not add to total because of independent rounding.

1. Includes federal and state cost shares equal to 10% of capital costs for VA, 50% of capital costs for MD, and 0% for remaining jurisdictions.
2. POTW NRT upgrades already funded or completed are not included.

Exhibit ES-6: Summary of Total Annual Cumulative Agricultural Costs[1] (millions of 2001 dollars)

Jurisdiction	Tier 1 (cost of current programs funded to 2010)	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)
Delaware	$2.2	$6.3	$9.4
District of Columbia	$0.0	$0.0	$0.0
Maryland	$8.3	$33.8	$49.6
New York	$1.8	$14.7	$28.3
Pennsylvania	$22.2	$90.9	$146.6
Virginia	$21.6	$67.9	$118.3
West Virginia	$5.1	$12.7	$24.2
Total	$61.2	$226.3	$376.3

Detail may not add to total because of independent rounding.

1. Based on current cost share program information, federal and state cost-share programs would account for approximately 60% of annual costs in Tier 1 and 75% of costs in Tiers 2 and 3; farmers incur the remaining costs.

Agriculture Costs

Annual costs are highest in Pennsylvania for all tier scenarios. Virginia has the second highest share of costs in all scenarios, followed by Maryland. Together, Pennsylvania and Virginia account for 70% of annual agricultural costs.

Total capital costs in the agricultural sector are $312 million for Tier 1, $850 million for Tier 2, and $1.5 billion for Tier 3. The distribution of capital costs across states is similar to the annual cost distribution shown in Exhibit ES-6.

Forestry Costs

Annual costs to implement forest harvesting BMPs range from $23.5 million in Tier 1 to $30.8 million in Tier 3. Thus, baseline implementation in Tier 1 accounts for most of the costs in this sector. **Exhibit ES-7** provides annual cost estimates by tier scenario. This sector has the smallest share of annual costs in all tier scenarios because implementation acre estimates are small. All costs are annual because practices are assumed to be implemented on different harvest acres each year.

Exhibit ES-7: Summary of Annual Forest Harvest Costs by Tier and Jurisdiction (millions of 2001 dollars)

Jurisdiction	Tier 1 (cost of current programs funded to 2010)	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)
Delaware	<$0.1	<$0.1	$0.1
District of Columbia	$0.0	$0.0	$0.0
Maryland	$1.6	$1.8	$2.0
New York	$3.6	$4.1	$4.5
Pennsylvania	$13.9	$15.6	$17.4
Virginia	$3.0	$4.1	$5.1
West Virginia	$1.3	$1.5	$1.7
Total	$23.5	$27.1	$30.8

Note: Detail may not equal total due to rounding.

Urban Costs

Exhibit ES-8 provides annual costs by tier and jurisdiction for urban areas. These costs are for storm water BMPs and exclude POTW costs. Tier 1 costs are highest in Maryland and Virginia, with each accounting for 40% of annual Tier 1 costs. Maryland's share of costs declines in Tier 2 (32%) and Tier 3 (29%) while shares for other states, except Delaware, increase across the scenarios. This is indicative of Maryland's higher baseline BMP implementation rate compared to most other states. Virginia's share of total annual costs is 41% for Tiers 2 and 3. Pennsylvania's share of total annual costs increases from 15% in Tier 1 to 21% in Tier 3.

Exhibit ES-8: Summary of Cumulative Annual Urban Costs by Tier and Jurisdiction (millions of 2001 dollars)

Jurisdiction	Tier 1 (cost of current programs funded to 2010)	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1 + Tier 2 + Tier 3)
Delaware	$0.5	$1.0	$2.4
District of Columbia	$0.3	$2.1	$8.3
Maryland	$23.8	$47.3	$119.5
New York	$1.7	$6.4	$21.6
Pennsylvania	$8.8	$27.0	$87.7
Virginia	$24.1	$59.3	$170.5
West Virginia	$0.9	$2.5	$7.5
Total	$60.2	$145.5	$417.6

Note: Detail may not add to total due to rounding.

Storm water retrofits account for over 90% of annual urban costs in all tier scenarios. Although the total number of retrofit acres is small (e.g., less than 0.4% of watershed acres in Tier 2 and 1.8% in Tier 3), the per-acre cost is high compared to other sectors. Nevertheless, the average cost per household for the 4.9 million urban households in the watershed by 2010 is expected to be small, ranging from $12 in Tier 1 to $85 in Tier 3. These estimates assume that all costs are borne by urban households. However, federal and state cost share funds or other cost-saving opportunities might reduce these costs.

Total capital costs are $0.5 billion for Tier 1, $1.1 billion for Tier 2 and $3.2 billion for Tier 3. The distribution of capital costs across states is similar to the distribution of annual costs shown in Exhibit ES-8.

Onsite Waste Management System Costs (Septic Systems)

There are no onsite waste management system (OSWMS) costs for Tiers 1 and 2. This is because no existing onsite systems require an upgrade to a septic system with an advanced nitrogen removal capability in these two tier scenarios. Costs are minimal for Tier 3 because, as specified in this tier, only 1% of existing systems require upgrades or replacement. The annual cost for Tier 3 is $13 million and total capital costs equal $68 million. The average annual cost per household implementing the BMP is $1,020.

As noted above, this estimate does not include costs for new homes. The estimated annual cost for new homes is not included because: 1) developers have an opportunity to offset incremental OSWMS costs with savings in other construction costs, and 2) costs would be absorbed into the price of a new home mortgage. Furthermore, the per-system cost of $1,020 used in the cost analysis is for single system upgrades, whereas new homes built in developments will most likely have lower costs because they can use multi-home systems with lower average per-home costs.

REGIONAL ECONOMIC IMPACTS ANALYSES

At the request of the Chesapeake Bay Program, EPA's National Center for Environmental Economics (NCEE) evaluated the socioeconomic impact of attaining revised water quality criteria, designated uses, and boundaries for the Chesapeake Bay and its tidal waters. The objective of this analysis is to estimate the economic impacts of both the direct and indirect effects of compliance. Measures of economic impacts include changes in the value of regional output, or goods produced, employment, as well as wages and income, which are indicative of the potential for widespread socioeconomic impacts.

Given the size of the regional economy ($1.4 trillion in personal income in 1999 in the 6-state area and the District of Columbia, including $574 billion in Bay counties; in 2001 dollars, the values become $1.5 trillion and $610 billion, respectively), net impacts over this area are not likely to be seen. For example, baseline gross regional product in the state of Maryland is forecast to grow by 37% by 2010, corresponding to 19% growth in employment and 17% growth in real disposable personal income. The Tier 3 scenario would result in a net increase in output, employment, and value added above baseline levels. The stimulus results from increased spending in high wage industries (e.g., wastewater treatment technologies) as well as an influx of funds for pollution controls (e.g., federal cost shares for agricultural BMPs). Not included are additional market benefits likely to result from improved water quality (e.g., commercial and recreational fishing industries). Therefore, the regional economy should expand as a result of the tier scenarios.

The estimated annual cost of Tier 3 for 2010 populations ($1.1 billion in 2001 dollars) represents 0.2% of personal income in the Bay counties in 1999. Even if all capital costs ($8.0 billion) for this scenario were incurred in one year, they represent only 1.4% of personal income in the Bay counties in 1999. Although these data indicate that the pollution controls specified in the tier scenarios will not result in substantial and widespread social and economic hardship, there may be localized areas that need funding priority or special considerations.

SCREENING-LEVEL IMPACT ANALYSIS

U.S. EPA (1995) guidance requires **multiple** analyses to determine whether costs to meet water quality standards will have a substantial financial impact on those responsible for paying the costs **and** a widespread social and economic impact on the community. The guidance recommends several tests to determine if compliance costs might have a substantial financial impact. For the widespread impact analysis, macroeconomic modeling is the best approach because it can show how incremental costs affect the sectors implementing controls and the sectors that receive revenues as a result of the expenditures. U.S. EPA conducted a macroeconomic analysis at a regional level for the UAA Workgroup. The results, as described above, indicate positive net impacts on regional output and employment because the expenditures occur in sectors that have higher regional output multipliers and employment-to-output ratios compared to the sectors incurring costs. In addition, the costs are small compared to the size of the regional economy ($1.4 trillion in personal income in 1999 in the 6-state area and the District of Columbia, including $574 million in Bay counties). This result illustrates the importance of considering the full range of economic impacts rather than focusing only on costs. It also shows that control costs may not have substantial **and** widespread adverse social and economic impacts at the watershed level.

Nevertheless, there may be localized areas that need funding priority. The UAA Workgroup developed a screening analysis to identify where the estimated costs of the tier scenarios would *no*t likely pose substantial and widespread social and economic hardship. And, although the tier scenarios are hypothetical constructs rather than actual programs developed by the jurisdictions in their tributary strategies, the Bay Program wanted to provide these screening results to jurisdictions as information or a starting point for their analyses. The screening analysis is provided in Part III. The 12 sector-related screening variables selected by the UAA Workgroup include:

- Agriculture: Average BMP costs/net cash return
- Agriculture: Crop plus portion of hay BMP costs/crop plus hay sales
- Agriculture: Livestock plus portion of hay BMP costs/livestock sales
- Agriculture: Average BMP costs/median household income
- Agriculture: Percent of county earnings from agriculture, agriculture services, food and kindred products, and tobacco sectors/total county earnings
- Forestry: Percent of county earning from forestry and logging/total county earnings
- Urban: Average BMP costs/median household income
- Onsite Treatment Systems: Average BMP costs/median household income
- Onsite Treatment Systems: Percent of households affected in county
- POTWs: Current household sewer rate plus average new household cost/median household income
- POTWs and Urban Combined: Total sewer costs (current plus new) plus average urban BMP cost/median household income
- Industrial: Percent of county earnings from industrial sectors containing affected facilities/total county earnings.

Depending on the sectors with which they are associated, the screening model variables indicate when control costs are small relative to household incomes or the local economy, and, therefore when substantial impacts are unlikely.

It is important to note that this screening analysis is just that; it does not provide conclusions about, for example, threshold values beyond which a more comprehensive analysis is warranted. It does not seek to determine where cost-share assistance may be most useful. Rather, the screening results only show the ranges of values of the different variables, and it is left up to the jurisdictions to evaluate this information.

POTW and Industrial Sources

Exhibit ES-9 shows the results of the screening analysis for the POTW sector, and lists the number of counties or independent cities with screening variables that exceed 1% as a result of costs that would be imposed under Tiers 2 and 3. For the POTW sector, the screening analysis consists of comparing total potential sewer bills to median household income, based on EPA (1995) guidance indicating that substantial impacts are unlikely when this ratio is less than 1%. Except for the District of Columbia, CSO and SSO costs are not included in this analysis.

Overall, variable values greater than 1% account for 15% of counties and cities under Tier 2, and 20% under Tier 3. Virginia has the largest number of counties, followed by Pennsylvania. These states also have the largest number of counties or independent cities in the analysis and, therefore, having the greatest number of counties with variable values above 1% is not necessarily indicative of having a high potential for impacts. In fact, the incidence of variable values exceeding 1% is greater in Delaware (1 out of 3 counties) and West Virginia (3 or 4 out of 11 counties) than either Virginia or Pennsylvania.

These results reflect capital cost-share provisions of 10% in Virginia and 50% in Maryland, which reduces the amount of costs borne by households in these states; no grant funds are assumed for other states or the District of Columbia. This approach is also based on EPA (1995) guidance, which indicates that sources of funding (e.g., federal and state grants and cost-share funds) should be considered in evaluating economic and social hardship conditions.

Exhibit ES-9: POTW Screening Analysis Results for Cumulative Costs

Jurisdiction (# Counties in Watershed)	Number of Counties with POTW Screening Variable > 1%	
	Tier 2	Tier 3
Delaware (3 of 3)	1	1
District of Columbia (1 of 1)	0	0
Maryland (24 of 24)	0	1
New York (19 of 62)	1	1
Pennsylvania (42 of 67)	5	8
Virginia (97 of 135)[2]	18	22
West Virginia (11 of 55)	4	4
Total (197)	29	37

1. The POTW variable is average cost per household divided by median household income. The average cost includes current household sewer fees plus incremental average household control costs for the tier scenario. Includes CSO costs for the District of Columbia.
2. Includes independent cities as well as counties.

Industrial point sources incur control costs under Tiers 2 and 3. The screening analysis identifies the relative county-level earnings derived from the industrial sector or sectors in which the point sources are classified. **Exhibit ES-10** lists the number of counties or independent cities by state for which the screening variable value in Tier 3 exceeds 5%. The remaining jurisdictions have variable values of less than 5% (and generally less than 1%), except for 8 counties for which the variable cannot be evaluated because of missing data, indicating that the affected sectors are not a large part of the local economy. may not . Note, however, that these values are not indicative of where control costs would pose hardship, but merely show the size of the sector containing a facility that may need to implement controls.

Exhibit ES-10: Industrial Screening Analysis Results for Cumulative Costs

Jurisdiction (# Counties in Watershed)	Number of Counties with Industrial Screening Variable > 5%[1]
Delaware (3 of 3)	0
District of Columbia (1 of 1)	0
Maryland (24 of 24)	2
New York (19 of 62)	0
Pennsylvania (42 of 67)	5
Virginia (97 of 135)[2]	4
West Virginia (11 of 55)	1
Total (197)	12

Exhibit ES-10: Industrial Screening Analysis Results for Cumulative Costs

Jurisdiction (# Counties in Watershed)	Number of Counties with Industrial Screening Variable > 5%[1]

1. The industrial screening variable is earnings in the affected sectors divided by total earnings. Results exclude 8 counties with missing earnings data for a sector that includes a substantial discharger; 1 county is in Maryland, 3 are in Pennsylvania, and 4 counties are in Virginia.
2. Includes independent cities as well as counties.

Agriculture

The screening analysis includes both a cost variable (based on identifying potential for substantial impacts) and an earnings variable for the agricultural sector that is similar to the earnings variable for industrial sources (as indication of whether impacts could be widespread). The cost variable compares (implied) average annual per-farm BMP costs to median household income. Because the screening analysis includes two variables, the results in **Exhibit ES-11** reflect the joint outcome of both variables.

EPA (1995) provides profitability tests of impacts for businesses. However, the agricultural industry as a whole is highly subsidized, which means that these sources are not typical private businesses, and EPA guidance for evaluating private sector business impacts may not be appropriate. Many agricultural producers do not meet the profitability requirement in EPA guidance (private sector entities must be profitable before implementing pollution controls in order for substantial impacts to result from such costs). However, data are not available to exclude individual unprofitable farms from the analysis. At the same time, the agricultural sector is not similar to municipalities, and so the public sector tests in EPA (1995) also do not apply. The screening variable comparing costs to household income provides information to supplement the private sector tests that compare costs to net cash return and sales, although interpretation of this mix of concepts is difficult (i.e., there is no benchmark for comparing business-related expenses to household income).

Exhibit ES-11: Agriculture Screening Analysis Results for Cumulative Costs

	Number of Counties with MHI Screening Variable > 1% and Farm and Related Earnings Screening Variable > 5%[1]		Number of Counties with MHI Screening Variable > 1% and Farm Only Earnings Screening Variable > 5%[1]	
Jurisdiction (# Counties in Watershed)	Tier 2	Tier 3	Tier 2	Tier 3
Delaware (3 of 3)	1	1	0	0
District of Columbia (1 of 1)	0	0	0	0
Maryland (24 of 24)	1	1	0	0
New York (19 of 62)	2	2	0	0
Pennsylvania (42 of 67)	8	8	0	0
Virginia (97 of 135)[2]	9	10	5	5
West Virginia (11 of 55)	1	1	1	1

Exhibit ES-11: Agriculture Screening Analysis Results for Cumulative Costs

Jurisdiction (# Counties in Watershed)	Number of Counties with MHI Screening Variable > 1% and Farm and Related Earnings Screening Variable > 5%[1]		Number of Counties with MHI Screening Variable > 1% and Farm Only Earnings Screening Variable > 5%[1]	
	Tier 2	Tier 3	Tier 2	Tier 3
Total (197)	22	23	6	6

1. The MHI screening variable is average BMP cost per farm household divided by median household income. Note that this variable represents a mix of private sector and public sector concepts (i.e., business-related expenses compared to household income), and may be difficult to interpret. The earnings screening variable is earnings in farm and related sectors divided by total earnings in the first set of results and farm income only in the second set of results. The related sectors include farm services, tobacco products, and food and kindred products manufacturing.
2. Includes independent cities as well as counties.

Further, there is great uncertainty in the extent of costs that will actually be borne by farmers. The 2002 Farm Bill increases federal overall conservation funding by 80% above the level committed by the last (1996) farm bill. In addition, the new law permits a greater percentage of BMP installation costs (90%, up from 75% in the 1996 bill) to be granted to limited-resource farmers under the Environmental Quality Incentives Program. The 2002 Farm Bill cost share provisions are not reflected in this economic analysis. Therefore, costs paid by farmers may be lower than those used in the screening analysis, and impacts may be overstated. As one example, although specific provisions for the yield reserve BMP in the tier scenarios are not included in the bill, the program may be funded under an innovative technologies clause of the bill (personal communication with T. Simpson, Chair, Chesapeake Bay Program Nutrient Subcommittee, May 2002). If implemented, this cost-share program could result in annual incentive payments of $20 to $40 per acre that are not included in the screening analysis. Funding for this program alone would reduce the agricultural costs borne by farmers in Tier 3 by $17 million to $42 million per year.

Also, due to the large number of programs and sources across states, the cost-share information may be incomplete. The cost-share assumptions in the impact analysis are very complex because they vary by state, program, and BMP. Cost shares may include a variety of contract arrangements including a capital cost share, an annual rental payment, an up-front incentive payment, and an annual maintenance cost. For this analysis, the Chesapeake Bay Program did not factor in the substantial annual rental payments but instead assumed that they would offset any revenue losses resulting from BMP implementation. If instead, rental payments more than offset any losses (e.g., BMPs are implemented on marginal land such that little revenue is lost), the screening analysis may overstate impacts.

As shown in Exhibit ES-11, under Tier 2, there are 22 counties that do not have MHI and earnings screening variable values below the values shown. This result uses the earnings screening variable for farm income and related sectors. When this variable is limited to farm income only, only 5 counties in Virginia and one county in West Virginia have values that exceed the values shown for both screening variables.

Under Tier 3, 23 counties have high values for both screening variables. These results are nearly identical to Tier 2 results despite BMP cost increases. This happens because the earnings screening variable is constant across the tier scenarios. Thus, even if higher costs increase the likelihood of substantial impacts in some counties, the farming sector's small contribution to the local economy limits its ability to have a widespread adverse impact measured by impacts on overall county incomes.

Forestry

The screening analysis for forestry impacts uses an earnings variable that compares forestry sector earnings to total earnings. No counties or independent cities are likely to experience hardship as a result of forestry BMPs because forestry represents a small share (less than 3%) of earnings in all jurisdictions. The small values indicate that the sector is small relative to the county economy and, therefore, a sector-level substantial impact (if any) is unlikely to have widespread ramifications.

Urban

Like the POTW sector, the screening analysis consists of comparing average annual per-household costs to median household income, based on EPA (1995) guidance for evaluating substantial impacts. Few counties exceed a 1% ratio value under Tier 2 (**Exhibit ES-12**). Under Tier 3, 162 out of 197 jurisdictions still have a small screening variable value (i.e., < 1%), despite a substantial increase in annual BMP costs.

Exhibit ES-12: Urban Screening Analysis Results for Cumulative Costs

Jurisdiction (# Counties in Watershed)	Number of Counties with Urban Screening Variable > 1%[1]	
	Tier 2	Tier 3
Delaware (3 of 3)	0	0
District of Columbia (1 of 1)	0	0
Maryland (24 of 24)	1	1
New York (19 of 62)	0	4
Pennsylvania (42 of 67)	3	9
Virginia (97 of 135)[2]	4	19
West Virginia (11 of 55)	0	2
Total (197)	8	35

1. The urban screening variable is average household BMP costs divided by median household income. Does not include CSO/SSO costs.
2. Includes independent cities as well as counties.

Urban households may incur costs for urban BMPs as well as POTW controls. Under these combined costs, 145 jurisdictions have variable values of less than 1% (**Exhibit ES-13**). The remaining 52 areas with higher variable values for combined costs require further analysis to evaluate impact potential.

Under Tier 3, the screening analysis shows that variable values for combined costs are less than 1% in 117 jurisdictions. Further analysis would be needed for the 80 areas that have higher screening variable values.

Exhibit ES-13: Urban and POTW Combined Screening Analysis Results for Cumulative Costs

Jurisdiction (# counties in watershed)	Number of Counties with Combined Screening Variable > 1%[1]	
	Tier 2	Tier 3
Delaware (3 of 3)	1	1
District of Columbia (1 of 1)	0	0
Maryland (24 of 24)	5	8
New York (19 of 62)	4	8
Pennsylvania (42 of 67)	13	22
Virginia (97 of 135)[2]	26	36
West Virginia (11 of 55)	3	5
Total (197)	52	80

1. The combined cost screening variable is average urban BMP and POTW costs per household divided by median household income. Includes CSO costs for the District of Columbia.
2. Includes independent cities as well as counties.

Onsite Waste Management Systems

Similar to the agriculture sector, the screening analysis for OSWMS costs includes both a cost variable (designed to identify whether impacts would be substantial) and a variable for the percent of households affected (designed to identify whether impacts would be widespread). The cost variable compares average annual per-household BMP costs to median household income. The results indicate that, because the onsite waste management BMP affects so few households (less than 1% of existing onsite systems), there is little potential for any substantial financial impacts to also be widespread.

Introduction

In developing revised water quality criteria, designated uses, and boundaries for those uses to protect living resources in the Chesapeake Bay and its tidal waters, EPA's Chesapeake Bay Program Office prepared a technical support document (*Technical Support Document*; U.S. EPA Chesapeake Bay Program. 2003. *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability*). The document provides information to Chesapeake Bay jurisdictions for development of water quality standards for dissolved oxygen, clarity, and chlorophyll *a*, based on EPA's regional criteria guidance. Part of the jurisdictions' water quality standards development process may be to conduct use attainability analyses (UAAs). The information contained in the *Technical Support Document* is to assist states in development of their individual UAAs, and serves as a basis for state-specific documents that will be initiated after the revised criteria for the Chesapeake Bay are finalized by EPA.

This document supplements the *Technical Support Document* by presenting economic analyses performed by the Chesapeake Bay Program. Part I of this document provides estimates of the potential control costs associated with three modeling scenarios (the tier scenarios) of nutrient reduction measures. Part II describes economic modeling of the potential impacts of these control costs in the Bay region. Part III documents a screening-level analysis of potential impacts, also based on the costs of the tier scenarios. Several appendices provide additional information. Appendix A summarizes the types of benefits that may arise from the tier scenarios, and existing studies related to Bay water quality. Appendix B presents detailed calculations supporting the screening analysis. Appendix C provides detailed results from the screening analysis in tabular format, and Appendix D provides additional results in map format. Appendix E contains three case study sensitivity analyses of the screening analysis results related to potential costs for combined sewer overflows. Appendix F includes information related to evaluating impacts associated with potential pollutant loading caps for publicly owned treatment works. Finally, Appendix G provides information related to sanitary sewer overflows submitted in comments on the draft economic analyses.

The economic analyses provide information related to evaluating impacts from the implementation of the nutrient reduction measures defined in the *Technical Support Document*. However, the Bay Program did not use these analyses to delineate boundaries for the new refined designated uses. Although this information may be useful to states in developing their own UAAs, economic analyses to show substantial and widespread impacts from meeting water quality standards would need to be more rigorous than the analyses performed by the Bay Program. Direction regarding the types of information and analyses necessary to perform a UAA is included in Part III of this document.

The *Technical Support Document* and this economics document do not represent a regulation or a mandatory requirement, but rather provide a compilation of the basin-wide, UAA-related analyses assimilated collaboratively by the affected jurisdictions. EPA encourages the jurisdictions to use the information in this document and, when appropriate, to perform additional analyses tailored to each jurisdiction during their respective water quality standards development process. The Chesapeake Bay Program's analyses address all dischargers and sources in the watershed needing controls to meet the new refined designated uses, as modeled under three hypothetical control scenarios. Local jurisdictions can use more site-specific control and cost information, and evaluate local economic impacts.

Part I: Documentation of Estimated Costs of the Tier Scenarios

As part of its assessment of actions to remove the Chesapeake Bay and its tidal tributaries from the list of impaired waters under the Clean Water Act, U.S. EPA's Chesapeake Bay Program Office estimated the costs and nutrient (nitrogen and phosphorus) reduction potential of nutrient removal technology and best management practices under several alternative scenarios. This report summarizes the purposes, methods, and results of the cost assessment. Note that sediment reduction is not specifically addressed, unless it is included in the removal practices. Control of air sources is also not addressed in the scenarios.

1. BACKGROUND AND OBJECTIVES

As described in the *Technical Support Document*, the Chesapeake Bay Program developed tiered implementation scenarios of nutrient reduction measures for the Chesapeake Bay watershed based on the extent of controls already in place as of the year 2000 (the 2000 Progress scenario), and estimates of the controls that would be in place if current implementation rates were continued through the year 2010 (the Tier 1 scenario). Then, Tiers 2, 3, and E3 (which represents a theoretical limit of technology, but is physically implausible) scenarios add incremental increases in implementation levels. The tier scenarios, developed by various stakeholder workgroups, are based on the Chesapeake Bay Program's estimates of 2010 populations and land uses in the basin. This report provides estimates of the cost of Tiers 1, 2, and 3.[1] Note that these cost estimates reflect, in part, the extent of efforts to date which vary across states. However, state data on controls in place throughout the watershed are incomplete, which may result in overestimates of costs for the tiers.

This report provides estimates of the total annual cost of achieving the tier scenarios, total capital cost requirements, and, to the extent that information could be compiled, estimates of how these costs may be shared between the public and private sectors. For example, the Chesapeake Bay Program assumed that current agricultural cost-share and incentive payments are continued (i.e., there are no limits in program funding). Similarly, it assumed that the states of Maryland, and Virginia to a lesser extent, would provide grants to assist in funding nutrient reduction technologies for publicly owned treatment works. Costs for the remaining practices specified in the tier scenarios are attributed to the private sector (although public programs could be used to fund these controls as well).

In addition to summarizing the resources required for each level of control implementation, the cost estimates can also be used to investigate the potential economic impacts of the scenarios. The Chesapeake Bay Program's Use Attainability Analysis (UAA) Workgroup used these estimates to develop screening-level impact analyses based on the same assumptions described above regarding how costs may be shared between the public and private sectors (see Part III).

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[1] No cost estimates were developed for the E3 scenario which the Chesapeake Bay Program regards as physically implausible.

U.S. EPA also used the estimates in a regional economic impact analysis for the UAA Workgroup.

Part I of this report is organized as follows. Section 2 describes the methods for estimating the cost of nutrient reduction technologies for point sources and best management practices (BMPs) for nutrient control. Section 3 summarizes results, including capital and total annual costs, by political and hydrogeologic boundaries.

2. METHODS

The sections below describe the methods for estimating the costs of the tier scenarios for POTW and industrial sources (Section 2.1) and agriculture, forestry, urban, and onsite waste management system sources (Section 2.2).

2.1 POTWs and Industrial Sources

The Chesapeake Bay Program convened a multi-stakeholder Nutrient Removal Technology (NRT) Task Force to develop point source costs for the tier scenarios. The Task Force's method and estimated costs are described in detail under separate cover (NRT Cost Task Force, 2002), and summarized below.

The NRT Task Force developed costs for significant municipal and industrial facilities located in the watershed that discharge nitrogen and phosphorus. Significant municipal facilities are generally defined as wastewater treatment plants that discharge flows of 0.5 million gallons per day (mgd) or greater, although the threshold may vary slightly from jurisdiction to jurisdiction. Significant industrial facilities are those discharging nutrient loadings greater than or equal to those discharged by a municipal wastewater treatment with a flow capacity of 0.5 mgd, which equates to approximately 75 lbs/day of total nitrogen (TN) and 25 lbs/day total phosphorus (TP) based on a municipal discharge of 18 mg/L TN and 6 mg/l TP.

2.1.1 Point Source Nutrient Reduction Scenarios

The tier scenarios incorporate varying levels of nutrient reductions for point sources. For municipal facilities, Tier 1 includes current or planned pollutant controls; Tier 2 requires end-of-pipe effluent concentrations of 8.0 mg/L TN, and either 1.0 mg/L TP or the permit limit (whichever is lower); and Tier 3 requires end-of-pipe effluent concentrations of 5.0 mg/L TN, and the lower of 0.5 mg/L TP or the permit limit. For industrial facilities, Tier 1 represents no change from current levels, and the effluent concentrations required for Tiers 2 and 3 generally correspond to those of municipal facilities. Tier 1 also includes a reduction in combined sewer overflows (CSOs) in the District of Columbia. **Exhibit 1** provides a summary of the tier scenarios for municipal and industrial facilities and the District of Columbia CSOs.

Exhibit 1: Scenarios of Nutrient Reduction for Point Sources

Source	Tier 1	Tier 2	Tier 3
Significant Municipal Wastewater Treatment Facilities (as of 2000)	Existing NRT facilities and those planned to go to NRT by 2010: 2010 flow with 8.0 mg/L TN effluent concentration and year 2000 concentrations of TP. For all remaining facilities: 2010 flow with year 2000 TN and TP concentrations.	Reach and maintain 8.0 mg/L TN and 1.0 mg/L TP effluent concentrations at 2010 flows at all facilities. (Phosphorus concentration is 1.0 mg/L or permit limit, whichever is more stringent.)	Reach and maintain 5.0 mg/L TN and 0.5 mg/L TP effluent concentrations at 2010 flows at all facilities. (Phosphorus concentration is 0.5 mg/L or permit limit, whichever is more stringent.)
Significant Industrial Wastewater Treatment Facilities (as of 2000)	Maintain current levels or permit conditions if less.	Generally a 50% reduction from Tier 1, or 2000 concentrations or permit conditions if less.	Generally a 80% reduction from Tier 1, or 2000 concentrations or permit conditions if less.
Non-significant Municipal Wastewater Treatment Facilities (as of 2000)	Maintain current TN/TP concentrations with 2010 flows.	Maintain current TN/TP concentrations with 2010 flows.	Maintain current TN/TP concentrations with 2010 flows.
Combined Sewer Overflow (CSO) (District of Columbia only)	43% reduction in CSO.	43% reduction in CSO.	43% reduction in CSO.

Note that for municipal facilities, TN and TP concentrations may increase from one tier to the next. For example, concentrations for some facilities increase between 2000 Progress and Tier 1 because the NRT Task Force believes that some facilities may not be able to operate as efficiently at 2010 flows as they do at 2000 flows and, therefore, the 2000 concentration may not be representative of 2010 conditions. For facilities with TN concentrations less than 8 mg/L in 2000, the Task Force assumed concentrations would increase to 8 mg/L by 2010. The same principle is true for TP (i.e., the Task Force assumed concentrations would increase to 1 mg/L by 2010 if the 2000 concentration is less than 1 mg/L).

2.1.2 Overview of Method

The NRT Task Force developed costs for controlling nitrogen and phosphorous separately using estimates obtained directly from affected facilities, where available, and applying the methods described below if facilities did not provide estimates. However, for Tier 1, which represents current or planned controls, costs are zero for municipal facilities that did not provide costs. There are also no costs for industrial facilities under Tier 1, since it represents no change from 2000 effluent concentrations. In addition, the costs of upgrades for federal facilities are excluded from the analysis, because households in the watershed will not incur direct costs for these facilities.

The NRT Task Force developed estimates for capital and annual operating and maintenance (O&M) costs. This report also provides these estimates annualized over 20 years. For municipal facilities, the annualized estimates reflect an average 2001 Statewide Revolving Fund rate for each state (1.0% for DE, 2.2% for MD, 2.5% for NY, 2.5% for PA, 3.9% for VA, and 0.7% for WV) and the national average rate of 2.4% (U.S. EPA, 2001c) for the District of Columbia. For industrial facilities, the annualized estimates reflect a 5.76% interest rate.[2] The summary of estimates in this report also incorporates the assumption (based on current experience) that federal and state grant programs would contribute 50% of capital costs for NRT for municipal facilities in Maryland, 10% for municipal facilities in Virginia, and 0% for facilities in other states and the District of Columbia.

2.1.3 Nitrogen Removal: Municipal Facilities

As described above, there are only Tier 1 costs for municipal facilities for the removal of nitrogen if these facilities are either currently operating NRT or are planning to by 2010 and have not already obtained funds for their efforts. Costs for facilities are estimated from data obtained directly from facilities or by applying an estimating methodology developed by the NRT Cost Task Force. The methods for estimating costs for Tiers 2 and 3 for nonreporting facilities (i.e., those that did not provide estimates) are described below.

Tier 2. The NRT Task Force used capital cost estimates received from reporting municipal facilities, including all facilities with design flow greater than 30.0 mgd. For the remaining facilities, since the nitrogen removal goals for municipal facilities in Tier 2 are the same as those for Tier 1 (8 mg/L TN), the Task Force used capital cost estimates for upgrading 67 facilities provided by U.S. EPA to extrapolate costs for upgrading nonreporting facilities to Tier 2 requirements. The estimates are based on actual construction costs, engineering design estimates, or preliminary engineering reports and facilities plans. The NRT Task Force fit a line to these data and estimated the following capital costs equation:

$$\textit{Capital Cost} = 2{,}023{,}829 + 7 - 4{,}351.8039 \times Q - Q^2$$

where Q = design flow between 0.5 and 30.0 mgd.

To estimate O&M costs, the NRT Task Force assumed that only facilities with ammonia concentrations greater than 2 mg/L would require additional nitrification to convert ammonia-N to nitrate-N. Most of the operations costs for Tier 2 are associated with the change in electrical requirements for aeration during biological treatment. The nitrification process requires oxygen, specifically, 4.57 lbs of oxygen per pound of ammonia nitrogen removed. Thus, the oxygen requirement can be calculated given a plant's effluent ammonia concentration. Once the oxygen requirement is known, the brake horsepower can be calculated using operating parameters for a typical aeration system.

The O&M costs also account for the possible denitrification energy cost savings due to lower oxygen requirements. The Task Force calculated electrical costs assuming 2.86 pounds of oxygen saved per pound of nitrate denitrified. In calculating nitrification and denitrification O&M costs, the Task Force used the projected 2010 flow rate. Change in solids production is

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[2] The 5.76% interest rate is based on the average market rate between 1998 and 2002 for business loans of between \$100,000 and \$10,000,000 (Federal Reserve, 2002, 2001, 2000, 1999, 1998), and a marginal corporate tax rate of 20%. The average interest rate over the last five years is approximately 7.2%. Because loan repayments reduce corporate tax liability, the net interest rate on a loan reflects this tax advantage, which is 80% of the stated rate (i.e., 1–20%). Thus, the effective interest rate is 5.76% (7.2% x 0.8).

negligible, and no additional labor is required. Maintenance costs are estimated as 2% of initial capital costs per year.

Tier 3. The NRT Task Force acknowledged certain improvements to a standard activated sludge plant would be necessary to achieve TN levels of 5 mg/L, and made the following assumptions:

- Plants are currently achieving TN of 8 mg/L
- Additional treatment comprises secondary anoxic zone with methanol addition following aeration and improvements to nitrification, clarification, flow splitting, and aeration
- Incremental costs include 30% program implementation associated with engineering, construction management, legal, bonding, and administrative fees.

The NRT Task Force fit lines to capital cost pollutant control estimates for plants with capacities of 0.1, 1.0, 10 and 30 mgd to develop separate cost curves:

0.1 mgd < Q < 1.0 mgd
$\mathit{Capital\ Cost} = 967.06 \times Q + 144.44$
1.0 mgd < Q < 30 mgd
$\mathit{Capital\ Cost} = 386.01 \times Q + 864.83$

The Task Force used a similar method to estimate O&M costs, using plant capacities of 0.1, 1.0, 10 and 30 mgd to develop linear cost curves. O&M costs include methanol purchase, handling, stabilization, and disposal or reuse costs from increased solids production, energy, and maintenance costs, and include the following assumptions:

- 3.1 pounds of methanol are needed for every pound of nitrate reduced
- Methanol costs are $1.00 per gallon for bulk storage, except for the 0.1 mgd plant where costs are $2.00 per gallon for a 55-gallon drum feed
- The process will yield 0.12 pounds of solids per pound of methanol applied
- Solids handling, stabilization and disposal or reuse costs are $300 per dry ton
- Energy costs for mixing and other uses for each plant size are $0.05/kWh
- Maintenance costs are 2% of initial capital costs.

2.1.4 Nitrogen Removal: Industrial Facilities

The industrial cost estimates are described in detail in NRT Cost Task Force (2002). As described above, there are no reductions in nitrogen from industrial facilities required under Tier

1. In general, Tier 2 reflects levels of reduction on the order of 50% from Tier 1 unless permit conditions are more stringent. Tier 3 reflects a reduction of about 80% beyond Tier 1 unless permit conditions are more stringent. For Tiers 2 and 3, the NRT Task Force developed costs based on 2000 effluent concentrations. The Task Force used site-specific cost estimates where they were provided; otherwise, it assumed that onsite controls or transportation of effluent to a POTW would be required. Estimated costs for Tiers 2 and 3 are zero whenever 2000 TN or TP concentrations are less than or approximately equal to the concentrations required by each tier. For the remaining facilities, the Task Force estimated costs using the same methodology as for municipal facilities, even where it is known that some industrial wastewater is not treatable biologically.

2.1.5 Phosphorus Removal: Municipal Facilities

As described above, there are only costs for municipal facilities for the removal of phosphorus if these facilities provided estimates for current or planned controls. The methods for estimating costs for Tiers 2 and 3 for facilities that did not provide estimates are described below.

Tier 2. The NRT Task Force developed costs based on 2000 TP effluent concentrations. Costs are zero for facilities with effluent already below the Tier 2 requirement of 1 mg/L TP. The Task Force assumed that facilities discharging between 1 mg/L and 2 mg/L TP are operating chemical precipitation, and would only require O&M costs associated with increased chemical addition and sludge handling. Removal of 1 mg/L of TP requires 14.4 mg/L of alum, which costs $269 per ton. Sludge handling costs are $300 per dry ton of sludge. The amount of sludge produced is calculated from the stoichiometric coefficients of the sludge reaction and the 2010 flow rate. Facilities discharging TP concentrations greater than 2 mg/L require treatment controls. The NRT Task Force assumed that facilities would install chemical precipitation using alum. Cost curves for chemical precipitation installation are:

$0.1 \text{ mgd} < Q < 1.0 \text{ mgd}$
$\textit{Capital Cost} = 94{,}444 \times Q + 65{,}556$
$1.0 \text{ mgd} < Q < 30 \text{ mgd}$
$\textit{Capital Cost} = 15{,}172 \times Q + 144{,}828$

The Task Force approximated costs for plants with capacities outside of this range using the maximum or minimum cost; it calculated O&M costs using the method for facilities discharging between 1 mg/L and 2 mg/L TP, and assumed maintenance costs of 2% of capital costs per year.

Tier 3. The NRT Task Force made the following assumptions in developing costs:

- Tier 2 requirements are already in place (i.e., facilities are already operating chemical precipitation), therefore, there are no additional capital costs

- Facilities are operating at 1.0 mg/L TP or less

- O&M costs are calculated as described in Tier 2.

2.1.5 Phosphorus Removal: Industrial Facilities

As described above, there are no reductions in phosphorus from industrial facilities required under Tier 1. For Tiers 2 and 3, the NRT Task Force estimated TP removal costs using the same methodology used to estimate TN removal costs.

2.1.6 Limitations and Uncertainties in the Analysis of Point Source Costs

There are a number of limitations and uncertainties inherent in the method for estimating point source costs. **Exhibit 2** illustrates the sources of potential bias, and the potential impact on the estimates.

Exhibit 2: Sources of Uncertainty in the Point Source Cost Estimates

Source	Potential Impact on Costs	Comments
Costs for reducing TN and TP derived separately	+	Some technologies may control TN and TP simultaneously; thus costs could be lower to treat N and P at the same time
Costs may include growth-related costs not related to the tier scenarios	+	Planning-level estimates for 2010 may incorporate costs that would be incurred anyway to serve increased populations; no attempt is made to estimate baseline costs [upgrades necessary to treat 2010 flows sufficient to meet local water quality standards or anticipated total maximum daily loads (TMDLs) without implementation of the tier scenarios]
Costs include estimates provided by facilities for which no nutrient reductions are indicated	+	Current effluent concentrations for these facilities meet the levels specified in the tier scenarios
Costs for NRT obtained from facilities	?	These estimates have not been verified.
Costs include biological treatment to reduce TN and TP at many industrial facilities	?	Biological treatment may not be a feasible option for certain industrial facilities, and more or less costly treatment controls may be needed instead
Estimates based on cost equations reflect the same treatment to reduce TN and TP levels at all facilities	?	Costs are not based on facility-specific treatment processes or operational procedures and, therefore, may over- or underestimate costs

\+ = assumption results in overestimating costs
? = impact of assumption on cost estimates is unknown

2.2 Forestry, Agriculture, Urban, and OSWMS Sources

The tier scenarios also include varying implementation levels of nutrient reduction BMPs for agricultural operations, forest harvesting operations, urban and mixed open (land with herbaceous cover not classified as agricultural, urban, or forest) land, and onsite wastewater management systems (OSWMSs). Tier 1, which represents current implementation levels extended to 2010, incorporates the Phase I and Phase II Storm Water Rules and other ongoing state and local programs (e.g., nutrient management planning on crop and hay land in Maryland

and Delaware). However, as described below, the degree to which it incorporates anticipated revisions to the concentrated animal feeding operation (CAFO) regulations and state programs submitted under the Coastal Zone Reauthorization Amendments (CZARA) of 1990 is unknown. **Exhibit 3** summarizes the tier scenarios for these sources.

U.S. EPA anticipates that CAFOs will incur costs to implement or improve animal waste management systems, develop and implement nutrient management plans, and transfer excess manure offsite under revisions to the effluent guidelines for this sector. However, because EPA is still finalizing the CAFO rule, the extent of overlap with the tier scenarios is unknown. For instance, although Tier 1 requirements for animal waste systems indicate continuing the level of implementation based on the average rate of 1997-2000 (Exhibit 3), this level is most likely lower than would be required under the final CAFO regulations.

Section 6217 of the CZARA requires 29 states and territories, including the basin states of Delaware, Maryland, New York, Pennsylvania, and Virginia, to develop programs to implement practices to control nonpoint source pollution in areas where land and water uses have a significant impact on coastal waters. Although state program were supposed to be approved by 1995 and fully implemented by 1999, this schedule has not been met. Administrative changes in 1998 required that participating states submit 15-year program strategies outlining the NPS management measures they plan to implement through a sequence of 5-year an implementation plans that coordinate BMP implementation with other programs such as the Chesapeake Bay Program. Management measures can differ by state depending on the relative impact of different types of NPS on water quality. Thus, BMP implementation that would occur under Section 6217 of CZARA may overlap the tiers to an unknown degree for the following controls:

- Agricultural BMPs, including forest riparian buffers, nutrient management plans, animal waste management, excess manure removal, stream protection, grazing land protection, conservation tillage, wetland restoration, and retirement of erodible land

- Silvicultural BMPs, including forest harvesting practices to reduce erosion

- Urban BMPs, including environmental site design and urban riparian forest and grass buffers

- Onsite disposal system BMPs, including denitrification.

Exhibit 3: Nutrient Reduction Scenarios for Agriculture, Forestry, Urban, and OSWMS Sources

BMP	Tier 1	Tier 2	Tier 3
Agriculture: Cropland Conversions to Forest or Hayland			
Forest buffers (Pasture)	Continue current level of implementation using average rate of 1997-2000. Includes fencing.	Increase level of implementation up to a total of 20% of the remaining stream reaches in pasture. Includes fencing.	Increase level of implementation up to a total of 30% of the remaining stream reaches in pasture. Includes fencing.
Forest buffers (Cropland)	Continue current level of implementation using average rate of 1997-2000.	Increase level of implementation up to a total of 20% of the remaining stream reaches in cropland.	Increase level of implementation up to a total of 30% of the remaining stream reaches in cropland.
Grass buffers (Cropland)	Continue current level of implementation using average rate of 1997-2000.	25% of remaining stream reaches within cropland.	50% of remaining stream reaches within cropland.
Forest buffers (Hayland)	Continue current level of implementation using average rate of 1997-2000.	25% of remaining stream reaches within hayland over Tier 1.	50% of remaining stream reaches within hayland over Tier 1.
Wetland restoration (Cropland)	Continue current level of implementation using average rate of 1997-2000.	Increase level of implementation up to a total of 33% of the remaining goal.	Increase level of implementation up to a total of 66% of the remaining goal.
Retirement of highly erodible land (HEL)	Continue current level of implementation using average rate of 1997-2000.	Retirement of HEL-Wetland Restoration-buffers (combined) comprise 10% of cropland within each county.	Retirement of HEL-Wetland Restoration-buffers (combined) comprise 15% of cropland within each county.
Carbon sequestration	Not applicable.	Not applicable.	Applied to 15% of remaining E3 cropland after land conversion programs applied.
Agriculture: BMPs on Cropland			
Conservation tillage	Continue current level of implementation using average rate of 1997-2000.	Applied to 30% of remaining cropland beyond Tier 1.	Applied to 60% of remaining cropland beyond Tier 1.
Farm plans (soil conservation and water quality plans)	Continue current level of implementation using average rate of 1997-2000.	Applied to 30% of remaining agricultural land (crop, hay, pasture) beyond Tier 1.	Applied to 70% of remaining agricultural land (crop, hay, pasture) beyond Tier 1.
Cover crops	Continue current level of implementation using average rate of 1997-2000.	Applied to 40% of remaining cropland beyond Tier 1.	Applied to 75% of remaining cropland beyond Tier 1.

Exhibit 3: Nutrient Reduction Scenarios for Agriculture, Forestry, Urban, and OSWMS Sources

BMP	Tier 1	Tier 2	Tier 3
Nutrient management plan implementation	MD & DE: 100% of cropland and hayland. Other basin states: Continue current level of implementation using average rate of 1997-2000.	MD & DE: 100% of cropland and hayland. Other basin states: Applied to 30% of remaining cropland and hayland beyond Tier 1.	MD & DE: 100% cropland and hayland. Other basin states: Applied to 30% of remaining cropland and hayland beyond Tier 2.
Yield reserve	Not applicable.	Not applicable.	Applied to 30% of the cropland and hayland under nutrient management. Replaces nutrient application component of nutrient management plan.
Excess manure removal	Assume alternative use for excess manure.	Assume alternative use for excess manure.	Assume alternative use for excess manure.
Animal waste management systems	Continue current level of implementation using average rate of 1997-2000.	Applied to 25% of remaining confined animal units beyond Tier 1 (combines storage system and barnyard runoff controls).	Applied to 60% of remaining confined animal units beyond Tier 1 (combines storage system and barnyard runoff controls).
Stream protection without fencing	Continue current level of implementation using average rate of 1997-2000.	Applied to 10% of remaining stream reaches within pasture land beyond Tier 1.	Applied to 25% of remaining stream reaches within pasture land beyond Tier 1.
Stream protection with fencing	Continue current level of implementation using average rate of 1997-2000.	Applied to 15% of remaining stream reaches within pasture land beyond Tier 1.	Applied to 75% of remaining stream reaches within pasture land beyond Tier 1.
Grazing land protection	Continue current level of implementation using average rate of 1997-2000.	Applied to 25% of remaining pasture land beyond Tier 1.	Applied to 50% of remaining pasture land beyond Tier 1.
Forestry			
Forest harvesting BMPs (erosion control)	Forestry BMPs are properly installed on 80% of all harvested lands.	Forestry BMPs are properly installed on 90% of all harvested lands.	Forestry BMPs are properly installed on 100% of all harvested lands with no measurable increase in nutrient and sediment discharge.
Urban and Mixed Open Land			
Urban land conversion (signatories only)	Full 2000-2010 urban land conversion based on 2010 population.	2000-2010 urban conversion – reduced 10% (acres "returned" as 65% forest, 20% mixed open, 15% agriculture).	2000-2010 urban conversion – reduced 20% (acres "returned" as 65% forest, 20% mixed open, 15% agriculture).

Exhibit 3: Nutrient Reduction Scenarios for Agriculture, Forestry, Urban, and OSWMS Sources

BMP	Tier 1	Tier 2	Tier 3
Urban and Mixed Open Land (Continued)			
Storm water management and low impact development – new development (2001-2010)	66% of new development has storm water management (percent reduction: TN=35, TP=45, TSS=80).	75% of new development has storm water management. 25% of new development employs environmental site design and low-impact development techniques. Efficiencies represent a 75%/25% weighted average reduction (TN=40, TP=55, TSS=85).	50% of new development has storm water management. 50% of new development employs environmental site design and low-impact development techniques. Efficiencies represent a 50%/50% weighted average reduction (TN=45, TP=57, TSS=87).
Storm water management - recent development (1986-2000)	60% of recent development has storm water management (percent reduction: TN=27, TP=40,TSS=65).	60% of recent development in MD, PA, DC, VA has storm water management (percent reduction: TN=27, TP=40,TSS=65).	60% of recent development in MD, PA, DC, VA has storm water management (percent reduction: TN=27, TP=40,TSS=65).
Storm water retrofits – recent (1986-2000) and old (pre 1986) development	0.8% of recent and old (pre 1986) development is retrofitted (percent reduction: TN=20, TP=30,TSS=65).	5% of recent and old (pre 1986) development is retrofitted (percent reduction: TN=20, TP=30,TSS=65).	20% of recent and old (pre 1986) development is retrofitted (percent reduction: TN=20, TP=30,TSS=65).
Urban nutrient management	Continue to implement BMP at average annual rate through 2010, using average of 1997-2000 (percent reduction: TN=17%, TP=22%).	40% of urban pervious and mixed open lands are under nutrient management (percent reduction: TN=17%, TP=22%).	75% of urban pervious and mixed open lands are under nutrient management (percent reduction TN=17%, TP=22%).
Grass buffers (urban land)	All urban stream reaches are assumed to have either grass or tree buffers. Where urban disturbance has altered a stream reach beyond repair/ restoration, it is not included as a potential buffer area.	Reduce grass buffers by 10% below Tier 1 level (conversion to forest buffers).	Reduce grass buffers by 30% below Tier 1 level (conversion to forest buffers).
Forest buffers (urban land)	Not applicable.	Increase forest buffer acreage by the same amount of “reduced” grass buffer acreage.	Increase forest buffer acreage by the same amount of “reduced” grass buffer acreage.
Forest buffers (mixed open land)	Continue current level of implementation using average rate of 1997-2000.	Increase forest buffer acreage by the same amount as forest buffers on urban pervious.	Increase forest buffer acreage by the same amount as forest buffers on urban pervious.

Exhibit 3: Nutrient Reduction Scenarios for Agriculture, Forestry, Urban, and OSWMS Sources

BMP	Tier 1	Tier 2	Tier 3
Onsite Treatment Systems			
Denitrification with pumping (new systems, i.e., post 2000)	Maintain current concentration/load per system (36 mg/l TN).	10% of new treatment systems will meet a concentration for nitrogen of 10 mg/L TN per system at the edge-of-the adsorption field. Remaining systems meet existing concentration/load levels.	100% of new treatment systems will achieve 10 mg/L TN at the edge of the adsorption field.
Denitrification with pumping (existing systems, i.e., pre-2001)	Maintain current concentration/load per system (36 mg/l TN).	Maintain current concentration/load per system (36 mg/l TN).	1% of existing (per year) treatment systems will achieve 10 mg/L TN at the edge of the adsorption field (1% represents failed systems and opportunities for upgrades). Remaining systems maintain existing concentrations/loads.

HEL = Highly erodible land
TN = total nitrogen
TP = total phosphorus
TSS = total suspended solids.

Exhibit 4 provides the number of incremental acres of each BMP or number of systems for onsite wastewater management systems (i.e., beyond acres or systems in the 2000 Progress scenario) that correspond to the scenario descriptions in Exhibit 3. Negative numbers indicate that BMP implementation is currently greater in the Progress 2000 scenario than required by the tier scenario. For the BMPs that are applied to land, this reflects a change in land use. The change may be caused by an actual conversion of land from agricultural to other uses, for instance, because of urban growth projected to occur between 2000 and 2010. It also may be caused by agricultural BMPs that cause land to shift from one agricultural land use category to another. For example, higher implementation rates of forest or grass buffers, wetlands restoration, carbon sequestration, and retirement of highly erodible land BMPs on high till land leaves less land available for the conservation tillage BMP. In some cases, the conservation tillage acreage is actually negative because the total number of acres in the tier scenario is lower than the number of acres in Progress 2000. Negative numbers for excess manure removal in Maryland are related to a projected decline in the number of animal units in Maryland from 2000 to 2010, as well as shifting animal types between 2000 and 2010 and variation in the nutrient content of the manure of different animal species, and shifting land uses to which the manure can be applied.

Exhibit 4: Tier 1 BMP Scenario: Delaware

BMP	Number of Acres[1]				
Urban	**Pervious**	**Impervious**	**Ultra**	**Mixed Open**	
Forest Buffers	2	-	-	0	
Grass Buffers	565	-	-	-	
Environmental Site Design / Low-Impact Dev.	0	0	-	-	
Storm Water Retrofits	139	42	0	-	
Storm Water Management on New Dev.	1,137	425	-	-	
Nutrient Management	0	-	-	60,791	
Urban Land Conversion	0	0	-	-	
Forest Conservation	0	0	-	-	
Agriculture[2]	**High Till**	**Low Till**	**Hay**	**Pasture**	**Manure**
Forest Buffers	713	1,747	72	21	-
Grass Buffers	312	762	-	-	-
Wetland Restoration	56	133	4	0	-
Retirement of Highly Erodible Land	0	0	0	-	-
Tree Planting	0	0	-	0	-
Farm Plans	0	0	0	0	-
Cover Crops	-8	8	-	-	-
Stream Protection w/ Fencing	-	-	-	0	-
Stream Protection w/o Fencing	-	-	-	0	-
Nutrient Management Plan Implementation	49,761	112,223	4,872	-	-
Grazing Land Protection	-	-	-	0	-
Animal Waste Management Systems	-	-	-	-	4
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	71,287
Conservation Tillage	721	-	-	-	-
Forest	**Forest Land**				
Forest Harvesting Practices (Erosion Control)	175				
Onsite Wastewater Management Systems	**Existing Systems**	**New Systems**			
Denitrification w/ Pumping[3]	0	0			

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 1 BMP Scenario: District of Columbia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	1	-	-	0
Grass Buffers	144	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	138	0	148	-
Storm Water Management on New Dev.	0	0	-	-
Nutrient Management	0	-	-	0
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	0	0	0	0	-
Grass Buffers	0	0	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	0	0	0	-	-
Tree Planting	0	0	-	0	-
Farm Plans	0	0	0	0	-
Cover Crops	0	0	-	-	-
Stream Protection w/ Fencing	-	-	-	0	-
Stream Protection w/o Fencing	-	-	-	0	-
Nutrient Management Plan Implementation	0	0	0	-	-
Grazing Land Protection	-	-	-	0	-
Animal Waste Management Systems	-	-	-	-	0
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	0	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	0

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	0

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 1 BMP Scenario: Maryland

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	77	-	-	5,223
Grass Buffers	20,042	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	5,621	2,680	74	-
Storm Water Management on New Dev.	52,875	23,912	-	-
Nutrient Management	0	-	-	0
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	4,999	7,682	2,048	3,106	-
Grass Buffers	2,387	5,316	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	460	655	261	-	-
Tree Planting	0	0	-	0	-
Farm Plans	28,908	15,730	20,901	-15,416	-
Cover Crops	-12,699	-19,262	-	-	-
Stream Protection w/ Fencing	-	-	-	14,468	-
Stream Protection w/o Fencing	-	-	-	2,965	-
Nutrient Management Plan Implementation	52,963	51,298	20,392	-	-
Grazing Land Protection	-	-	-	0	-
Animal Waste Management Systems	-	-	-	-	94
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	-4,229
Conservation Tillage	-53,587	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	18,959

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	0

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 1 BMP Scenario: New York

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	18	-	-	0
Grass Buffers	4,755	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	1,103	540	0	-
Storm Water Management on New Dev.	1,229	1,351	-	-
Nutrient Management	0	-	-	0
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	0	0	0	0	-
Grass Buffers	0	0	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	1,840	630	3,546	-	-
Tree Planting	0	0	-	0	-
Farm Plans	0	0	0	0	-
Cover Crops	0	0	-	-	-
Stream Protection w/ Fencing	-	-	-	0	-
Stream Protection w/o Fencing	-	-	-	0	-
Nutrient Management Plan Implementation	2,936	3,238	11,867	-	-
Grazing Land Protection	-	-	-	7,750	-
Animal Waste Management Systems	-	-	-	-	124
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	10,975	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	43,278

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	0

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 1 BMP Scenario: Pennsylvania

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	89	-	-	16,461
Grass Buffers	23,134	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	4,142	2,269	0	-
Storm Water Management on New Dev.	4,799	5,978	-	-
Nutrient Management	0	-	-	0
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	0	0	0	1,015	-
Grass Buffers	165	96	-	-	-
Wetland Restoration	149	80	174	0	-
Retirement of Highly Erodible Land	2,826	2,408	0	-	-
Tree Planting	0	0	-	0	-
Farm Plans	436,031	9,190	14,030	18,254	-
Cover Crops	0	0	-	-	-
Stream Protection w/ Fencing	-	-	-	6,862	-
Stream Protection w/o Fencing	-	-	-	746	-
Nutrient Management Plan Implementation	193,001	11,878	0	-	-
Grazing Land Protection	-	-	-	3,193	-
Animal Waste Management Systems	-	-	-	-	1,334
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	3,092
Conservation Tillage	58,426	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	165,242

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	0

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 1 BMP Scenario: Virginia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	170	-	-	0
Grass Buffers	44,440	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	8,595	3,807	104	-
Storm Water Management on New Dev.	31,661	27,603	-	-
Nutrient Management	22,022	-	-	0
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	1,074	2,092	969	0	-
Grass Buffers	566	820	-	-	-
Wetland Restoration	103	347	552	0	-
Retirement of Highly Erodible Land	3,073	7,436	20,871	-	-
Tree Planting	0	0	-	0	-
Farm Plans	37,760	110,244	206,110	298,315	-
Cover Crops	-16,833	-18,224	-	-	-
Stream Protection w/ Fencing	-	-	-	10,170	-
Stream Protection w/o Fencing	-	-	-	0	-
Nutrient Management Plan Implementation	29,986	72,414	107,210	-	-
Grazing Land Protection	-	-	-	106,729	-
Animal Waste Management Systems	-	-	-	-	211
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	587,611
Conservation Tillage	-38,965	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	35,943

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	0

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 1 BMP Scenario: West Virginia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	7	-	-	0
Grass Buffers	1,941	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	379	177	0	-
Storm Water Management on New Dev.	1,342	845	-	-
Nutrient Management	0	-	-	0
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	21	38	189	0	-
Grass Buffers	138	232	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	15	44	312	-	-
Tree Planting	0	0	-	0	-
Farm Plans	7,789	7,381	70,643	143,516	-
Cover Crops	-559	210	-	-	-
Stream Protection w/ Fencing	-	-	-	600	-
Stream Protection w/o Fencing	-	-	-	4	-
Nutrient Management Plan Implementation	718	2,084	13,478	-	-
Grazing Land Protection	-	-	-	57,194	-
Animal Waste Management Systems	-	-	-	-	37
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	-9,491	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	15,816

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	0

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 2 BMP Scenario: Delaware

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	59	-	-	56
Grass Buffers	508	-	-	-
Environmental Site Design / Low-Impact Dev.	431	161	-	-
Storm Water Retrofits	868	260	0	-
Storm Water Management on New Dev.	1,292	483	-	-
Nutrient Management	7,634	-	-	74,473
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	696	3,166	123	283	-
Grass Buffers	391	1,710	-	-	-
Wetland Restoration	30	159	4	0	-
Retirement of Highly Erodible Land	2,683	9,716	369	-	-
Tree Planting	0	0	-	0	-
Farm Plans	10,078	36,604	1,389	1,351	-
Cover Crops	13,413	48,800	-	-	-
Stream Protection w/ Fencing	-	-	-	168	-
Stream Protection w/o Fencing	-	-	-	95	-
Nutrient Management Plan Implementation	30,784	116,373	4,452	-	-
Grazing Land Protection	-	-	-	1,126	-
Animal Waste Management Systems	-	-	-	-	5
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	71,374
Conservation Tillage	4,871	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	524

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	318

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 2 BMP Scenario: District of Columbia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	15	-	-	14
Grass Buffers	130	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	863	0	928	-
Storm Water Management on New Dev.	0	0	-	-
Nutrient Management	6,908	-	-	298
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	0	0	0	0	-
Grass Buffers	0	0	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	0	0	0	-	-
Tree Planting	0	0	-	0	-
Farm Plans	0	0	0	0	-
Cover Crops	0	0	-	-	-
Stream Protection w/ Fencing	-	-	-	0	-
Stream Protection w/o Fencing	-	-	-	0	-
Nutrient Management Plan Implementation	0	0	0	-	-
Grazing Land Protection	-	-	-	0	-
Animal Waste Management Systems	-	-	-	-	0
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	0	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	0

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	19

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 2 BMP Scenario: Maryland

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	2,057	-	-	7,571
Grass Buffers	17,824	-	-	-
Environmental Site Design / Low-Impact Dev.	17,760	8,097	-	-
Storm Water Retrofits	35,119	16,750	462	-
Storm Water Management on New Dev.	53,280	24,290	-	-
Nutrient Management	309,371	-	-	313,801
Urban Land Conversion	9,590	3,844	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	6,731	20,597	3,936	9,321	-
Grass Buffers	4,617	15,111	-	-	-
Wetland Restoration	1,202	3,108	639	0	-
Retirement of Highly Erodible Land	21,185	55,136	11,588	-	-
Tree Planting	0	0	-	0	-
Farm Plans	-128,557	77,256	9,403	-18,062	-
Cover Crops	72,590	249,608	-	-	-
Stream Protection w/ Fencing	-	-	-	16,722	-
Stream Protection w/o Fencing	-	-	-	3,031	-
Nutrient Management Plan Implementation	-109,167	108,552	6,860	-	-
Grazing Land Protection	-	-	-	44,956	-
Animal Waste Management Systems	-	-	-	-	99
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	-4,712
Conservation Tillage	3,667	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	21,328

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	3,226

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 2 BMP Scenario: New York

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	494	-	-	476
Grass Buffers	4,280	-	-	-
Environmental Site Design / Low-Impact Dev.	465	512	-	-
Storm Water Retrofits	6,891	3,375	0	-
Storm Water Management on New Dev.	1,396	1,536	-	-
Nutrient Management	55,875	-	-	231,893
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	1,857	1,254	4,060	2,416	-
Grass Buffers	1,857	1,254	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	6,806	7,700	15,616	-	-
Tree Planting	0	0	-	0	-
Farm Plans	37,425	24,979	66,070	53,963	-
Cover Crops	49,901	33,306	-	-	-
Stream Protection w/ Fencing	-	-	-	7,521	-
Stream Protection w/o Fencing	-	-	-	4,262	-
Nutrient Management Plan Implementation	33,791	29,636	71,136	-	-
Grazing Land Protection	-	-	-	46,753	-
Animal Waste Management Systems	-	-	-	-	267
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	61,590	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	48,688

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	596

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 2 BMP Scenario: Pennsylvania

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	2,395	-	-	19,377
Grass Buffers	20,753	-	-	-
Environmental Site Design / Low-Impact Dev.	1,471	2,038	-	-
Storm Water Retrofits	25,871	14,182	0	-
Storm Water Management on New Dev.	4,413	6,113	-	-
Nutrient Management	209,320	-	-	608,303
Urban Land Conversion	1,811	906	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	11,677	16,545	21,614	8,298	-
Grass Buffers	11,738	16,660	-	-	-
Wetland Restoration	320	618	543	0	-
Retirement of Highly Erodible Land	34,190	66,994	79,070	-	-
Tree Planting	0	0	-	0	-
Farm Plans	-209,479	307,677	527,958	200,582	-
Cover Crops	255,759	359,457	-	-	-
Stream Protection w/ Fencing	-	-	-	29,784	-
Stream Protection w/o Fencing	-	-	-	13,638	-
Nutrient Management Plan Implementation	-220,562	535,373	490,787	-	-
Grazing Land Protection	-	-	-	119,935	-
Animal Waste Management Systems	-	-	-	-	1,625
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	130,570
Conservation Tillage	269,892	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	185,897

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	1,346

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 2 BMP Scenario: Virginia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	4,587	-	-	4,417
Grass Buffers	39,755	-	-	-
Environmental Site Design / Low-Impact Dev.	10,395	9,768	-	-
Storm Water Retrofits	53,695	23,787	655	-
Storm Water Management on New Dev.	31,186	29,303	-	-
Nutrient Management	439,581	-	-	689,638
Urban Land Conversion	7,160	2,785	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	4,585	11,327	13,122	19,777	-
Grass Buffers	4,125	9,438	-	-	-
Wetland Restoration	276	894	1,255	0	-
Retirement of Highly Erodible Land	13,147	34,438	50,013	-	-
Tree Planting	0	0	-	0	-
Farm Plans	-39,267	189,619	310,139	524,263	-
Cover Crops	58,905	170,646	-	-	-
Stream Protection w/ Fencing	-	-	-	60,332	-
Stream Protection w/o Fencing	-	-	-	28,535	-
Nutrient Management Plan Implementation	-8,866	154,443	268,710	-	-
Grazing Land Protection	-	-	-	388,064	-
Animal Waste Management Systems	-	-	-	-	267
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	677,907
Conservation Tillage	13,427	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	48,540

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	2,252

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 2 BMP Scenario: West Virginia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	202	-	-	194
Grass Buffers	1,747	-	-	-
Environmental Site Design / Low-Impact Dev.	508	320	-	-
Storm Water Retrofits	2,371	1,107	0	-
Storm Water Management on New Dev.	1,525	960	-	-
Nutrient Management	19,780	-	-	79,091
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	202	446	2,892	6,637	-
Grass Buffers	234	596	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	942	2,542	10,506	-	-
Tree Planting	0	0	-	0	-
Farm Plans	1,304	9,688	58,958	140,496	-
Cover Crops	2,107	10,009	-	-	-
Stream Protection w/ Fencing	-	-	-	20,109	-
Stream Protection w/o Fencing	-	-	-	11,056	-
Nutrient Management Plan Implementation	2,238	9,494	42,784	-	-
Grazing Land Protection	-	-	-	123,147	-
Animal Waste Management Systems	-	-	-	-	71
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	-7,282	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	17,793

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	0	237

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 3 BMP Scenario: Delaware

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	172	-	-	169
Grass Buffers	395	-	-	-
Environmental Site Design / Low-Impact Dev.	862	322	-	-
Storm Water Retrofits	3,472	1,041	0	-
Storm Water Management on New Dev.	862	322	-	-
Nutrient Management	14,314	-	-	82,884
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	333	4,230	173	283	-
Grass Buffers	256	2,539	-	-	-
Wetland Restoration	5	184	4	0	-
Retirement of Highly Erodible Land	2,528	17,930	601	-	-
Tree Planting	0	0	-	0	-
Farm Plans	10,730	76,242	18,391	3,153	-
Cover Crops	11,463	81,666	-	-	-
Stream Protection w/ Fencing	-	-	-	839	-
Stream Protection w/o Fencing	-	-	-	70	-
Nutrient Management Plan Implementation	7,919	70,602	18,213	-	-
Grazing Land Protection	-	-	-	2,252	-
Animal Waste Management Systems	-	-	-	-	5
Yield Reserve	4,599	32,675	7,882	-	-
Carbon Sequestration	2,705	19,221	-	-	-
Excess Manure Removal	-	-	-	-	84,301
Conservation Tillage	-8,225	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	873

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	178	3,183

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 3 BMP Scenario: District of Columbia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	44	-	-	43
Grass Buffers	101	-	-	-
Environmental Site Design / Low-Impact Dev.	0	0	-	-
Storm Water Retrofits	3,454	0	3,715	-
Storm Water Management on New Dev.	0	0	-	-
Nutrient Management	12,952	-	-	515
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	0	0	0	0	-
Grass Buffers	0	0	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	0	0	0	-	-
Tree Planting	0	0	-	0	-
Farm Plans	0	0	0	0	-
Cover Crops	0	0	-	-	-
Stream Protection w/ Fencing	-	-	-	0	-
Stream Protection w/o Fencing	-	-	-	0	-
Nutrient Management Plan Implementation	0	0	0	-	-
Grazing Land Protection	-	-	-	0	-
Animal Waste Management Systems	-	-	-	-	0
Yield Reserve	0	0	0	-	-
Carbon Sequestration	0	0	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	0	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	0

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	32	188

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 3 BMP Scenario: Maryland

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	5,946	-	-	11,524
Grass Buffers	13,697	-	-	-
Environmental Site Design / Low-Impact Dev.	30,983	14,271	-	-
Storm Water Retrofits	140,422	67,002	1,846	-
Storm Water Management on New Dev.	30,983	14,271	-	-
Nutrient Management	573,056	-	-	629,729
Urban Land Conversion	19,181	7,689	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	4,163	30,526	5,833	9,572	-
Grass Buffers	3,571	24,562	-	-	-
Wetland Restoration	1,378	7,248	1,274	0	-
Retirement of Highly Erodible Land	19,011	102,747	18,278	-	-
Tree Planting	0	0	-	0	-
Farm Plans	-281,734	26,207	143,400	-17,280	-
Cover Crops	40,681	436,543	-	-	-
Stream Protection w/ Fencing	-	-	-	27,628	-
Stream Protection w/o Fencing	-	-	-	2,183	-
Nutrient Management Plan Implementation	-301,971	-147,228	54,284	-	-
Grazing Land Protection	-	-	-	89,961	-
Animal Waste Management Systems	-	-	-	-	106
Yield Reserve	38,721	203,325	86,064	-	-
Carbon Sequestration	22,777	119,603	-	-	-
Excess Manure Removal	-	-	-	-	-2,758
Conservation Tillage	-48,788	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	23,698

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	3,187	32,258

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 3 BMP Scenario: New York

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	1,445	-	-	1,427
Grass Buffers	3,329	-	-	-
Environmental Site Design / Low-Impact Dev.	931	1,024	-	-
Storm Water Retrofits	27,565	13,499	0	-
Storm Water Management on New Dev.	931	1,024	-	-
Nutrient Management	104,765	-	-	448,885
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	1,592	3,076	8,120	3,623	-
Grass Buffers	1,857	3,588	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	5,107	18,883	24,688	-	-
Tree Planting	0	0	-	0	-
Farm Plans	39,750	76,230	165,386	125,068	-
Cover Crops	42,589	81,675	-	-	-
Stream Protection w/ Fencing	-	-	-	37,351	-
Stream Protection w/o Fencing	-	-	-	3,113	-
Nutrient Management Plan Implementation	12,429	42,458	84,339	-	-
Grazing Land Protection	-	-	-	85,190	-
Animal Waste Management Systems	-	-	-	-	467
Yield Reserve	9,560	18,582	40,871	-	-
Carbon Sequestration	10,021	19,218	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	87,226	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	54,098

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	1,109	5,960

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).
Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.
1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 3 BMP Scenario: Pennsylvania

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	6,984	-	-	24,244
Grass Buffers	16,088	-	-	-
Environmental Site Design / Low-Impact Dev.	2,272	3,623	-	-
Storm Water Retrofits	103,404	56,728	0	-
Storm Water Management on New Dev.	2,272	3,623	-	-
Nutrient Management	391,174	-	-	1,224,540
Urban Land Conversion	3,621	1,811	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	10,011	32,328	43,233	12,448	-
Grass Buffers	11,670	37,817	-	-	-
Wetland Restoration	284	1,398	894	0	-
Retirement of Highly Erodible Land	26,170	142,777	112,749	-	-
Tree Planting	0	0	-	0	-
Farm Plans	-411,629	481,804	845,463	284,020	-
Cover Crops	217,537	698,013	-	-	-
Stream Protection w/ Fencing	-	-	-	120,271	-
Stream Protection w/o Fencing	-	-	-	9,954	-
Nutrient Management Plan Implementation	-464,123	482,723	531,400	-	-
Grazing Land Protection	-	-	-	234,634	-
Animal Waste Management Systems	-	-	-	-	2,031
Yield Reserve	66,818	211,831	227,743	-	-
Carbon Sequestration	51,185	164,238	-	-	-
Excess Manure Removal	-	-	-	-	220,368
Conservation Tillage	301,933	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	206,552

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	4,026	13,457

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 3 BMP Scenario: Virginia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	13,342	-	-	13,171
Grass Buffers	30,733	-	-	-
Environmental Site Design / Low-Impact Dev.	17,616	18,160	-	-
Storm Water Retrofits	214,670	95,141	2,619	-
Storm Water Management on New Dev.	17,616	18,160	-	-
Nutrient Management	824,828	-	-	1,331,151
Urban Land Conversion	14,319	5,571	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	3,460	18,842	25,290	28,143	-
Grass Buffers	3,818	18,783	-	-	-
Wetland Restoration	299	1,633	1,951	0	-
Retirement of Highly Erodible Land	11,004	65,910	76,856	-	-
Tree Planting	0	0	-	0	-
Farm Plans	-127,599	202,200	515,800	814,169	-
Cover Crops	44,574	311,176	-	-	-
Stream Protection w/ Fencing	-	-	-	259,909	-
Stream Protection w/o Fencing	-	-	-	20,835	-
Nutrient Management Plan Implementation	-94,658	80,973	258,073	-	-
Grazing Land Protection	-	-	-	665,509	-
Animal Waste Management Systems	-	-	-	-	344
Yield Reserve	21,847	107,610	164,381	-	-
Carbon Sequestration	15,936	78,977	-	-	-
Excess Manure Removal	-	-	-	-	298,035
Conservation Tillage	-17,781	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	61,136

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	3,867	22,519

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).

Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.

1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

Exhibit 4: Tier 3 BMP Scenario: West Virginia

BMP — Number of Acres[1]

Urban	Pervious	Impervious	Ultra	Mixed Open
Forest Buffers	590	-	-	582
Grass Buffers	1,359	-	-	-
Environmental Site Design / Low-Impact Dev.	1,017	640	-	-
Storm Water Retrofits	9,483	4,429	0	-
Storm Water Management on New Dev.	1,017	640	-	-
Nutrient Management	37,087	-	-	152,548
Urban Land Conversion	0	0	-	-
Forest Conservation	0	0	-	-

Agriculture[2]	High Till	Low Till	Hay	Pasture	Manure
Forest Buffers	164	778	5,595	9,781	-
Grass Buffers	168	974	-	-	-
Wetland Restoration	0	0	0	0	-
Retirement of Highly Erodible Land	759	4,404	14,963	-	-
Tree Planting	0	0	-	0	-
Farm Plans	-4,759	8,002	57,659	138,115	-
Cover Crops	456	16,689	-	-	-
Stream Protection w/ Fencing	-	-	-	97,255	-
Stream Protection w/o Fencing	-	-	-	8,051	-
Nutrient Management Plan Implementation	-588	8,239	41,361	-	-
Grazing Land Protection	-	-	-	187,528	-
Animal Waste Management Systems	-	-	-	-	119
Yield Reserve	986	5,115	23,336	-	-
Carbon Sequestration	907	4,642	-	-	-
Excess Manure Removal	-	-	-	-	0
Conservation Tillage	-9,017	-	-	-	-

Forest	Forest Land
Forest Harvesting Practices (Erosion Control)	19,770

Onsite Wastewater Management Systems	Existing Systems	New Systems
Denitrification w/ Pumping[3]	372	2,365

Source: Based on the CBP Watershed Model. Calculated by subtracting Progress 2000 from the Tier scenario, except when a negative result would occur for practices with large upfront costs (e.g., forest buffers).
Notes: A dash (-) indicates the BMP is not applicable; a zero indicates zero implementation.
1. Units are manure acres for Animal Waste Management Systems, wet tons per year for Excess Manure Removal, number of systems for Onsite System Denitrification, and land acres for all other BMPs.
2. Negative values reflect the conversion of land from agricultural to other use, or from one agricultural land type to another.
3. BMP applies to 0% of existing and new systems in Tier 1; 0% of existing systems and 10% of new systems in Tier 2; and 1% of existing systems and 100% of new systems in Tier 3.

When these reductions in acres are multiplied by the estimated annual practice costs, the result will be a cost savings. For instance, cover crop costs are incurred every year, and if the land is converted out of agricultural production, the cover crop costs will no longer be incurred. However, Exhibit 4 does not report net reductions in implementation for practices for which the major portion of the annual cost is a sunk cost (e.g., forest buffers), because no cost savings will occur from the land conversion or changes in BMP application.

The following sections document the derivation of unit costs for the practices contained in Exhibit 4. The unit costs are annual implementation costs in constant 2001 dollars. The measurement units match the BMP quantities, which are generally expressed in acres affected each year. Therefore, most of the unit costs represent an average or typical cost per acre per year ($/ac/yr). The per-acre format is necessary to estimate annual costs for the different control scenarios from the Chesapeake Bay Program's watershed model. Annual costs include annualized capital expenditures (e.g., for infrastructure) and annual operating and maintenance costs.

2.2.1 Agriculture

Cost-sharing is commonly used to encourage implementation of agricultural BMPs. These programs provide four types of financial assistance: a cost offset for upfront BMP implementation expenses (**Exhibit 5**), annual land rent (**Exhibit 6**), annual maintenance payments, and one-time incentive payments.[3] The Chesapeake Bay Program used the upfront cost shares to offset initial BMP implementation costs, and assumed that the annual rental revenue completely offsets any net revenue losses the farmer might incur because of changes in production practices or foregone production. Thus, where the actual net revenue loss is less than the annual rental payment, costs to the farmer are overestimated. Annual maintenance and one-time incentive payments are subtracted from farmer costs, but other costs of maintaining BMPs (O&M) are generally not eligible for cost-share.[4]

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[3] Conservation Reserve Enhancement Programs in DE, MD, PA, VA, and WV, and the draft Program for the Susquehanna watershed in NY, provide annual maintenance payments of $5/ac/yr for a 10- to 15-year contract for forest and grass riparian buffers, wetland restoration, retirement of highly erodible land, tree planting, and farm plans (soil conservation and water quality plans). In Maryland, the CREP program also offers a one-time incentive payment of $100/ac for forest and grass riparian buffers, wetland restoration, and retirement of highly erodible land. In Virginia, the CREP program offers a one-time incentive payment of $50 or $75/ac (for 10- or 15-year contracts, respectively) for forest and grass riparian buffers, wetland restoration, retirement of highly erodible land, tree planting, and farm plans (soil conservation and water quality plans). The cost estimates reflect an average incentive payment of $62.50/ac (i.e., the average of $50/ac and $75/ac) in Virginia.

[4] Farms that implement BMPs as a result of regulations imposed by the CAFO Rule or CZARA are eligible for funding from federal and state cost sharing programs.

Exhibit 5: Capital Cost Funding for Agricultural BMPs from Known State and Federal Programs[1]

Practice	DE	MD	NY	PA	VA	WV
Forest Buffers	87.5%	87.5%	87.5%	100%	75%	75%
Grass Buffers	87.5%	87.5%	87.5%	100%	75%	75%
Wetland Restoration	87.5%	87.5%	87.5%	100%	75%	75%
Retire Erodible Land	87.5%	87.5%	87.5%	100%	75%	75%
Tree Planting	87.5%	87.5%	75%	75%	75%	75%
Nutrient Management Plan	$10/ac/ 3yrs[2]	$6/ac/ 3yrs[2]	87.5%	80%	$3/ac/yr[2]	75%
Cover Crops	75%	$20/ac/yr[2]	87.5%	$15/ac/yr[2]	75%	75%
Stream Protection w/ Fence	75%	87.5%	87.5%	100%	75%	75%
Stream Protection w/o Fence	75%	87.5%	87.5%	80%	75%	75%
Grazing Land Protection	75%	87.5%	87.5%	80%	75%	75%
Animal Waste Management	75%	87.5%	87.5%	80%	75%	75%

Sources: DDA (2002a), MDA (2000), NY Soil and Water Conservation Committee (no date), PA DEP (1998, 2001), USDA-FSA (1997a, 1997b, 1999a, 1999b, 2000a, 2000b, 2002a, 2002b), USDA-NRCS (no date, 1998, 2001a, 2001b, 2001c, 2001d, 2001e, 2001f), VA DCR (2001), personal communication with Gary Smith (PA NRCS, April 2002), Cedric Karper (PA DEP, May 2002), John Long (MD NRCS, May 2002), Mark Waggoner (MD NRCS, May 2002), Michelle Esch (MACS, May 2002), Lester Stillson (DE NRCS, April 2002), Ken Carter (VA NRCS, May 2002), Dana Bayless (VA Division of Conservation and Recreation, April 2002), Teresa Koon (WV Soil Conservation Agency, May 2002), Rick Heaslip (WV NRCS, April 2002), and Emily Dodd (NY State Department of Agriculture and Markets, May 2002 and November 2002).

1. Percentage rates reflect a percentage of actual installation (capital) costs.
2. Certain programs in some states pay a fixed rate rather than a percentage of costs: in DE (two programs pay $5/ac each for a 3-year nutrient management plan); in MD (MACS pays $6/ac for a 3-year nutrient management plan, and $20/ac/yr for cover crops); in PA (PA EQIP pays $15/ac/yr for cover crops); and in VA (VACS pays $3/ac/yr for nutrient management plans).

Exhibit 6: Annual Funding from Identified Programs for Land Rental Associated with Agricultural BMPs, as a Percent of USDA Dryland Rental Rate for County[1]

Practice	DE	MD	NY[2]	PA	VA	WV[2]
Forest Buffers	250%[3]	190%	145%	220%	240%[4]	120%
Grass Buffers	170%[5]	170%	145%	220%	240%[4]	120%
Wetland Restoration[6]	125%[5]	125%	145%	175%	195%[4]	75%
Retire Erodible Land	100%	150%	145%	175%	220%[4]	100%
Tree Planting	230%[3]	100%	145%	100%	100%	100%

Sources: USDA-NRCS (no date); USDA-FSA (2002b, 2002c, 2000a, 2000b, 1999a, 1999b, 1997b); personal communication with Emily Dodd (NY State Department of Agriculture and Markets, November 2002).

1. Reflects rental payments from the USDA CRP (or WRP, for wetland restoration) and state CREP programs. Rental payments are made only for BMPs that result in taking land out of agricultural production. Rates shown do not include annual maintenance or one-time incentive payments. Rental payments are also made for certain practices associated with farm plans (see Section 2.2.1.6).
2. NY CREP program for the Bay watershed is pending USDA approval; percentages shown are from NY state draft program documents.
3. The annual rental payment cannot exceed $150 per acre.
4. The annual rental payment cannot exceed $100 per acre.
5. The annual rental payment cannot exceed $110 per acre.
6. USDA WRP rental payment can be 0%, 75% or 100% of dryland rental rate, depending on length of contract; the analysis uses 75%, which corresponds to a 30-year contract.

The funding percentages listed in Exhibits 5 and 6 reflect the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) in all states, and Environmental Quality Incentive Program (EQIP) cost shares for DE, MD, PA, VA, and WV.[5] In addition, the exhibits include cost sharing from the Maryland Agricultural Water Quality Cost-Share Program (MACS) and Wildlife Habitat Incentives Program (WHIP) in Maryland; the Virginia Agricultural BMP Cost-Share Program (VACS) in Virginia; the Delaware Department of Agriculture Nutrient Management Cost Share Program in Delaware; the NY Agricultural Nonpoint Source Abatement and Control Program (ANPSACP); the Pennsylvania Department of Environmental Protection (DEP) Chesapeake Bay Financial Assistance Funding Program and Streambank Fencing Program in Pennsylvania; and the West Virginia Potomac Headwaters Water Quality Project (implemented under Public Law 534) in West Virginia.

The funding levels shown indicate the potential cost share if all programs are fully funded at current rates. In most cases, farmers are eligible for funding from more than one program (e.g., installation costs for riparian forest buffers in Maryland can be cost-shared under EQIP at 75%, CRP/CREP at 87.5%, MACS at 87.5%, and WHIP at 75%). Although most programs require

[5] New York is developing a CREP program for portions of the state that will include the Chesapeake Bay watershed. Information cited here is based on draft information provided by Emily Dodd, NY State Soil and Water Conservation Committee, November 2002, and information in USDA-FSA (2002c). Because the agreement has not been finalized, the information used in the analysis is subject to change.

landowners to contribute a portion of installation costs, certain programs, such as the Pennsylvania DEP Stream Bank Fencing Program, provide 100% funding for installation of selected BMPs.

Exhibit 5 does not reflect changes to the Wetlands Reserve Program (WRP), CRP, or EQIP in the 2002 Farm Bill, including an increase in the possible EQIP cost-share percentage for limited-resource farmers to 90% (from 75%) for eligible BMPs. Although relatively few small farmers meet the definition of a limited-resource farmer, they are likely to be the ones least able to pay additional BMP costs. Also, Virginia, Maryland, and possibly other states have additional rewards for farmers implementing BMPs in the form of tax credits. The estimates below do not incorporate tax credits, which means that some estimates will overstate farmer costs.

The annual cost of agricultural BMPs reflects amortized capital costs plus annual O&M payments. Capital costs are commonly paid upfront when a BMP is implemented (i.e., the farmer does not take out a loan). However, to estimate an annual cost for evaluating financial impacts, the Chesapeake Bay Program amortized capital costs at 5% (instead of assuming no interest cost) to represent an opportunity cost (since farmers typically implement BMPs with profits from a good year, these funds cannot then be saved for a future year). Capital costs are amortized over the typical contract period provided by the cost share programs for each BMP. However, if contract period does not apply (e.g., BMPs not cost shared through the CRP or CREP programs), the annualization period is the estimated useful life of the practice.

Cost estimates for agricultural BMPs are reported in the original dollar year reported in the source studies (where known), as well as in constant 2001 dollars [updated using the USDA Economic Research Service (ERS) index of prices paid by farmers (USDA-ERS, 2001)]; averages reflect 2001 dollars.

2.2.1.1 Forest Buffers

In the Watershed Model, forest buffers are 100-foot-wide strips of forest along riparian corridors in both agricultural and urban land. Implementation costs consist of planting tree seedlings in the first year and relatively intensive maintenance in the years immediately following implementation (replacement planting, herbicides or mowing to reduce competition, and plastic tubes to shelter seedlings from herbivory). Costs can also include reductions in net revenue and out-of-pocket expenses to implement the BMP. The variables that drive cost estimates for forest buffers are the costs of seedlings and shelters, and the amount of intensive maintenance in the first years.

The amount of intensive maintenance required on forest buffers is directly related to the degree of establishment desired and, therefore, the reduction efficiency of the practice. However, information on the level of maintenance required for various reduction efficiencies is not available. Therefore, the estimates below reflect the assumption that forest buffers are mowed in the early years to reduce competition, and shelters to reduce herbivory are used on 50% of trees. Four sources (Palone and Todd, 1998, USDA, 1999, Hairston-Strang, 2002, and MDA, 2002b) contain comprehensive estimates of the cost of installation and maintenance, and two additional sources provide less complete information (MD DNR et al., 1996, and VA SNR, 2000). The final cost estimate is based on the first four sources.[6]

Exhibit 7 shows cost estimates for individual components of forest buffer installation and maintenance (costs shown reflect constant 2001 dollars, adjusted from the original sources where necessary), and the average cost for each component across sources, where applicable. The costs for the latter two sources (Hairston-Strang, 2002 and MDA, 2002b) are somewhat lower than the costs for the first two sources. One reason for the difference may be that the costs shown for the other two sources are based on an assumption that tree shelters are used on 50% of the trees planted, whereas the costs from the latter two sources are based on surveys of actual implementation costs in Maryland. The average capital cost for installation among the four sources is $1,284 per acre.

Exhibit 7: Cost Estimates ($/acre) for Riparian Forest Buffers[1]

Component	Palone & Todd (1998)	USDA (1999)	Hairston-Strang (2002)[3]	MDA (2002b)[4]	Average Cost
Site preparation	13	nd	1,000	812	1,284
Planting and replacement planting	616	613			
Tree shelters[2]	1,511	528			
Initial grass buffer for immediate soil protection	nd	42			
Mowing ($/time)	13	8	30	nd	17
Herbicide ($/time)	60	nd	100	nd	80

nd = No data. Costs are one-time installation costs unless otherwise noted.
1. All costs shown are in constant 2001 dollars, updated from original study estimates using the USDA/ERS index for prices paid by farmers (USDA-ERS, 2001), and reflect per-acre costs.
2. Costs shown for tree shelters reflect installation of shelters on 50% of trees planted.
3. Costs shown are an average of a representative sample of actual costs for installing forest buffers in different regions in Maryland.
4. Costs shown are average practice costs in Maryland for 2001-2002 according to the Maryland Agricultural Water Quality Cost-Share (MACS) program.

Hairston-Strang (2002) indicates that a representative maintenance schedule for the first few years of establishment would be to mow three times per year for three years, and to spray herbicides for weed control once. Based on this, the Chesapeake Bay Program calculated maintenance costs as equal to nine times the average mowing cost ($153 per acre total) plus the average cost for spraying herbicides ($80 per acre total), or $233 per acre. The overall cost for installation and maintenance, therefore, is $1,517 per acre.

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[6] Of the less documented sources, MD DNR et al. (1996) indicates a capital cost of $480/ac/yr ($534 in 2001 dollars) for planting and establishment, which is $60/ac/yr annualized at 5% over 12 years. VA SNR (2000) indicates a cost of $230/ac/yr for the practice ($232 in 2001 dollars), but does not specify service life, interest rate, or what cost components are included.

The potential service life for a forest buffer may be on the order of 75 years (MD DNR et al., 1996). However, as stated above, to estimate financial impacts, capital costs are annualized over contract periods. (As a result, impacts in future years will be lower by the amount of the capital cost if the service life of the practice exceeds the contract period). CREP offers 10- and 15-year contracts for forest buffers, and most landowners choose 15-year contracts. The historical practices of the Conservation Reserve Program suggest that farmers will likely be able to extend contracts for 10 additional years. Therefore, capital costs are annualized over 25 years.

Annualizing the total installation and early maintenance costs of $1,517 at 5% over 25 years gives an annualized capital cost of $108 per acre, of which 85% is installation cost. Cost-sharing is available for the installation costs at rates ranging from 75% to 100%. In addition, CREP programs offer annual maintenance payments of $5/ac/yr. One-time incentive payments are also available in Maryland and Virginia, and Maryland also offers an additional sign-up bonus. Thus, the net farmer costs for forest buffers range from -$8/ac/yr (i.e., a net revenue gain) to $34/ac/yr.

In addition to the implementation cost, there is an opportunity cost associated with taking land out of production. In some cases, land bordering streams or rivers is more productive than the farm or field average because of higher soil fertility associated with the flood plain, but in many cases riparian borders are considered marginal land because of greater erosion, steep slopes, poor drainage, periodic flooding, and low soil fertility (Palone and Todd, 1998; USDA, 1999). As stated above, the land rental payment from CREP likely offsets any net revenue losses from changes in land use resulting from this practice.

2.2.1.2 Grass Buffers

In the Watershed Model, grass buffers are 100-foot-wide strips of grass along riparian corridors. Establishment costs include purchase of seed, fertilizer and lime, initial planting, and mowing to maintain the practice and to prevent grasses from going to seed, in addition to opportunity costs from taking land out of production. Maintenance costs include mowing. An important consideration in calculating a cost for grass buffers is whether warm-season grasses (WSG) or cool-season grasses (CSG) are used. WSG seed is more expensive, but the grasses grow better in drought and provide better wildlife habitat. CSG seed is cheaper, sod establishment is faster, and sediment load reduction is generally greater because the plants are more active in spring and fall (Nakao et al., 1999). Data on the relative use of cool- and warm-season grasses are not available, so costs are based on equal use of cool- and warm-season grasses.

Several sources provide cost estimates for grass buffers. The Chesapeake Bay Program used estimates from Nakao et al. (1999) and Yeh and Sohngen (1999) because they itemize costs for seed, fertilizer and lime, and planting costs, and because they distinguish the costs of warm season and cool season grasses.[7] **Exhibit 8** shows the resulting cost estimates for each component of the BMP.

[7] Data from the MACS program, indicating a maximum cost-share amount of $200/acre for CSG buffers and $400/acre for WSG buffers, are not included in the estimates because these represent maximum payment amounts rather than practice costs. The higher maximum payments likely reflect the potential for site preparation costs to be much greater than average.

Exhibit 8: Grass Buffer BMP Costs ($/acre)[1]

Component	Estimated Cost (CSG)[2]	Estimated Cost (WSG)[3]
Seed	$21	$120[4]
Fertilizer and lime	$38	$38
Labor and equipment[5]	$23	$23
Total cost	$82	$181

CSG = Cool-season grass
WSG = Warm-season grass

1. All costs shown are in 2001 dollars, updated from current dollars using the USDA/ERS index for prices paid by farmers (USDA-ERS, 2001), and reflect costs for installation.
2. From Nakao et al. (1999).
3. From Sohngen and Yeh (1999).
4. Based on average seed costs for switchgrass ($40/ac), big bluestem ($150/ac), and indiangrass ($160/ac).
5. Based on costs for no-till planting.

The average cost for the installation of grass buffers, based on 50% implementation of CSG and 50% implementation of WSG buffers, is $132/acre. Annualized at 5% over 10 years (the minimum term of a CRP/CREP contract), installation costs are $17/ac/yr.

Possible O&M costs for grass buffers consist of mowing. Four sources for mowing costs are reflected in the estimate for this practice: USDA, 1999 ($8/ac/time in 2001 dollars), Palone and Todd, 1998 ($13/ac/time in 2001 dollars), Hairston-Strang, 2002 ($30/ac/time), and Nakao et al., 1999 ($25/ac/time in 2001 dollars). The average cost for mowing from these sources is $19/ac/time. If mowing is necessary to maintain buffer strips, then it would need to happen two to three times per year (Hairston-Strang, 2002; Nakao et al., 1999). In locations where topography allows hay harvesting, revenue from haying could offset mowing costs. For instance, Nakao et al. (1999) found that net revenues from haying filter strips in Ohio (i.e., revenue from hay less costs of cutting and baling) averaged $91 per acre.+

Some cost-share programs do not permit grasses to be harvested for hay. However, this may refer to the regular harvest of grasses down to stubble, which would reduce the capacity of a grass buffer to trap nutrients and sediment as it is designed to do. If grasses must be mowed, then the clippings should be removed from the buffer so that they do not enter water bodies and contribute nutrients. Even if the grass is mowed too high to be sold for hay, it could be used on the farm as bedding, feed, mulch or fertilizer. In addition, some native warm-season grasses may not need to be mowed. A mowing cost is not currently included in the cost estimate. Although costs for some areas may be higher if mowing is necessary and the cost is not offset by using the clippings, costs for some areas may be lower than the $17/ac/yr estimate because it is based on average seed costs for three different warm-season grasses; if switchgrass is used (by far the cheapest of the three), actual costs could be substantially lower. The installation cost accounts for 100% of the total annual cost of $17/ac/yr and, therefore, installation cost-sharing applies to 100% of the total cost.

The annual rental payment for this BMP ranges from 120% to 240% of the dryland rental rate across states. As stated above, this likely offsets any net revenue losses from changes in land use and, therefore, the cost of the BMP is out-of-pocket expenses less cost-share funding for installation of the buffer. Cost-sharing ranges from 75% to 100% of implementation costs (see Exhibit 5), and CREP programs also provide annual maintenance payments of $5/ac/yr. One-time incentive payments are also available in Maryland and Virginia. Thus, net unit costs range from -$13/ac/yr (i.e., a net cost savings) to -$1/ac/yr.

2.2.1.3 Wetland Restoration

Wetland restoration reverses wetland reclamation, or the draining of wetlands so they can be planted. Significant earth moving may be required (e.g. to plug or fill drainage ditches that were dug in the process of reclamation). O&M costs include inspecting embankments and structures for damage or erosion, and management of unwanted vegetation (USDA-NRCS, 1998).

Three sources contain cost estimates for this practice. The USDA Farm Service Agency's Practice Summaries for Active CREP Contracts for states with CREP programs (USDA-FSA, 2002a) reports wetland restoration cost-shares for Delaware (2001-2002), Maryland (1998-2002), Pennsylvania (2001-2002), and Virginia (2001-2002). The average cost-share amount per acre for these states is $915 (in 2001 dollars), and represents cost-share for installation but not O&M costs. Assuming that average cost-share is 75% and O&M costs are 3% of total initial capital costs (USDA-SCS, 1980 in NCSU, 1982 reports O&M for permanent vegetative cover on critical areas, a comparable BMP, is 3% of initial capital costs), the initial capital costs are $1,221/acre and annual O&M costs are $37/acre. Under the Wetlands Reserve Program, contract terms range from 30 years to indefinite. Annualizing the capital cost at 5% over 30 years and adding O&M costs results in an annual cost of $116/ac/yr. Sixty-eight percent of this cost is annualized capital (installation) cost and therefore eligible for cost-share; the remainder is O&M, which is not eligible for cost-share.

Of the other two sources identified, Wetland Science Institute (2000) provides costs for site preparation and materials and planting costs for putting in oak seedlings or seeds, but does not include costs for putting in other species or O&M costs. Average costs for site preparation and materials and planting are $123 per acre ($124 in 2001 dollars), which is very close to the estimates based on actual wetland restoration projects cost-shared by CREP as reported above. The second source (EPA, 1997a) reports average costs for constructed wetlands for controlling urban runoff at between $749 and $20,000 per acre (in current dollars); however, as this source does not elaborate as to what costs are included, how costs are calculated, or how costs in agricultural areas might differ from costs in urban areas, these estimates are not used.

Funding for wetland restoration ranges from 75% to 100% of installation costs (see Exhibit 5), and CREP programs also provide annual maintenance payments of $5/ac/yr. One-time incentive payments are also available in Maryland and Virginia. Thus, net farmer costs range from $32 to $52/ac/yr. Annual rental rates range from 75% to 195% of the USDA dryland rental rate within a county. As stated above, this annual revenue likely offsets any net revenue losses attributable to changes in land use.

2.2.1.4 Retirement of Highly Erodible Land (HEL)

In the Watershed Model, this practice consists of converting agricultural land to the mixed open land use category. Although either grass or trees may be used as a cover, in the Watershed Model this practice is modeled as a conversion to mixed open land use, and the load from mixed open land use is closer to the load from hayland than the load from forest. Thus, the cost estimates used reflect the costs of establishing grass cover. Additional costs accrue as a result of foregone net revenues from crop plantings.

Several sources contain cost estimates ranging from $9/ac/yr to $157/ac/yr (in 2001 dollars) for permanent vegetative cover on critical areas (VA SNR, 2000; MD DNR, 1996; VA DEQ, 1993; EPA, 1997a; and Camacho, 1992). The estimates from these sources reflect different assumptions about what type of cover is used, service life, O&M costs, and net revenue impacts, among others. Documentation on most of the sources is quite sparse, so there is little basis for comparison.

This practice could entail planting of grass or forest cover, and is therefore similar to the riparian grass and forest buffer BMPs. To reflect the way this practice is modeled in the Watershed Model, the establishment cost reflects the cost of grass buffers, $17/ac/yr. The implementation cost share, which ranges from 75% to 100% across states, annual maintenance payments of $5/ac/yr from CREP programs, and one-time incentive payments available in Maryland and Virginia, reduce net implementation costs to - $13/ac/yr to - $1/ac/yr. Furthermore, as stated above, annual revenues per acre that equal 100% to 220% of the USDA dryland rental rate across states (Exhibit 6) likely offset any revenue loss associated with land retirement.

2.2.1.5 Tree Planting

In the Watershed Model, the tree planting BMP occurs in any area except along a river or stream, and is modeled as a land use conversion from agricultural or urban land to forest. Because this BMP is very similar to forest buffers, the unit cost of $108/ac/yr for forest buffers applies. As with forest buffers, the cost includes a combination of mowing and herbicide sprays to reduce competition in the initial years.

The cost-share for implementation ranges from 75% to 87.5% across states, and CREP programs offer annual maintenance payments of $5/ac/yr. One-time incentive payments are also available in Virginia. Thus, net farmer costs range from $23 to $34/ac/yr. The federal CRP program and state CREP programs offer annual payments ranging from 100% to 230% of the USDA dryland rental rate (Exhibit 6) to offset net income losses from land planted to trees, and this rental payment likely offsets any net revenue losses.

2.2.1.6 Farm Plans/Soil Conservation and Water Quality Plans

In the Watershed Model, farm plans represent comprehensive management plans according to which structural or management practices are implemented to bring total soil loss to an acceptable level (the specific level depends on local conditions). Specific practices that may be implemented include contour farming, strip cropping, terrace systems, diversions, and grassed waterways. Farm plans also frequently include conservation tillage, nutrient management plans, cover crops, and other practices that are included as separate BMPs in the Watershed Model.

Several sources provide cost estimates for individual practices that may be implemented in accordance with a farm plan. However, estimating a single per-acre cost is more difficult than for other BMPs because only some of these practices may be used depending on site-specific conditions. The costs in the cost analysis are based on estimates from Camacho (1992), who obtained 14 representative farm plans from state contacts in Pennsylvania, Maryland, and Virginia. These plans include different application rates for the individual practices, and represent plans for different regions in the watershed. Camacho estimated the median cost per acre for the development of plans as well as the practices implemented under the plans, but the costs in his report include some costs from practices included separately in the Watershed Model (such as cover crops and conservation tillage).

To avoid double-counting costs for BMPs that are included separately in the Watershed Model, the Chesapeake Bay Program calculated an average cost of farm plans using Camacho's data, subtracting the costs of these "duplicated" BMPs. In addition, it differentiated costs for development and implementation of farm plans on hay and pasture land from the costs for plans on cropland, because some practices associated with farm plans would be applied only to one type of land and not the other. For example, strip-cropping on cropland involves alternating strips of row or grain crops with strips of closer growing crops; the closer growing strips reduce erosion by slowing runoff and capturing soil particles. This practice would not be used in hay production or pasture land because the sod remains intact. After eliminating the "duplicated" BMPs from the representative farm plans in Camacho (1992), the practices for cropland include strip-cropping, contour strip-cropping, contour farming, terraces, diversions, grassed waterways, and crop rotation. For hay and pasture land, the applicable practices are diversions, grassed waterways, terraces, and contour planting.

Costs for the practices implemented according to farm plans may differ depending on topography, since more intensive management may be needed to control soil erosion on sloping or mountainous land than on coastal plain. However, the estimates based on Camacho (1992) for practices associated with farm plans (excluding the costs of the duplicate BMPs) are not significantly different between the two topographic regions ($19/ac/yr on coastal land versus $20/ac/yr in sloping regions, in 2001 dollars). The average cost of the practices associated with farm plans is $19/ac/yr for plans on crop land, and $15/ac/yr on hay and pasture land (in 2001 dollars). These estimates include planning and technical assistance (for the practices associated with the farm plan, although not for the farm plan itself), installation costs, and annual O&M, with installation costs annualized at 10% over the life of the practice (ranging from 5 to 10 years for the individual practices). The Chesapeake Bay Program re-annualized these costs at a 5% rate over 10 years by backing out the original capital cost (assuming O&M costs equal 5% of the initial capital cost that reflects annualizing at 10% over 10 years). The adjusted estimates are $16/ac/yr for farm plans on cropland and $13/ac/yr on hay and pasture.

These costs do not include the cost of the plan itself. Based on costs for designing nutrient management plans from USDA (1999), the estimated cost for a farm plan is $5 per acre, and the estimated useful life is 10 years (MD DNR et al., 1996). Adding in the resulting annual cost of

$0.50 per acre results in an estimated cost of the plan and the practices associated with it of $17/ac/yr on cropland and $13/ac/yr on hay and pasture (the costs for hay and pasture do not appear to change because of rounding). Seventy percent of the costs for the BMP on cropland, and 69% for hay and pasture land, are annualized capital and therefore eligible for cost-share. The annualized capital portion of the cost does not include the cost of the plan itself, since cost-sharing programs generally do not pay for the plan itself but only for the practices associated with it.

Funding for installation of practices associated with farm plans ranges from 75% to 100% over the states, which applies to the 70% of costs that are annualized capital (69% for farm plans on hay and pasture land). Annual maintenance payments of $5/ac/yr are available from CREP programs for certain practices (such as grassed waterways) associated with farm plans. One-time incentive payments for the installation of certain practices are also available in Virginia. However, the Chesapeake Bay Program did not incorporate maintenance or incentive payments because data are insufficient to identify the proportion of land on which the eligible practices would be implemented. Thus, net farmer costs range from $5 to $8/ac/yr for farm plans on crop land and from $4 to $6/ac/yr for farm plans on hay and pasture. Annual rental payments from CRP and CREP equal to 100%–200% of USDA dryland rental rates by county likely offset any net revenue losses resulting from land taken out of production or changes in production activity. However, due to a lack of data on how much land is taken out of production as a result of the practices associated with farm plans, cost-share totals do not include these rental payments.

2.2.1.7 Cover Crops

Cover crops are grasses and legumes planted on cropland in the fall after the main crop is harvested, and killed in the spring before the main crop is planted. In addition to building organic matter and improving nutrient uptake, they reduce soil erosion in late fall, winter, and early spring.

The major costs are purchasing cover crop seed and machinery and labor for planting. Although some estimates of costs include the costs of tillage or herbicide in the spring to kill the cover crop, these costs are not included because they are necessary regardless of whether a cover crop is used (except when spring weather conditions or special management requirements necessitate a separate round of tillage or herbicide for the cover crop). Benefits come from sediment erosion protection and holding nutrients not utilized during the growing season.

Several sources (Mannering et al., 1985; Roberts et al., 1998; VA SNR, 2000; MD DNR et al., 1996; Camacho, 1992; Lichtenberg et al., 1994) report estimates of cover crop costs ranging from $10/ac/yr to $37/ac/yr in current dollars ($12/ac/yr to $49/ac/yr in 2001 dollars). Because of variations in these estimates and sometimes incomplete documentation regarding what costs are included, costs are based on another source (personal communication with Ken Staver, Wye Research and Education Center, Queenstown, MD, May 2002). For a rye cover in a no-till system, Staver estimates seed costs at $12/ac and planting costs at $15/ac.

The resulting cost estimate of $27/ac/yr does not reflect possibly greater costs due to the possibility of an additional herbicide application in the spring, nor does it reflect increased risk (for instance, in a wet spring the need to turn in the cover crop may delay spring planting). However, it also does not reflect potential cost offsets due to improved yields. Yield increases have the potential to make the cover crop pay for itself or generate net revenue. For example, one group of researchers observed an average net revenue increase of $16/ac/yr in no-till corn using vetch, clover, wheat, and pea cover crops because the cover crops increased nutrient uptake and the marginal productivity of nitrogen (Lichtenberg et al., 1994).

Cost-sharing for cover crops in some programs is provided at a fixed dollar rate; other programs pay a percentage of incurred costs. Expressed as a percentage of the estimated cost of $27/ac/yr, rates range from 56% to 87.5%. Thus, the net farmer cost ranges from $3 to $12/ac/yr.

2.2.1.8a Streambank Protection with Fencing

Streambank protection consists of fencing to keep animals out of streams, alternative water and shade sources in pastures, and practices at stream crossings to reduce soil erosion from hooves and reduce the amount of time animals spend in the water (e.g., culverts or concrete fords at stream crossings). The Watershed Model reports linear fence miles for stream protection as well as total acreage protected. Ideally, the cost analysis would incorporate the linear fencing data to calculate the cost of fencing and use protected acreage data to estimate the costs of other practices associated with streambank protection. Fence miles is ideal for fence costs, but uninformative for alternative water source costs.

Linear fence cost estimates from U.S. EPA (1997a) range from $2,330 to $2,677 per mile (or $2,816 to $3,235 in 2001 dollars, which is $365 to $420 per mile when annualized at 5% over 10 years). Most of these are for permanent fencing (presumably barbed wire) in the West and Midwest; one source notes that less expensive electric fencing may be sufficient for smaller, more intensively managed pastures in the East, but no estimates of these costs are available. The average of the costs identified ($395/mile) may thus overestimate costs if farmers use less expensive fencing.

Two sources provide cost estimates for the suite of practices associated with the streambank protection with fencing BMP. USDA-ASCS (1990, cited in EPA, 1997a) reports average costs ranging from $14/ac/yr in the Pacific region ($18/ac/yr in 2001 dollars) to $76/ac/yr in the Southeast region ($97/ac/yr in 2001 dollars) for stream protection practices that may include, depending on the site, filter strips along streams, channel vegetation, fencing, pipelines, streambank and shoreline protection, field borders, tree planting, troughs or tanks for water in pastures, and stock trails or walkways at stream crossings.[8] MD DNR et al. (1996) reports a cost of $100/ac/yr ($111/ac/yr in 2001 dollars) for a suite of practices called "streambank protection with fencing," based on records from the Maryland Agricultural Water Quality Cost-Share (MACS) Program. Averaging this estimate with the estimate for the Southeast region from

[8] Because this data source includes the costs of filter strips on a proportion of acres, but in this analysis filter strip costs are accounted for separately, using the costs from this source may result in double-counting some costs for acres in the Watershed Model to which both the forest buffer BMP and the streambank protection BMP are applied.

USDA-ASCS (1990) results in a cost of $104/ac/yr (2001 dollars) for streambank protection with fencing.

The cost-share for streambank with fencing ranges from 75% to 100%. Of the two sources for costs of streambank protection with fencing, neither breaks out capital from O&M costs. Assuming that capital costs are annualized at 5% over10 years and O&M costs are 5% of the initial capital costs, capital costs represent 72% of the total annual cost. Thus, the cost-share rates apply to 72% of the annual cost estimate. The net farmer cost of streambank protection with fencing ranges from $29 to $48/ac/yr with fencing.

2.2.1.8b Streambank Protection without Fencing

Only one source identifies costs for streambank protection without fencing. MD DNR et al. (1996) reports costs of $67/ac/yr ($75 in 2001 dollars) based on records from the MACS program. Thus, the estimated cost for streambank protection without fencing is $75/ac/yr.

The cost-share for streambank without fencing ranges from 75% to 87.5%. The sources for costs of streambank protection do not break out capital from O&M costs. Assuming that capital costs are annualized at 5% over10 years and O&M costs are 5% of the initial capital costs, capital costs represent 72% of the total annual cost. Thus, the cost-share rates apply to 72% of the annual cost estimate. For streambank protection without fencing, net farmer costs range from $28/ac/yr to $35/ac/yr.

2.2.1.9 Nutrient Management Plan Implementation

In the Watershed Model, this BMP consists of reducing fertilizer application to 130% of a crop's need. Under some plans, fertilizer may also be applied more frequently, in lower amounts that reflect more immediate soil deficiencies and crop needs. Costs result from equipment and labor for soil testing and hiring of a consultant to design the plan, plus the costs of any additional passes over the field to fertilize.

A number of sources provide cost estimates, including Camacho (1992), MD DNR et al. (1996), VA SNR (2000), USDA (1999), and U.S. EPA (2001a). Several sources suggest that landowners can save money by implementing nutrient management plans. Assuming a 3-year useful life for a plan once it is developed, and including the costs of soil testing, implementation, and, in some cases, cost savings and yield increases, net cost estimates range from -$30/ac/yr (i.e., a net cost savings) to $14/ac/yr in current dollars. A simple average is -$1.02/ac/yr, which implies a net cost savings.

However, nutrient management plans that are based on reducing phosphorus applications may require the use of custom fertilizers rather than manure, which would mean that farmers are less likely to be able to use manure generated on the farm (which is where cost savings from nutrient management plans traditionally accrue) (J. Rhoderick, MD Department of Agriculture, personal communication, November, 2002). Four sources provide sufficient cost breakdowns to calculate costs of plan development and implementation alone (i.e., without cost savings). Using a 3-year useful life for the plan, estimates based on these sources (Camacho, 1992; MD DNR et al., 1996;

USDA, 1999; U.S. EPA, 2001a) range from $3/ac/yr to $14/ac/yr in 2001 dollars, with an average of $7/ac/yr in 2001 dollars. Thus, the estimated cost is $7/ac/yr.

Most state and some federal programs provide cost-share funding for plan development and implementation. Many programs pay a fixed dollar amount per acre and others pay a percentage of costs. On a percentage basis (i.e., converting annual or annualized fixed amounts to a percentage of the estimated annual cost where necessary), the cost-share rate for this practice ranges from 28.6% to 87.5%. Thus, the estimate of the net farmer cost ranges from $0.87 to $5.00/ac/yr.

2.2.1.10 Grazing Land Protection

In the Watershed Model, grazing land protection refers to rotational grazing. Costs of the practice consist of permanent fencing around pastures and temporary or semi-permanent fencing around paddocks, labor to move water sources and animals between paddocks, and possibly increased administrative/monitoring costs. Some other operational costs, such as the cost of spreading manure over pasture land, may decline as a result of this practice.

Three sources provide costs for grazing land protection. Based on cost-share records from the Bay watershed, Camacho (1992) reports median total capital costs, including planning and technical assistance, of $119 per acre ($139 in 2001 dollars) and annual O&M costs of $5 per acre ($6 in 2001 dollars) for a suite of practices that includes grazing land protection, intensive rotational grazing systems, spring development, and trough/tank installation. Annualizing the capital cost at 5% over 10 years and adding O&M results in annual costs of $24/ac/yr. USDA-ASCS (1990 and 1991, cited in EPA, 1997a) reports costs of $10/ac/yr in the Southeast region ($13/ac/yr in 2001 dollars), and $35/ac/yr in the Northeast ($45/ac/yr in 2001 dollars), for a suite of practices including critical area planting, ponds, fencing, pipeline, spring development, stock trails and walkways, troughs/tanks, water-harvesting catchments, and wells. Shulyer (1995) reports a total cost of $2.50/ac/yr ($3 in 2001 dollars) for a "grazing land protection" BMP that includes grazing land protection systems, spring development, and stream protection; however, this estimate it is substantially lower than estimates reported from other sources and documentation is lacking. Therefore, the average cost reflects both the Northeast and Southeast regions in USDA-ASCS (1990 and 1991, cited in EPA, 1997a) and the $24/ac/yr estimate based on Camacho (1992), or $27/ac/yr. Assuming a 10-year useful life for capital components and O&M representing 5% of the initial capital cost, 72% of this cost is annualized capital and therefore eligible for cost-share.

State and federal cost sharing for this practice ranges from 75% to 87.5% of installation costs. Thus, the net farmer cost ranges from $10 to $12/ac/yr. However, because the data sources used to derive costs for grazing land protection and the sources used to derive costs for streambank protection may include some overlapping practices, the use of these estimates may result in double-counting some costs on acres in the Watershed Model to which both BMPs are applied.

2.2.1.11 Animal Waste Management Systems

In the Watershed Model, the animal waste management system BMP refers to the construction and maintenance of facilities to handle, store, and utilize wastes generated from animal confinement operations (Chesapeake Bay Program Modeling Subcommittee, 1998). Waste management facilities may take on many forms depending on the animal species and handling method. They may include lagoons, ponds, and concrete tanks for treatment and/or storage of liquid wastes, storage sheds and pits for treatment and/or storage of solid wastes, and other structures such as concrete berms to divert waste to storage structures. The tier scenarios in the Watershed Model report animal waste management system BMP application in manure acres; one manure acre represents 145 animal units (AU), and one animal unit represents a certain number animals, depending on the species: for instance, one AU represents 0.71 dairy cows, 1 beef cow, 5 hogs, 250 layers, 500 broilers, or 100 turkeys (Chesapeake Bay Program Modeling Subcommittee, 1998).

Some of the costs for this BMP will be incurred under EPA's revised Concentrated Animal Feeding Operation (CAFO) regulations. Under these regulations, CAFOs will incur costs to implement or improve animal waste management systems, develop and implement nutrient management plans, and transfer excess manure offsite. The extent to which the Watershed Model tiers overlap costs of the CAFO Rule is unknown at this time. For instance, the Tier 1 requirements for animal waste systems indicate continuing the level of implementation based on the average rate of 1997-2000 (Exhibit 3); this level is most likely lower than would be required under the final CAFO regulations. [Note that the cost of technology-based regulations such as the CAFO rule would not be considered in analysis of substantial and widespread impact (U.S. EPA, 1995).]

Several sources contain estimates of the costs of animal waste management systems:

- MD DNR et al. (1996) reports average capital costs of $17,570 for a poultry waste system and $63,533 for other livestock system, but did not report the number of animals served by those systems and therefore the estimate cannot be converted to an average cost per manure acre

- Virginia Department of Environmental Quality (1993) reports a cost of $27,000 but does not indicate any units (e.g., whether this represents annual or one-time costs, or how many animals would be addressed)

- Tippett and Dodd (1995) reports capital costs for anaerobic lagoons of $5.60 per animal for poultry and $79 per swine and O&M costs equal to 10% of initial capital costs; however, these estimates are based on an analysis using records of state and federal cost-share funding from 1985 to 1994, although they did not convert to constant dollars before averaging

- Shulyer (1995) reports annual costs of $8,187 per manure acre, but did not document what assumptions were used to generate the annual cost (e.g., useful life, interest rate, animal species considered)

- U.S. EPA (2001a) estimated costs for model farms of varying sizes and using a range of technologies for several animal types (e.g., beef, dairy, swine, poultry); cost breakdowns for swine and poultry do not provide sufficient resolution to permit calculation of an average cost per animal unit or manure acre, but indicate an average cost per manure acre for beef ($2,114 in 2001 dollars) and dairy ($14,243 in 2001 dollars), based on annualizing capital costs over 10 years at 5%

- Camacho (1992) reports median costs per ton of wet manure treated in an animal waste management system, based on records of state and federal cost-share funding for farms in the Chesapeake Bay watershed and also based on costs from a manual prepared for the Pennsylvania Department of Environmental Resources; median costs per wet ton are $12.73 for capital ($14.83 in 2001 dollars), $2.16 for one-time planning and technical assistance ($2.52 in 2001 dollars), and $1.28 for O&M ($1.49 in 2001 dollars)

- Maryland Department of Agriculture (2002a) reports the average cost of installing a comprehensive animal waste management system for different size systems; the cost for systems that serve 100 or more animal units is $315 per animal unit (in the Watershed Model, nutrient reduction efficiencies are based on systems that service 145 animal units)

However, only the last two sources listed, Camacho (1992) and Maryland Department of Agriculture (2002a), provide sufficient information to calculate an annual cost per manure acre in constant dollars using a known interest rate, and incorporate costs for poultry waste systems.

To utilize the data from Camacho (1992), the Chesapeake Bay Program calculated the sum of capital and planning/technical assistance costs (annualized at 5% over 10 years) plus O&M costs to produce an estimate of $3.27 per wet ton of manure treated. Combining this estimate with data from the 1997 Census of Agriculture on animals in the watershed counties, and standard assumptions about manure excreted for different animal species (shown in **Exhibit 9**), produces an average cost per manure acre in the watershed. Based on the weighted average value of 12.52 tons of manure excreted per animal per year in the watershed counties, the average annual cost per manure acre is $5,932 (equal to $3.27 per wet ton manure treated times 12.52 tons wet manure per animal unit per year times 145 animal units per manure acre).

Exhibit 9: Derivation of Average Manure Excretion in Bay Watershed

Species	Animals Per Animal Unit	Wet Manure Excreted (tons/animal unit/yr)	Equivalent Wet Manure Excreted (tons/animal/yr)	Animals in Watershed Counties[1]	Animal Units in Watershed Counties
Dairy	0.71	14.9	20.99	1,383,201	1,948,170
Beef	1	6.7	6.7	661,807	661,807
Swine	5	11.7	2.34	265,743	53,149
Layers	250	9.7	0.04	110,725	443

Exhibit 9: Derivation of Average Manure Excretion in Bay Watershed

Species	Animals Per Animal Unit	Wet Manure Excreted (tons/animal unit/yr)	Equivalent Wet Manure Excreted (tons/animal/yr)	Animals in Watershed Counties[1]	Animal Units in Watershed Counties
Broilers	500	13.1	0.03	1,861,093	3,722
Turkeys	100	10.2	0.1	nd	nd
Weighted average[2]	n/a	12.52	n/a	n/a	n/a

Sources: Animals per animal unit and wet manure excreted from Gilbertson, 1979, cited in Chesapeake Bay Program, 1998; animal populations from USDA-NASS, 1999. nd = No data; n/a = not applicable.

1. Number of animals in watershed counties indicates inventory of animals in 1997, except broilers, which indicates number sold in 1997.
2. Average is weighted by number of animal units by species in watershed counties in 1997.

The Chesapeake Bay Program used similar assumptions to derive an annual cost based on the data from MDA (2002a). Annualizing the capital cost of $315 per animal unit at 5% over 10 years results in an annual cost of $41/animal unit/yr. Adding O&M costs equal to 10% of the initial capital cost (i.e., 10% x $315) results in an annual cost of $72/animal unit/yr, or $10,440 per manure acre per year. Averaging the estimates from Camacho (1992) and MDA (2002a) produces an annual cost of $8,186 per manure acre per year. Approximately 56% of this cost is annualized capital and therefore eligible for cost-share.

Cost sharing is provided by various programs including EQIP and several state programs. Cost share percentages range from 75% to 87.5% of installation costs. The net farmer cost, therefore, ranges from $4,175 to $4,748/manure acre/yr.

2.2.1.12 Yield Reserve

The yield reserve BMP involves applying 75% to 85% of the fertilizer recommended in a nutrient management plan (i.e., 98% to 111% of a crop's need instead of 130%). This BMP is only applied in the Tier 3 scenario. Costs consist of development and application of an NMP ($7/ac/yr, as described above). To encourage participation in a federal pilot program, the proposed program has an incentive payment of $40/ac/yr (which may fall to $20/ac/yr to $30/ac/yr in a subsequent bid program phase) and also provides insurance against revenue losses associated with lower crop yields (personal communication with T. Simpson, University of Maryland, March 2002). In the long run, the cost of this program could equal annual revenue on the order of $20/ac/yr less than the NMP cost, or net revenue of about $13/ac/yr. However, a dedicated Yield Reserve program was not included in the 2002 Farm Bill, and although various opportunities remain to fund a program through other parts of the Bill or through other sources (personal communication with T. Simpson, University of Maryland, May 2002), the potential cost savings are not included (i.e., the estimate is $0/ac/yr instead of -$13/ac/yr).

2.2.1.13 Carbon Sequestration/Bio-Energy

The carbon sequestration BMP is potentially an extension of the retirement of highly erodible land and grass buffer strip BMPs. Similar to these BMPs, the land owner plants permanent grass cover (such as switchgrass) and maintains it for 10 years or longer. This BMP differs, however, in that the land owner is allowed to harvest top growth and sell it as a biofuel for electricity generation or co-generation. If the biofuel is used in a co-fired coal plant, then it generates CO_2 offsets through fuel substitution. Also, continuous switchgrass ground cover is expected to sequester soil carbon in the root zone because only the top growth is harvested.

Annual harvest of switchgrass for biofuel increases the cost of this BMP. Turhollow (2000) estimates that the average "delivered" cost (i.e., including transportation) per ton of harvestable biomass is $52 (1999$). This cost incorporates costs for establishment (which includes land rent), maintenance, harvest, and transportation. Given his average yield rate of 5 tons per acre per year, the cost per acre is $260 (5 x 52). At issue is whether potential revenues for biofuel and carbon sequestration can offset this cost or at least the incremental cost of biofuel harvest and transportation.

Potential revenue sources include (1) annual sale of biomass as a fuel source for a co-fired coal and biomass generator, (2) value of CO_2 credits for replacing fossil fuel with biomass fuel, and (3) value of CO_2 credits for additional soil carbon sequestration. **Exhibit 10** provides revenue estimates that indicate a potential for revenue from all three sources to nearly offset the $260/acre annual cost (revenues range from $229/acre to $261/acre).

This is not a contractual BMP and, therefore, there is no reason to expect a farmer to incur annual harvest and transportation costs if the fuel sales and CO_2 credits for fuel-switching do not offset annual costs. Therefore, the maximum cost for this BMP is the installation cost, which is $100/acre in 1999 dollars (Turhollow, 2000). Converted to 2001 dollars and annualized at 5% over 10 years, the cost is $13/ac/yr. It is conceivable, however, that the additional sources of revenue could result in a lower average cost, which would mean that the estimate exceeds the actual cost of this BMP.

Exhibit 10: Estimates of Potential Revenue for Carbon Sequestration BMP

Source	Assumptions	Revenue/Acre
Fuel Sales	5 tons/acre annual average yield[1] x 15 million Btu/ton (MMBtu/ton)[2] x $1.05 per MMBtu[3]	$79
CO_2 fuel-switching credits	5 tons/acre annual average yield[1] x 15 MMBtu/ton[2] x 178 lbs CO_2/MMBtu coal[4] ÷ 2000 lbs per ton x $20/ton CO_2[5]	$134
CO_2 sequestration credits	0.2–0.66 tons carbon/acre annual average sequestration rate[6] x 44/12 conversion factor from carbon to CO_2 x $20/ton CO_2[5]	$16–$48[7]
Total		$229–$261

1. Midpoint yield rate from Turhollow (2000) and Walsh and Lichtenberg (1995).
2. Heat content of switchgrass (Turhollow, 2000).
3. Projected delivered price of coal for electric generation in 2010 in 2000 dollars (EIA, 2001).
4. Projected CO_2 emissions rate for supercritical pulverized coal generation in 2010 (DOE, 2002). This analysis assumes net biomass emissions of zero (i.e., annual sequestration in biofuel portion of biomass offsets its annual combustion emissions). Thus, total avoided CO_2 emissions equals avoided coal CO_2 emissions.
5. Approximate upper bound of observed past trades (CO2e.com).
6. Calculated from 0.5 to 1.5 tons per hectare rate in CAST (1998).
7. This range is similar to the range of $20 to $25 per acre revenue for carbon sequestration submitted in a comment by R. Handley (Project Director, Northeast Regional Biomass/Biofuels Program, Coalition of Northeastern Governors). The cost-per-acre for planting and harvesting in this comment is $55 to $65, which is substantially less than the potential biofuel revenue alone.

2.2.1.14 Manure Excess

In the Watershed Model, this BMP represents implementation of alternative uses for excess manure from livestock operations, as opposed to spreading manure on fields. The practice may be necessary either because of declining agricultural land on which to spread the manure, or because of nutrient management plans that reduce land application. In the Watershed Model, BMP implementation requirements are expressed in units of wet tons of manure that must be exported per year.

Based on model farm cost estimates developed for the economic analysis of the proposed CAFO rule (U.S. EPA, 2001a), the estimated cost is $3.11 per wet ton per year, and represents an average across different beef and dairy farm sizes in the Mid-Atlantic states as well as transportation options and nutrient application limitations.

Cost-share funds for manure transportation off farms are available in Maryland through the Manure Transportation Program and in Delaware through the Nutrient Management Relocation Program. As of May 2002, the Maryland program was scheduled to pay 12 cents per ton-mile (or 15 cents on the Eastern Shore), plus a $1.50 per ton load rate, up to $20/ton-mile, for poultry litter. The program would also pay generally 87.5% of costs for transporting manure of other animals, subject to caps depending on moisture content and distance (personal communication with N. Astle, Maryland Manure Transportation Program, May, 2002). However, in Maryland the recipient of the manure generally pays the remaining costs of transportation, so that the net cost to the producing farmer is zero, or the farmer may even make positive returns in the process of selling the manure (personal communication with N. Astle, May, 2002).[9] The Delaware program pays 15 cents per ton-mile plus a $2.50 per ton load rate up to $20 per ton (Delaware Department of Agriculture, 2002b).

For Maryland and Delaware, the costs for hauling manure are cost-shared so the net cost to farmers is zero. In other states with no cost-share the net farmer cost is $3.11 per ton.[10]

2.2.1.15 Conservation Tillage

In the Watershed Model, conservation tillage (CT) is defined as leaving at least 30% of the crop residue on the field between crops and reducing disturbance of the soil surface/upper horizon. Several sources of cost information indicate that CT is well-accepted by agricultural producers. For example, Tippett and Dodd (1995) note that the federal government gives incentive payments to encourage the practice for the first three years, after which time it is hoped that farmers see net benefits and continue to use the practice on their own.

The main cost driver for this practice is the possible purchase of new equipment appropriate for the conservation tillage system. Because conservation tillage must be rotated with conventional tillage to avoid soil compaction, the practice requires the purchase or rental of equipment for both types of tillage systems (conventional and conservation). The only study that specifically states equipment costs are included is MD DNR et al. (1996), which reports a cost of $17/ac/yr (or $19 in 2001 dollars). However, it appears based on reviewing the source of that estimate (as cited in the document) that the cost actually represents incentive costs rather than equipment costs. Therefore, additional research is required to document an average annual cost per acre.

Excluding such costs may not substantially bias the analysis. Many farmers are already implementing conservation tillage and, therefore, have already purchased equipment. Indeed, many of the net conservation tillage acres in the tier scenarios are negative, indicating high implementation rates in Progress 2000. To the extent bias exists, it is primarily an underestimate of costs to cost-share programs, which provide incentive payments for implementing this practice and tax credits for purchasing equipment.

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[9] Recent budget shortfalls in Maryland have decreased the amount provided under the cost-share program. The availability of future funding is unknown because projecting state budget outcomes is impossible; this issue can be dealt with in a sensitivity analysis.

[10] The estimated cost assumes manure is hauled an average distance of 18 miles from the producing farm, which is the average haul distance calculated by the U.S. EPA (2001a) for the CAFO Rule in the mid-Atlantic region. Longer hauling distances may be likely for farms on the Delmarva Peninsula. Net farmer costs are likely to remain zero for Delaware and Maryland farms, but the funds necessary for cost-share may increase.

Several additional sources also use government incentive payments rather than actual equipment or practice costs. These sources (MD DNR et al., 1996; Camacho, 1992; Tippett and Dodd, 1995; and VA SNR, 2000) report incentive payments around $15 to $25/ac/yr in current dollars, or about $20-25/ac/yr in constant 2001 dollars. Camacho (1992) notes that the incentive payments do not reflect practice costs. The four studies that estimate practice costs find net costs ranging from $-2/ac/yr (i.e., a net revenue gain of $2) to $5.60/ac/yr. Some variation is a function of what crop rotation is assumed; USDA (1999) estimates that conservation tillage in corn results in a net gain, while the practice results in net costs for soy and wheat.

The average of the practice costs from USDA (1999), Smolen and Humenik (1989, cited in U.S. EPA, 1997b), and Russell and Christensen (1984, cited in U.S. EPA, 1997b) is $2.72/ac/yr. This cost probably excludes any additional equipment costs that might be incurred (if farmers buy new equipment sooner than necessary rather than waiting until existing equipment needs to be retired), but it also excludes incentive payments from cost-share programs. Assuming that these costs balance each other, the net farmer cost is $2.72/ac/yr. There is inadequate data regarding the prevalence of equipment purchase related to implementation to incorporate state or federal funding applicable to the purchase of equipment for this BMP.

2.2.2 Forestry

In the Watershed Model, forest harvesting practices represent a suite of practices to control erosion on forest land harvested for timber. Practices may be either structural (e.g., culverts, broad-based dips, windrows) or managerial (e.g., preharvest planning, forest chemical management, fire management). Several sources provide cost estimates:

- Aust et al. (1996, cited in U.S. EPA, 2001b) estimated costs for implementation of various erosion control practices in Virginia and southeastern states, and reported costs per acre for "stringent, enforceable implementation" of $21.40/ac for the coastal plain, $38/ac for the Piedmont, and $49/ac in the mountains (1998 dollars); these costs appear to include technical assistance, quality control, and compliance

- South Carolina Forestry Commission (1993, cited in MD DNR et al. (1996), estimated costs of $12.15/mbf (1 mbf = 1,000 board feet) for loblolly/shortleaf, which is characteristic of flat sites, $14.31/mbf for oak/pine, which is characteristic of moderately sloped sites, and $14.50/mbf for oak/hickory, which is characteristic of steep sites (dollar year not reported); using data on board-feet of timber per acre in Maryland by topographic region from Frieswyk and Giovanni (1988) in MD DNR et al. (1996), this equates to $129/ac on flat sites, $152/ac on moderate sites, and $172/ac on steep sites (dollar year unknown)

- Lickwar, Hickman, and Cubbage (1992) estimated costs of $2.42/mbf or $12.56/ac on flat sites, $4.75/mbf or $24.33/ac on moderately sloped sites, and $6.08/mbf or $34.62/ac on steep sites (1987 dollars)

- Virginia Department of Environmental Quality (1993) estimated costs of $51/ac/yr (dollar year not reported) including construction, planning, technical assistance, and

O&M (based on annualizing capital costs at 10% over an unspecified practice life); however, this estimate is not usable because many assumptions are not documented.

Converting estimates from Aust et al. (1996, cited in EPA, 2001b), South Carolina Forestry Commission (1993, cited in MD DNR et al., 1996), and Lickwar, Hickman, and Cubbage (1992) into 2001 dollars (using the USDA-ERS index of prices paid by farmers (USDA-ERS, 2001), and assuming the costs in the South Carolina Forestry Commission report are in 1993 dollars, results in an average cost across the three land types of $84/ac/yr. Although this average does not reflect the Virginia DEQ (1993) report due to lack of documentation, the average value of the other three sources is comparable to the DEQ estimate of $51/ac/yr (after accounting for inflation in the latter estimate) and is also conservative.

The costs from the three sources appear to reflect total costs, rather than annual costs. However, the number of acres to which the BMP is applied is expressed as a number per year, and the BMP is likely to be applied to new land every year rather than previously harvested land. If previously harvested land is re-harvested (i.e., if selective harvests are performed on the same land more than once before 2010) and the BMP implemented previously can be re-used (e.g., a culvert that would not be damaged in the later harvest), the unit cost for this BMP will tend to be overstated.

The Forest Lands Enhancement Program, recently created by the 2002 Farm Bill, may provide public funds for landowners to implement erosion control practices during forest harvesting. However, the summaries of costs shown in Section 3 do not incorporate the potential for public cost sharing through this program.

In addition, Dissmeyer and Foster (1987, cited in EPA, 2001b) found that forest harvesting practices resulted in net cost savings in some cases in southern states due to avoiding problem soils, wet areas, and unstable slopes, and reducing erosion by revegetating cut and fill slopes. Thus, in areas where forest harvesting measures result in net cost savings, the cost estimate will overstate actual BMP costs.

2.2.3 Urban and Mixed Open Land

2.2.3.1 Forest Buffers

The cost to plant and maintain a forest buffer on agricultural land is also applicable to forest buffers on pervious urban and mixed open lands. One would expect that the cost estimate for the urban version of this BMP would be lower than the agricultural cost estimate because it excludes the foregone revenue of planting a buffer on cropland. However, the land rental payments under the CRP or CREP programs likely offset this net revenue impact among farmers. Consequently, the cost is $108/ac/yr for urban and agricultural buffers.

The net cost for agricultural tree buffers incorporates a cost share that ranges from 75% to 100% of installation costs. There is at least one cost-share program for urban forest buffers, the Maryland Buffer Incentive Program (BIP). This program provides private landowners with a one-time payment of $300/acre up to a maximum of $15,000 for planting and maintenance of riparian forest buffers; the program provides funding for about 300 acres ($90,000) per year (Environmental Law Institute, 2000). The estimates do not reflect this cost-share program. Palone and Todd (1998) provide some estimates of increases in lot value for lots adjacent to forest buffers, but the estimates also do not reflect offsets of this type because it is unknown whether the nonagricultural forest buffers are planted on private or public lands.

2.2.3.2 Environmental Site Design

The environmental site design (ESD) BMP, also called Low Impact Development (LID), is applied to land area under new development. The U.S. EPA (2000, p. 1) defines LID as

> a site design strategy with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape. ... LID principles are based on controlling storm water at the source by the use of micro-scale controls that are distributed throughout the site. This is unlike conventional approaches that typically convey and manage runoff in large facilities located at the base of drainage areas.

Because this BMP is applied to newly developed acres, the cost-per-acre must incorporate the cost savings associated with avoided storm water conveyance structures (e.g., curbs, gutters, and underground pipe) as an offset to the cost of ESD measures themselves. LID practices include bioretention, grass swales, vegetated roof covers, and permeable pavements. The concept is that investing in permeable substitutes to traditional impervious surfaces avoids the cost of the surface itself, and the corresponding costs of the infrastructure required to handle its storm water runoff.

Presently, the cost information for this innovative approach to land development is anecdotal and much of the information is qualitative. The U.S. EPA (2000) states that LID practices are more cost effective compared to conventional storm water structures and also provide more aesthetic landscape features. An earlier literature review (U.S. EPA, 1996) provides some case study examples showing net cost savings of practices that can be considered LID, e.g., a $100,000 rain garden versus $400,000 for conventional storm water ponds in the Somerset project in Prince George's County, MD. The NAHB Research Center, Inc. and U.S. EPA (2001) note the following cost implications for LID measures:

- Bioretention: minimal net construction costs because higher landscaping costs could be offset by lower storm water management costs elsewhere; low maintenance costs

- Swales and grassy channels: lower costs compared to paved or impervious infrastructure (one-half to one-third the cost of curb and gutter systems), low maintenance costs, decreased requirements for downstream facilities and related infrastructure costs

- Permeable paving: higher upfront costs and maintenance, but reduced need for storm water facilities help offset the initial cost differential.

A couple of case studies cited throughout the literature provide evidence that net costs are potentially negative (i.e., the ESD costs are lower than conventional impervious surface/storm water infrastructure investments). A study cited by the NRDC (2001) and the NAHB Research Center, Inc. and U.S. EPA (2001) is the redesign of a 130-acre development project in Sherwood, Arkansas. **Exhibit 11** provides a comparison of key development parameters between the original convention design and the revised design that preserved natural vegetation and drainage features, thereby reducing site preparation and storm water infrastructure costs. The cost comparison indicates that the latter reduced total costs by 15% and the cost per lot by 19%. The per-lot savings is higher because the revised design also increased the number of housing units.

Exhibit 11: Cost and Development Implications of Alternative Designs

Development Parameters	Conventional Development Plan	Green Development Plan
Lot yield	358	375
Street (linear ft.)	21770	21125
Collector street (linear ft.)	7360	0
Drainage pipe (linear ft.)	10098	6733
Total cost estimate	$4,620,600	$3,942,100
Cost per lot	$12,907	$10,512
Incremental amenities	na	23.5 acres open space/parks
Incremental lot value	na	$3,000 over competitors

Source: NAHB Research Center, Inc. and U.S. EPA (2001), citing Tyne and Associates. 2000. “Bridging the Gap: Developers Can See Green.” Land Development Spring/Summer: 27-31.

Two other case studies that provide cost information include:

- a project design that included bioretention areas, rain gardens, compact weir outfalls, depressions, grass channels, wetland swales, and a specially designed storm water basin at a new 270-unit apartment complex in Aberdeen, NC, reduced storm water costs by 72% or $175,0000 compared to a traditional storm water collection system by eliminating nearly all subsurface infrastructure along with curbs and gutters (BLUE Land, Water, Infrastructure, 1999)

- developers for the Pembroke Subdivision in Frederick County, MD, were able to eliminate plans for two storm water management ponds using LID practices (thereby avoiding $200,000 in infrastructure costs), preserve a two-and-a-half acre open space and wetlands, which provided wetland mitigation savings, add two lots to the 43-acre development (adding $100,000 in value), and preserve almost 50% of the site in undisturbed wooded condition (NRDC, 2001)

Thus, the expectation is that incorporating ESD measures in new development is likely to reduce costs and the case study data for new developments indicate potential for net cost savings. Developing an average cost savings per acre, however, is not feasible given the limited data.

Consequently, the net cost estimate of $0/acre reflects that any incremental ESD planning and implementation costs are completely offset through cost savings in avoided costs for conventional storm water management infrastructure that is required in most developments to handle the volume of storm water generated by creating impervious surfaces.

2.2.3.3 Storm Water Retrofits

The per-acre BMP costs for storm water retrofits distinguish between costs for pervious and impervious urban areas. In either case, there are a variety of practices that might be implemented; the choice of practice depends on a variety of site-specific conditions (e.g., site imperviousness, site size, climate, and land availability) that vary throughout the basin. Consequently, the unit costs reflects a wide variety of measures, including new construction (e.g., detention ponds, retention ponds, infiltration basins, swales, and sand filters) and retrofits to existing infrastructure (e.g., converting storm water management ponds to extended detention ponds). The costs are averages across three sources:

- Brown, W., and T. Schueler. 1997. The Economics of Storm water BMPs in the Mid-Atlantic Region. Final Report prepared by the Center for Watershed Protection (CWP) for the Chesapeake Research Consortium. As reported in related CWP documents and databases, including CWP. (no date). The Economics of Storm Water Treatment: An Update. Technical Note #90 from Watershed Protection Techniques 2(4): 395-499.

- Northern Virginia Planning District Commission (NVPDC). 1994. Urban Retrofit Techniques: Applicability, Costs, and Cost-Effectiveness. Prepared for Virginia Department of Environmental Quality.

- Livingston, E.H. 1999. "A Review of Urban Storm water Retrofitting in Florida." In *Proceedings of the Comprehensive Storm water & Aquatic Ecosystem Management Conference*, Auckland, New Zealand, February 22-26, 1999.

These studies provide cost estimates for a wide variety of BMPs designed for existing development. BMPs include actual retrofit projects as well as new construction. **Exhibit 12** shows mean unit costs for each study distinguish between pervious and impervious area, where feasible. In most cases, the cost estimates represent the total cost to treat both water quantity and water quality volumes since the retrofits must be conservatively sized to handle the total volume of storm water runoff. The costs represent costs per acre controlled in the watershed area, not costs per project acre.

Exhibit 12: Mean Annual Storm Water Retrofit Costs (2001 dollars per acre)[1]

Source	Pervious Urban Area	Impervious Urban Area
Brown and Schueler (1997)[2]	$287	$1,013

Exhibit 12: Mean Annual Storm Water Retrofit Costs (2001 dollars per acre)[1]

Source	Pervious Urban Area	Impervious Urban Area
NVPDC (1994)[3]		
Retrofit structures	$289	$289
New structures	$451	na
Livingston (1999)[4]	$312	$1,164
Mean across studies	$330	$820

Note: Capital costs from all studies are converted to 2001 dollars using the construction cost index in the Engineering News Record. Annualized capital costs are based on the assumption that financing terms of 5% over 20 years are available to municipalities. The interest rate is higher than borrowing rates for State Revolving Fund loans, which range from 0.7% to 3.9% throughout the basin states, to reflect that possibility that some municipalities may use alternative financing arrangements such as revenue bonds or bank loans, which tend to have higher rates. Costs include either annual O&M estimates provided by the study or annual O&M costs equal to 5% of total capital costs (CWP, no date).

1. Represents total structural costs, including costs to control storm water quantity as well as quality.
2. Example costs from CWP (no date) for a 50-acre residential development and a 5-acre commercial development to demonstrate the cost function derived in Brown and Schueler.
3. Average new structure costs based on 22 projects implementing a variety of technologies including wet pond creation and sand filter installation. Average retrofit costs are based on calculated averages for sites of 5 to 300 acres for five cost functions reported in the paper. Costs for retrofitting existing flood control structures do not differ by degree of perviousness.
4. Averages for various low-density and high-density retrofit projects throughout Florida.

Although the average cost for impervious urban areas represents an average over a wide range of site conditions, it may be too low to represent potential costs to retrofit ultra-urban places, which are large, densely populated areas. These areas can have limited space for constructed BMPs in conjunction with high runoff volumes generated by a high percentage of impervious surface.

Exhibit 13 shows populations, population density, and land area for urban areas in the Basin with more than 70,000 people (based on 2000 census data for population and land area). The places with population densities of over 10 people per acre (shown in bold in the table) may experience higher costs associated with storm water controls due to the space limitations discussed above: Baltimore, MD, Washington, D.C., Arlington, VA, Alexandria, VA, and Silver Spring, MD. Five storm water retrofit projects reported in Livingston (1999) treat water from areas with impervious surface accounting for 85% or more of total surface area. The cost-per-acre estimates (in 2001 dollars) for these highly urbanized areas are:

- $682/acre to install a detention pond and sand filter for a 9.2-acre medical complex in Pinellas County

- $699/acre for a wet detention pond and treatment system for a 121-acre site in Orlando
- $1,005/acre for a berm, weir, and pump system to reuse "first flush" from an 8.1-acre site for irrigation in Winter Park

- $3,269/acre for an alum injection system and lake restoration project for a 158-acre site in Tallahassee
- 4,986/acre to install an infiltration retrofit in a 2-acre parking lot in North Redington Beach.

Exhibit 13: Urban Places in the Chesapeake Bay Basin with Population > 70,000 (ultra-urban places in bold)

Urban Place	Population (2000)	Population Density (people/acre)	Size (square miles)
Baltimore city (MD)	651,154	12.6	80.8
Washington, D.C.	572,059	14.6	61.4
Virginia Beach city (VA)	425,257	2.7	248.3
Norfolk city (VA)	234,403	6.8	53.7
Chesapeake city (VA)	199,184	0.9	340.7
Richmond city (VA)	197,790	5.1	60.1
Arlington city (VA)	189,453	11.4	25.9
Newport News city (VA)	180,150	4.1	68.3
Hampton city (VA)	146,437	4.4	51.8
Alexandria city (VA)	128,282	13.2	15.2
Portsmouth city (VA)	100,565	4.7	33.2
Columbia city (MD)	88,254	5.0	27.6
Silver Spring city (MD)	76,540	12.7	9.4
Scranton city (PA)	76,415	4.7	25.2

These estimates produce an average cost of $1,930/acre for retrofits in ultra-urban areas. Stormwater control costs generally do not include land acquisition costs because most of the control technologies either require relatively little land area (e.g., infiltration basins) or do not require additional land purchase (e.g., retrofitting an existing detention pond to extend detention time).

Data provided by the Maryland Department of the Environment suggest that these estimates may overstate retrofit costs. A report of six case studies (MDE, 1997) indicates total capital costs that potentially range from $1,051 to $3,553 per acre; corresponding annualized costs would range from $84 to $285. A second set of 11 retrofit projects have a mean total cost of $3,529 per acre and an annualized cost of $283 per acre (S. Bieber, MD Department of Environment, personal communication, May, 2002). However, sufficient information to incorporate these data is not available.

There may be potential for cost savings through "piggybacking" storm water retrofits onto planned road or other infrastructure maintenance to reduce costs. An example provided by the Prince Georges County (MD) Department of Environmental Resources (personal communication with L. Coffman, 8/8/02) demonstrated how the cost of a particular storm water facility, a roadway bioretention system, might be cut by 46% if the system could be installed as part of a planned road repair activity. The cost savings accrue because some of the excavation and fill work cost is incurred for road repair regardless of whether a bioretention system is added. Thus, the incremental cost of bioretention is only 54% of the cost of a typical system.

This particular example does not provide enough information to incorporate potential cost-savings into the unit cost estimate for retrofits because the original retrofit cost studies do not include bioretention systems. However, this example suggests the possibility that piggybacking opportunities may reduce costs for other storm water management technologies.

The unit cost estimates already incorporate potential cost savings opportunities to some extent because some case study costs come from retrofitting existing storm water facilities. For example, the unit cost for impervious urban land is an average of three values: $1,164/acre/yr for a set of Florida case studies with unit costs ranging from $682/acre/yr to $2,269/acre/yr; $1,013/acre/yr from a function for detention pond costs estimated by Brown and Schueler based on case studies in the Mid-Atlantic region; and a $289/acre/yr average cost for retrofit projects for existing detention ponds in the Anacostia watershed. Thus, low-cost opportunities to alter existing storm water facilities are incorporated by including the Anacostia retrofit costs in the average unit cost estimate. Although piggyback opportunities may further reduce costs for storm water retrofits, further adjustments to the cost estimates derived above are not warranted because they already incorporate the effect of cost-savings opportunities.

2.2.3.4 Storm Water Management

This control is applied to new development that occurs between 2000 and 2010.[11] Although it will incorporate many of the same structural controls as retrofits, the unit cost estimates for this measure are lower because only the water quality volume is relevant since costs associated with water quantity will be borne regardless of water quality considerations. New development in urban areas is generally required to have infrastructure to quickly remove storm water from surface areas and store it while it is gradually released. Therefore, a portion of storm water management costs in new development would be incurred regardless of water quality concerns.

Exhibit 14 reports costs associated with water quality volumes for the three studies included in the retrofit section as well as a fourth study that provides costs for only the water quality volume. The BMP cost estimate is based on the mean values across all the studies ($150 on pervious and $450 on impervious urban areas).

Exhibit 14: Mean Annual Storm Water Management Costs (2001 dollars per acre)[1]

Source	Pervious Urban Area	Impervious Urban Area
Brown and Schueler (1997)[2]	$96	$338

[11] The Watershed Model also includes a storm water management BMP on recent development to account for reduced loadings from development that occurred between 1986 and 2000 compared to prior development. Costs incurred prior to 2000 are not addressed here.

Exhibit 14: Mean Annual Storm Water Management Costs (2001 dollars per acre)[1]

Source	Pervious Urban Area	Impervious Urban Area
NVPDC (1994)[4]	$150	na
Livingston (1999)[5]	$174	$460
U.S. EPA (1999b)[6]	$200	$552
Mean across studies	$150	$450

Note: Capital costs from all studies are converted to 2001 dollars using the construction cost index in the Engineering News Record, and amortized at 5% over 25 years. Annual O&M costs estimated as 5% of total capital costs (CWP, no date).

1. Represents the share of BMP costs attributable to storm water quality requirements.
2. Example costs from CWP (no date) for a 50-acre residential development and a 5-acre commercial development to demonstrate the cost function derived in Brown and Schueler.
4. Average new structure costs based on 22 projects.
5. Average costs for low-density and high-density projects throughout Florida.
6. Averages across subsets of costs for five different structures; water quality share only (based on functions in the study).

2.2.3.5 Urban and Mixed Open Nutrient Management

Urban and mixed open nutrient management involves a reduction of fertilizer applications to urban and mixed open land to reduce nutrient loadings. Although the principles and objectives of urban nutrient management are similar to its agricultural counterpart, there is one important difference–nutrient application in urban settings is not an essential input to food production. This means that although the costs associated with conducting soil samples and developing agronomically appropriate nutrient application rates are potentially transferrable to urban settings, any net revenue impact associated with yield reductions or increases is irrelevant. Furthermore, given the largely voluntary nature of urban nutrient application, it is difficult to justify a BMP unit cost assumption that would impose burdensome costs on urban households, through either direct household consumption of application services or indirect tax or fee increases to fund municipal landscape programs.

Consequently, the cost estimate is equal to the soil testing and plan development portion of the agricultural BMP cost. Only two sources are sufficiently documented to break out these costs from implementation costs; these two sources report costs of $5/ac (USDA, 1999), or $5.16/ac in 2001 dollars, and $7/ac (U.S. EPA, 2001a), or $7.22/ac in 2001 dollars, for plan development and soil testing. The mean cost is $6.19/ac; assuming the plan is good for 3 years, the annual cost is $2.06/ac/yr. This is consistent with incremental costs identified by MD DNR (E. Kanter, personal communication, 2002). Incremental application costs are unlikely because households and municipalities will minimize these types of cost impacts. State agencies and local communities might incur incremental administrative costs, but these costs are *de minimis* when converted to a per-acre basis because the BMP applies to millions of acres. Depending on state program requirements, businesses might also have additional record keeping or paperwork requirements (e.g., recording soil sample and nutrient application rate information for each customer). States can choose, however, to implement requirements that minimize these impacts on businesses (e.g., simply requiring some additional fields in customer databases to track soil sample results and nutrient application rates).

In the Watershed Model, this BMP is applied to both pervious urban and mixed open land. For pervious urban land, the estimated cost is $2.06/ac/yr. For mixed open land (defined as herbaceous land other than agricultural land), the estimate is one quarter of this cost ($0.52/ac/yr) based on information about mixed open land from the Chesapeake Bay Program Modeling Subcommittee (Chesapeake Bay Program, 2000). This document states that mixed open land has a fertilizer application rate equal to 25% of the rate for pervious urban land. The cost of $0.52/ac/yr represents a weighted average cost between 25% of acres to which fertilizer is applied and 75% of acres where the cost of fertilizer management is zero because no fertilizer is applied (either before or after implementation of the BMP).

One option for implementing this BMP is public education and outreach to urban and suburban residents to encourage lower fertilizer application. Two analyses provide cost estimates for an outreach program: a study of a community outreach program in Kettering, MD (Coffman, 2001), and the economic analysis of the Phase II Storm Water Rule (EPA, 1999b).

The first study was conducted by the Prince George's County Department of Environmental Resources (PGDER) in the town of Kettering, (population 2,800). Kettering and the PGDER implemented the outreach program in 1993-94 as a learning tool to determine what outreach efforts were most effective. The program covered many topics (including several unrelated to nutrient management, such as car care, backyard habitat, and recycling) and used numerous educational methods, including a monthly newsletter mailed to all households, workshops, regular water quality monitoring, and storm drain system monitoring to look for illegal discharges and connections. A full-time project manager supervised the program, aided by a citizen advisory committee. The project cost about $84,000, or about $75 per household (dollar year not provided). However, pre- and post-program surveys suggested that behavioral changes were minimal. The Kettering study is not incorporated for the following reasons:

- Most of the program's pollution reduction objectives (e.g., recycling, car products, and hazardous waste) are not included in the Bay watershed nutrient reduction scenarios

- The study gave no evidence that any of the outreach tools used were cost-effective

- Some alternatives to outreach suggested by the study, such as LID, are already implemented in the watershed scenarios.

The Economic Analysis of the Final Phase II Storm Water Rule (EPA, 1999b) also included an analysis of public education and outreach costs related to reducing pollutant loadings, including nutrients, from urban and suburban households. The National Association of Flood and Stormwater Management Agencies (NAFSMA) conducted a survey in 1998 of 1,600 jurisdictions to identify costs of existing programs for public education and outreach, illicit discharge detection and elimination, construction site storm water runoff control, post-construction storm water management in new and recent development, and pollution prevention for municipal operations. Fifty-six jurisdictions responded with usable cost and household data; the mean cost per household for all five of those activities is $9.16 per year (1998 dollars). A breakout is not provided; however, public education and outreach for nutrient control likely makes up a relatively small portion of the costs. Estimates from this source cannot be incorporated because no breakout is provided; however, the NAFSMA study appears to corroborate the idea that per-household or per-acre costs for this BMP would be relatively low.

2.2.3.6 Urban Land Conversion

In the Watershed Model, urban land conversion is a 10% to 20% reduction in planned new development acres in Tiers 2 and 3, respectively. These acres mostly represent conserved forest land and agricultural land. There are no corresponding changes in 2010 population or housing unit estimates, which implies that this BMP is achieved through a variety of approaches that do not affect overall population growth. Approaches include using infill or brownfield development in place of greenfield development, building up instead of out, and clustering greenfield development to preserve natural areas and mature trees.

Net cost estimates for any of these approaches will equal incremental development costs (e.g., additional planning/design costs, additional administrative costs/fees, and higher costs for "building up" structural materials) minus cost savings (e.g., reduced site preparation costs and reduced infrastructure costs for road and utility services) and increased property values. Thus, net BMP costs reflect net revenue impacts to developers.

Literature reviews (Redman/Johnston Associates, Ltd, 1998; U.S. EPA, 1998) provide several case studies that demonstrate infrastructure cost savings and/or increased property values that are substantial enough to offset incremental development costs. For example, the cost of providing utilities for low-density development can be almost two times higher than the cost for compact development (Pelley, 1997). Delaware case studies, cited in CWP (1998), report cost savings ranging from 39% to 63% for new cluster developments that preserved woodland areas in addition to reducing street widths and implementing vegetated BMPs.[12] Furthermore, leaving mature trees on a site can bring about premium property values (NAHB Research Center, Inc. and U.S. EPA, 2001).

Any incremental planning costs and net revenue impacts are likely completely offset by infrastructure cost savings and property value increases. Thus, there is no net revenue impact for the developer.

[12] Reduced road widths and vegetated BMPs that promote onsite infiltration are considered part of the ESD BMP. Thus some of the cost savings in these case studies would be attributed to ESD and some to urban growth reduction.

2.2.3.7 Forest Conservation

Forest conservation, which occurs only in the 2000 Progress scenario, is patterned after the Maryland Forest Conservation Act, which seeks to preserve existing forest land that is at risk during land development and plant trees in developed areas. Until actual program costs are available, the unit cost estimate for this BMP equals the weighted average cost across two conservation scenarios. In the first scenario, a developer sets aside already forested land onsite for preservation. In the second scenario, tree planting occurs in an off-site location.

The unit cost estimate for the first scenario is the same as the urban growth reduction BMP. The cost for that BMP is $0/ac/yr, which assumes that any incremental costs associated with development plans that conserve forested acres are offset by cost savings and incremental property values.

For the second scenario, the planting and maintenance cost components reflect the forest buffer cost estimate developed for agricultural land. The cost for this BMP is $108/ac/yr. No cost-sharing is available as in the agricultural sector although lands set aside in conservation easements might qualify for tax credits.

The overall unit cost of this practice is weighted to reflect program data indicate that at least 80% of the forest conservation acres come from retained forest acres on developed sites and less than 20% of acres are planted (MD DNR, 1999). Thus, the weighted average cost is $22/ac/yr.

2.2.4 Onsite Wastewater Management Systems

As shown in Exhibit 3, the denitrification BMP for onsite wastewater management systems (OSWMSs; also called onsite disposal systems, or OSDS) reduces the total nitrogen (TN) concentration of edge-of-field effluent to 10 mg/L. A variety of technologies are available to reduce nitrogen and other pollutants, but only two reduce TN sufficiently (according to the results of third-party field tests) to meet the 10 mg/L edge of field concentration. The two technologies are Amphidrome from F.R. Mahony and the MicroFAST system from BioMicrobics.

The Amphidrome process consists of a deep bed filter that alternates between aerobic and anoxic treatment, allowing for nitrification and denitrification in a single reactor. A cyclical action is created by allowing a batch of wastewater to pass from the anoxic tank through the filter into the clear well, and then reversing the flow through a pump. The cycles are repeated until the desired effluent quality is achieved. In a test by the Massachusetts Alternative Septic System Test Center (MASSTC, 2002), the Amphidrome process achieved average concentrations of 10.9 mg/L TN at the edge of the leaching trench soil absorption system (the soil absorption system is distinct from the drainage field; that is, the 10.9 mg/L TN is the concentration at the end of the technology train and more nitrogen may be removed in the drainage field). MicroFAST is a fixed film, aerated system utilizing a combination of attached and suspended growth. Microorganisms in the inner aerated media chamber digest nutrients in the wastewater. A test by the MASSTC shows average concentrations of 12.2 mg/L TN at the edge of the leaching field soil absorption system (MASSTC, 2001a).

In Tiers 1-3, denitrification is implemented for a percentage of new systems installed between 2001 and 2010 (0% in Tier 1, 10% in Tier 2, and 100% in Tier 3), and 1% of existing systems in Tier 3 (0% in Tiers 1 and 2). The 1% in Tier 3 represents failed systems and opportunities for upgrades (i.e., systems that would be replaced regardless of the tier requirements for end-of-pipe effluent concentrations). The cost for the BMP in new homes is not addressed here because the additional expense associated with denitrification would be included in the cost of a new home and can easily be offset by cost reductions in other materials or features in the new home. Similarly, the annual O&M costs described below are relatively small and could be easily offset by selecting lower maintenance materials or features elsewhere in the home such as lower maintenance exteriors or energy-saving appliances. The development of BMP costs for existing systems is described below.

For existing systems, the BMP cost is the cost of installing denitrification technology during a system upgrade or repair. **Exhibit 15** summarizes the costs for the two technologies. The MicroFAST treatment unit costs $3,200 (including installation, tax, and freight) for a 3-bedroom house with an average flow of 330 gpd, and electricity to operate the system would cost about $20 per month, according to a sales representative (personal communication with B. Ehrhart, Virginia DEQ, October 2002). A service contract including quarterly inspections would cost $300 per year, based on costs for Massachusetts (MASSTC, 2001a). Annualizing the $3,200 capital cost at 7.4% over 20 years results in an annualized capital cost of $312, and adding the O&M costs of $240 (electricity) and $300 (service contract) results in an annual cost of $852 per system. The Amphidrome unit costs $7,500 including installation, tax, and freight for a 3-bedroom house with an average flow of 330 gpd according to a sales representative (personal communication with B. Ehrhart, Virginia DEQ, November 2002). Electricity costs for the Amphidrome are estimated at $23 per year, based on information from the manufacturer (personal communication with P. Pedros, F.R. Mahony, November 2002). A service contract including quarterly inspections would cost about $300 per year according to the Massachusetts study (MASSTC, 2002). Annualizing the $7,500 capital cost at 7.4% over 20 years results in annualized capital costs of $730, and adding the annual O&M costs of $23 (electricity) and $300 (service contract) results in annual costs of $1,053 per system. Averaging the costs for the two technologies produces an annual average cost of $953.

This BMP also includes frequent pumping (i.e., every 3 years). The pumping costs are a mean value based on four sources: NSFC (1998), MASSTC (2001b), Austin City Connection (2001), and U.S. EPA (1999a). These sources report pumping costs that range from $124 to $268/system, with an average cost of $202/system. The cost for pumping every 3 years would be $67/system/yr (dividing the pumping cost by 3). Thus, the cost for denitrification combined with frequent pumping is $1,020/system/yr, of which $521 or 51% is annualized capital cost. This cost may exceed actual average costs for several reasons. First, it is based on a quarterly service contract, which is required by Massachusetts law for some onsite system permits but may not be required by laws in the basin states. Second, homeowners could potentially save costs by having the unit serviced or inspected at the same time as it is pumped out. Finally, regular pumping is already required for onsite system maintenance; therefore, this cost overestimates incremental O&M costs to current onsite system owners.

Exhibit 15: Onsite Wastewater Management System Denitrification BMP Costs[1]

Component	MicroFAST Cost	Amphidrome Cost	Average Cost
Treatment unit[1]	$3,200	$7,500	$5,350
Annualized capital cost ($/yr)[2]	$312	$730	$521
Electricity ($/yr)	$240	$23	$132
Service contract ($/yr)	$300	$300	$300
Holding tank pumping ($/yr)	$67	$67	$67
Total annual cost	$919	$1,120	$1,020

Sources: MASSTC (2001a, 2001b, 2002), NSFC (1998), Austin City Connection (2001), U.S. EPA (1999a). All costs are in 2001 dollars.
1. Includes installation, tax, and freight.
2. Annualized at 7.4% over 20 years.

In Section 3, costs for OSWMSs are reported as accruing to households. However, U.S. EPA (2002) identified several loan, cost-share, and other programs that can help homeowners pay for upgrades, including upgrades to reduce nutrient pollution:

1. The Clean Water State Revolving Funds (CWSRF), which traditionally provide low- and no-interest loans for upgrades at POTWs but which can also be used for installation, repair, and upgrade of OSWMS in small-town, rural, and suburban areas; the Hardship Grant Program of the CWSRF also provides grants for improving onsite treatment in low-income regions

2. The Nonpoint Source Pollution Program of the U.S. EPA OWOW provides cost-share for onsite system repairs and upgrades

3. The U.S. Department of Agriculture Rural Housing Service offers direct loans, loan guarantees, and grants to low- or moderate-income individuals to finance upgrades

4. State grants through the U.S. Department of Housing and Urban Development Community Block Grant Program can provide funds for improvements to OSWMSs, channeled through town or county government agencies

2.2.5 Summary of BMP Unit Costs

Exhibit 16 provides a summary of the annual unit costs for each of the agricultural, harvested forest land, urban land, and onsite system BMPs. The annual costs include annualized capital costs and annual O&M costs. The table also reports the initial capital cost per acre or system along with the assumptions used to annualize the capital cost (i.e., the annualization rate and time period).

Exhibit 16: Summary of Unit BMP Costs

BMP	Land Use[1]	Total Annual Cost[2]	Capital Cost[2]	Annualization Rate	Annualization Period (years)
Agriculture					
Forest Buffers	HT, LT, H, P	$108	$1,284	5%	25
Grass Buffers	HT, LT	$17	$132	5%	10
Wetland Restoration	HT, LT, H, P	$116	$1,221	5%	30
Retirement of Highly Erodible Land	HT, LT, H	$17	$132	5%	10
Tree Planting	HT, LT, P	$108	$1,284	5%	25
Farm Plans	HT, LT	$17	$92	5%	10
Farm Plans	H, P	$13	$69	5%	10
Cover Crops	HT, LT	$27	na	na	na
Stream Protection w/Fencing	P	$104	$578	5%	10
Stream Protection w/o Fencing	P	$75	$417	5%	10
Nutrient Management Plan Implementation	HT, LT, H	$7	$19	5%	3
Grazing Land Protection	P	$27	$150	5%	10
Animal Waste Management Systems	M	$8,186	$35,398	5%	10
Yield Reserve	HT, LT, H	$7	$19	5%	3
Carbon Sequestration	HT, LT	$13	$100	5%	10
Excess Manure Removal	M	$3.11	na	na	na
Conservation Tillage	HT	$2.72	na	na	na
Forestry					
Forest Harvesting Practices (Erosion Control)	F	$84	na	na	na
Urban					
Forest Buffers	PU, MO	$108	$1,284	5%	25
Grass Buffers	PU	$17	$132	5%	10
Low-Impact Development	PU, IU	$0	$0	5%	20
Storm Water Retrofits	PU	$330	$2,550	5%	20
Storm Water Retrofits	IU	$820	$6,336	5%	20
Storm Water Retrofits	UU	$1,930	$14,912	5%	20
Storm Water Management on New Development	PU	$150	$1,159	5%	20
Storm Water Management on New Development	IU	$450	$3,477	5%	20
Nutrient Management	PU	$2.06	$5.61	5%	3
Nutrient Management	MO	$0.52	$1.42	5%	3
Urban Land Conversion	PU, IU	$0	$0	5%	25
Forest Conservation	PU, IU	$22	$257	5%	25
Onsite Systems					
Denitrification w/ Pumping	na	$1,020	$5,350	7.4%	20

na = not applicable.

1. HT = High Till; LT = Low Till; H = Hay; P = Pasture; M = Manure acres (1 manure acre = 145 animal units); PU = Pervious Urban, IU = Impervious Urban; UU = Ultra-Urban; MO = Mixed Open; F = Forest.
2. Costs are in 2001 dollars per acre, except for excess manure removal ($/wet ton) and onsite system denitrification ($/system), and reflect the cost of the practice before offsets from federal and state cost share programs. For more information on practice costs, see written documentation.

Exhibit 17 provides state-level information on the agricultural BMP cost shares. It shows the variation in farmer costs by state and BMP. Farmer costs for most BMPs are lowest in Delaware, Maryland, New York, and Pennsylvania because these states have the largest cost-share percentages. Farmer costs tend to be highest in West Virginia because this state's programs have lower cost-share percentages for BMP installation costs than other basin states. Virginia has installation cost-share percentages similar to West Virginia, but has higher incentive payments for many BMPs.

2.2.6 Limitations and Uncertainties in the Analysis

The estimated costs above reflect a number of assumptions that may result in under- or overestimates of actual costs. **Exhibit 18** illustrates the sources of potential bias in the cost estimates, as well as the potential impact on costs (if known).

3. RESULTS

This section provides the resulting estimates of costs of the tier scenarios. The overview in Section 3.1 provides cost summaries at the watershed, state, sector, and state basin levels. The section also includes estimates of the potential distribution of total costs between the federal, state, and local sectors, although the actual incidence may differ. Section 3.2 provides estimates including federal and state contributions, and total facility-level costs for point sources, without incorporating expected grant funding available for municipal facilities.

3.1 Overview of Estimated Costs

This section provides a summary of total annual costs and total capital costs at the watershed, state, sector, and basin levels of aggregation. Total annual costs refer to the cumulative costs for each tier scenario. Cumulative cost reflects the total cost of implementing nutrient controls in a scenario, above the cost of the Progress 2000 scenario. Total annual costs include annualized capital costs for control technologies or BMPs that require initial capital expenditures and annual O&M expenditures.

Exhibit 19 shows total annual cumulative costs for each of the three tier scenarios. These estimates represent the annual costs at full implementation of all controls. Therefore, actual annual costs during the period that controls are gradually phased in will be lower.

Exhibit 19 also shows the average annual costs for each of the projected 6.3 million households by 2010, if all costs were paid by households living in the watershed. These annual costs are small compared to median household incomes in the watershed. The median estimate for the counties in the watershed is $49,300. This estimate is in 2001 dollars and reflects incomes in the 2000 Census of Population. Average median incomes across the states range from $37,800 for the watershed counties in New York to $58,300 for Maryland.

Exhibit 17: Comparison of Estimated Farmer and Federal/State Program Costs for Agricultural BMPs across States (2001 $/ac/yr)[1]

BMP	Total Practice Cost	Farmer Cost						Federal/State Cost-Share					
		DE	MD	NY	PA	VA	WV	DE	MD	NY	PA	VA	WV
Forest Buffers	108	23	(8)	23	11	28	34	85	116	85	97	80	74
Grass Buffers	17	(3)	(13)	(3)	(5)	(7)	(1)	20	30	20	22	24	18
Wetland Restoration	116	42	32	42	32	46	52	74	84	74	84	70	64
Retirement of HEL	17	(3)	(13)	(3)	(5)	(7)	(1)	20	30	20	22	24	18
Tree Planting	108	23	23	34	34	28	34	85	85	74	74	80	74
Farm Plans (Cropland)	17	7	7	7	5	8	8	10	10	10	12	9	9
Farm Plans (Hay and Pasture Land)	13	5	5	5	4	6	6	8	8	8	9	7	7
Cover Crops	27	7	7	3	12	7	7	20	20	24	15	20	20
Stream Protection with Fencing	104	48	38	38	29	48	48	56	66	66	75	56	56
Stream Protection without Fencing	75	35	28	28	32	35	35	41	47	47	43	41	41
Nutrient Management Plan Implementation	7	4	5	1	1	4	2	3	2	6	6	3	5
Grazing Land Protection	27	12	10	10	11	12	12	15	17	17	16	15	15
Animal Waste Management Systems	8,186	4,748	4,175	4,175	4,519	4,748	4,748	3,438	4,011	4,011	3,667	3,438	3,438
Yield Reserve	7	0	0	0	0	0	0	7	7	7	7	7	7
Carbon Sequestration	13	13	13	13	13	13	13	0	0	0	0	0	0
Excess Manure Removal	3.11	0.00	0.00	3.11	3.11	3.11	3.11	3.11	3.11	0.00	0.00	0.00	0.00
Conservation Tillage	2.72	2.72	2.72	2.72	2.72	2.72	2.72	0.00	0.00	0.00	0.00	0.00	0.00

Numbers in parentheses indicate net negative costs (i.e., a cost savings).

1. Total practice costs do not include land rental costs or opportunity costs of taking land out of production. State and federal costs include installation cost share, annual maintenance, and one-time incentive payments but do not include land rental payments.

Exhibit 18: Sources of Uncertainty in the BMP Cost Estimates

Source	Potential Impact on Costs	Comments
The extent to which the tier scenarios overlap with other requirements for which costs will be incurred anyway (e.g., under the CAFO rule or CZARA) is unknown.	+	Including costs to implement the forthcoming CAFO regulations and state CZARA programs overstates the costs attributable to the tier scenarios.
Tax credits are not incorporated into farmer portion of agricultural BMP costs.	+[1]	Net farmer cost would be lower for producers claiming a tax credit for implementing BMPs.
Land rental payments assumed to offset revenue loss to farmers.	+	To the extent that rental payments exceed the net revenue loss associated with practices that involve converting land out of agricultural production, farmer costs are overestimated .
Annualized capital costs based on a finance or contract period rather than the useful life of equipment or material.	+	Annual costs will overstate actual costs when the equipment or material is still generating nutrient control benefits beyond the finance or contract period.
The average BMP unit cost estimates may have small overlaps with other BMP costs and, therefore, double-count costs.	+	Most unit BMP cost estimates correct for known practice overlaps, but there may be overlaps that are not accounted for and, therefore, costs are double-counted. For example, the unit cost estimate for streambank protection BMP includes an unknown amount of forest buffer costs, and the unit cost estimate for grazing land protection BMP includes an unknown amount of streambank protection costs.
Storm water retrofits do not include cost savings of "piggy back" opportunities.	+	Municipalities can realize substantial cost savings if retrofit projects can be implemented during planned maintenance, repair, or redevelopment activities.
All OSWMS denitrification costs apportioned to homeowners.	+[1]	Several grant and low-interest loan programs are available and would reduce the household share of the costs of OSWMS upgrades.
Annualized capital costs are based on assumed financing rates.	?	Actual financing rates may differ from sector- or state-specific rates.
Constant unit BMP costs applied to all BMP acres in the Basin.	?	Actual BMP costs will vary from site to site.

+ = assumption results in overestimating costs
? = impact of assumption on cost estimates is unknown
1. Sign shown reflects an impact on direct farmer or household costs; the impact on total costs is zero since this assumption affects only the distribution of costs.

Exhibit 19: Total Annual Cumulative Costs (millions of 2001$)

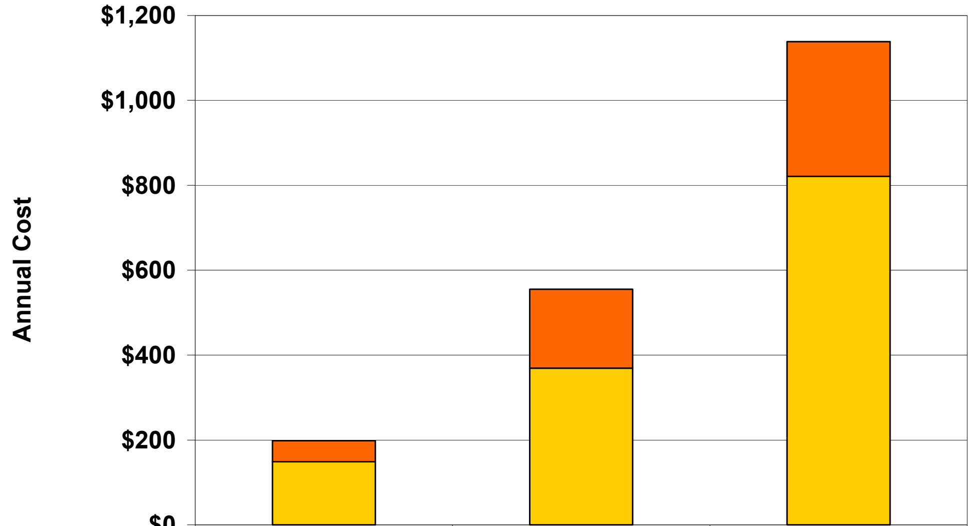
Cost Category	Tier 1 (cost of current programs funded to 2010)[1]	Tier 2 (Tier 1 + Tier 2)	Tier 3 (Tier 1+ Tier 2 + Tier 3)
Total Annual Costs ($millions)[2]	$198	$555	$1,139
Implied Cost per Household (before cost-share)[3] ($)	$31	$88	$181
Share of Watershed Median Household Income ($49,300)	0.1%	0.2%	0.4%

1. Tier 1 costs do not include POTW NRT projects that have already been completed or funded.
2. Includes costs paid by federal and state cost-share programs.
3. Actual household costs will vary by location and type of household (e.g., urban or farm) and will be reduced by the federal and state funding shares. The impact analysis addresses these distributional effects.

The average cost for households in the watershed will be lower than the estimates shown in Exhibit 19 because federal and state cost-share programs provide financial support for nutrient controls. **Exhibit 20** illustrates the estimated breakdown between local costs and federal/state costs based on the cost-share assumptions described previously. Those assumptions use current cost-share information for the agricultural sector, and state estimates for the POTW sector, to project future funding. Actual cost-share amounts may differ. There are no estimates of cost shares for urban BMPs. Nevertheless, retrofit BMPs applied to developed areas may receive substantial support from federal and state sources. Furthermore, there may be "piggy back" opportunities that reduce incremental retrofit BMP costs to a fraction of the unit costs shown above because BMPs can be cost-effectively integrated into planned infrastructure upgrades, repairs, or investments.

Federal and state programs for agricultural and POTW controls could provide $49 million of annual Tier 1 costs (or 25%), $186 million of annual Tier 2 costs (or 33%), and $317 million of annual Tier 3 costs (or 28%). The total cost-share contribution increases from Tier 1 to Tier 2 because agricultural costs increase relative to other sectors, and most costs in that sector are covered by cost-share programs. The total cost-share contribution declines from Tier 2 to Tier 3 as urban costs increasingly dominate total costs.

Total capital costs that correspond to the annual costs reported in Exhibit 19 are $1.4 billion for Tier 1, $3.6 billion for Tier 2, and $8.0 billion for Tier 3. These estimates include anticipated federal and state cost shares. These costs will be incurred slowly over time as controls are gradually implemented. Nevertheless, comparing them to annual economic statistics provides crucial perspective because–despite their magnitude–they are small compared to total annual personal income, which in 1999 was $574 billion ($610 billion in 2001 dollars) in the watershed counties and $1.4 trillion ($1.5 trillion in 2001 dollars) in the basin states and the District of Columbia (BEA, 2001).



	Tier 1	Tier 2	Tier 3
Total	$198	$555	$1,139
Fed./State	$49	$186	$317
Local	$149	$369	$821

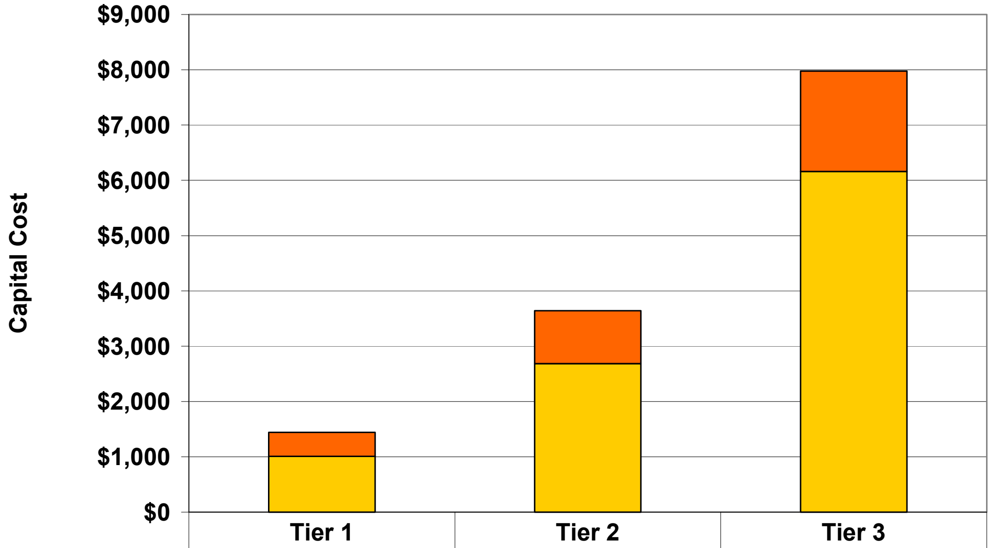
Exhibit 20: Estimated Distribution of Annual Costs (millions of 2001$)

Exhibit 21 shows the share of capital costs estimated for federal and state programs and the remainder estimated for private businesses and households in the watershed. These shares are based on the cost-share program funding levels described in the POTW and agricultural BMP cost sections. Actual cost-share amounts may differ. The percent of total capital costs paid through cost-share programs in Exhibit 21 is approximately the same as the percent of total annual costs in Exhibit 20.

3.1.1 Cost Distribution by State

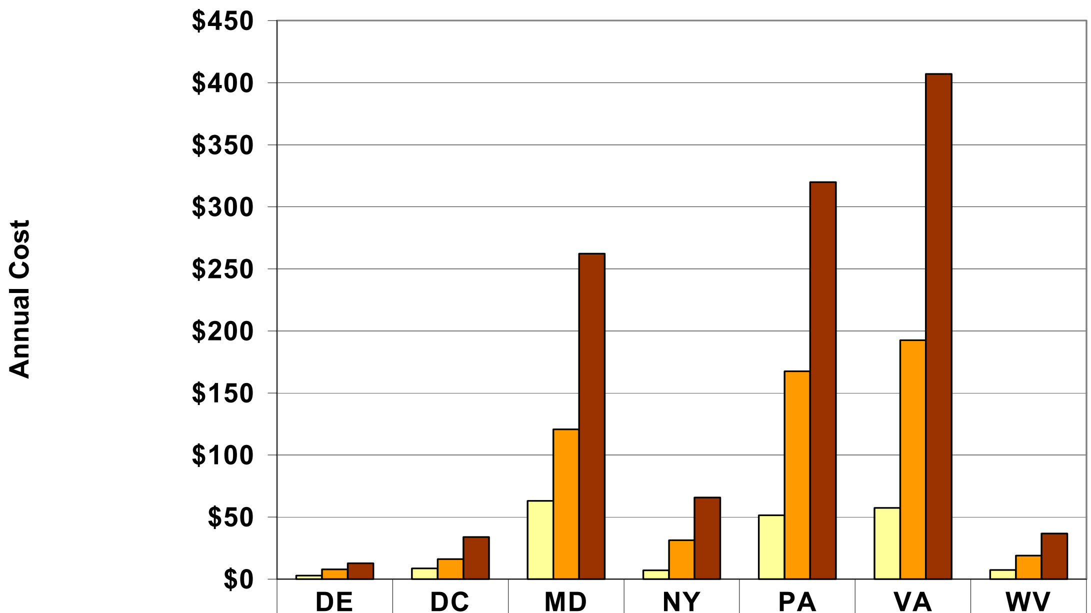
A breakdown of annual costs by state (**Exhibit 22**) shows that three states–Maryland, Pennsylvania, and Virginia–account for almost 90% of costs across all three tier scenarios. Maryland has the largest share of annual Tier 1 costs, followed by Virginia and Pennsylvania. However, Virginia has the highest share of Tier 2 and Tier 3 costs, followed by Pennsylvania and Maryland. Maryland's shift from highest baseline (i.e., Tier 1) costs to third highest Tier 2 and Tier 3 costs signifies its high baseline implementation commitment. (Note, however, that Tier 1 costs do not completely reflect this commitment since they do not include the cost of NRT upgrades at POTWs that have already been funded or completed.)

The cumulative cost estimates shown in Exhibit 22 do not reflect the incremental costs of implementing controls beyond current implementation levels. The incremental costs for Tiers 2 and 3 can be derived by subtracting the Tier 1 costs from the cumulative Tier 2 and 3 costs, respectively. For example, the annual incremental cost of Tier 2 is $357 million ($555 million minus $198 million).



	Tier 1	Tier 2	Tier 3
Total	$1,442	$3,644	$7,975
Fed./State	$433	$957	$1,815
Local	$1,009	$2,686	$6,161

Exhibit 21: Estimated Distribution of Capital Costs (millions of 2001$)

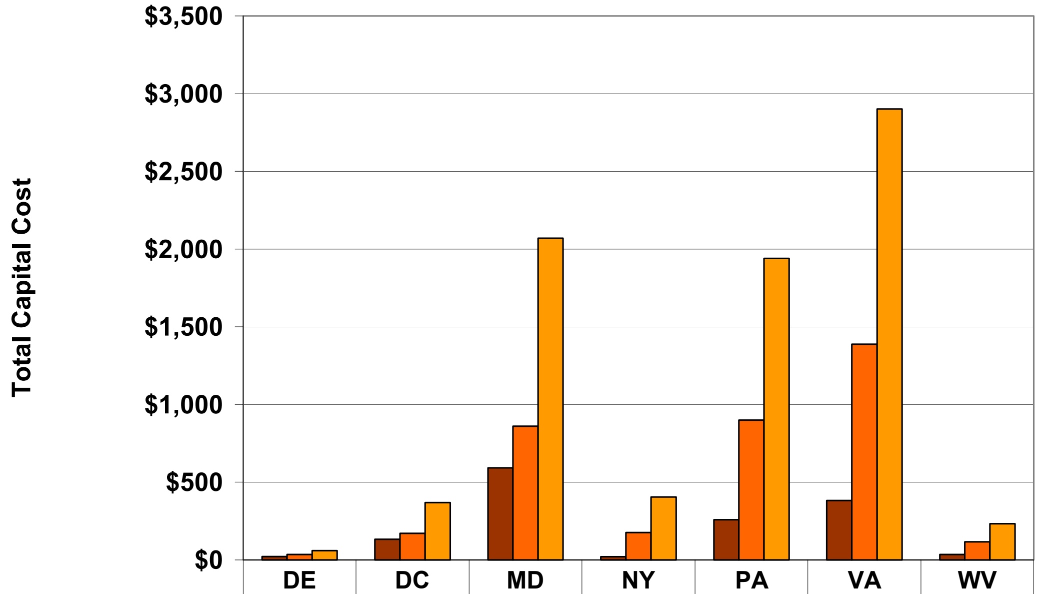


	DE	DC	MD	NY	PA	VA	WV
Tier 1 ($198)	$3	$9	$63	$7	$51	$57	$7
Tier 2 ($555)	$8	$16	$121	$31	$167	$192	$19
Tier 3 ($1,139)	$13	$34	$262	$66	$320	$407	$37

Exhibit 22: Total Annual Cumulative Costs by State and Tier (millions of 2001$)

Note: Costs for Blue Plains WWTF are apportioned to DC, MD and VA according to the method recommended by MWCOG (2002).

The distribution of capital costs across the states (**Exhibit 23**) follows the same pattern as annual costs in Exhibit 22. Maryland, Pennsylvania, and Virginia account for almost 90% of watershed costs across all tier scenarios. Maryland costs are highest in Tier 1, followed by Virginia and Pennsylvania. Tier 2 and Tier 3 capital costs in Virginia are highest, followed by Maryland and Pennsylvania. These costs include the portion that will be funded through federal and state cost-share programs as well as costs that will be paid by businesses and households in the watershed. Similar to annual costs, they are the cumulative costs of implementing each tier scenario.



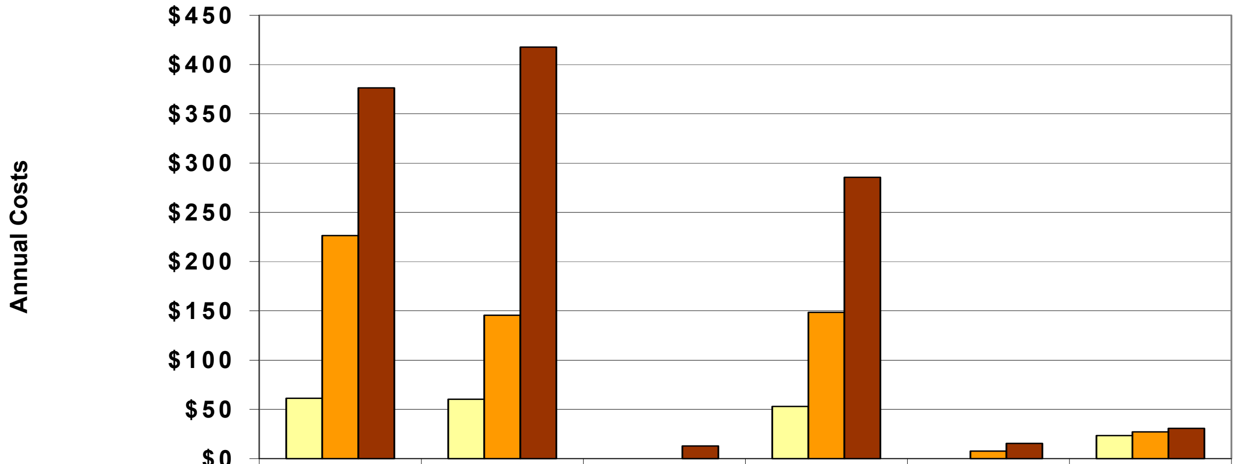
	DE	DC	MD	NY	PA	VA	WV
Tier 1 ($1,442)	$21	$133	$592	$20	$258	$382	$35
Tier 2 ($3,644)	$36	$170	$860	$175	$899	$1,387	$116
Tier 3 ($7,975)	$60	$368	$2,069	$405	$1,940	$2,901	$232

Exhibit 23: Total Cumulative Capital Costs by State and Tier (millions of 2001$)

Note: Costs for Blue Plains WWTF are apportioned to DC, MD and VA according to the method recommended by MWCOG (2002).

3.1.2 Cost Distribution by Sector

In **Exhibit 24**, annual costs by sector (aggregated across states) show that the agriculture, POTW, and urban (plus mixed open) sectors account for the vast majority of costs across all tiers. The agriculture and urban sectors account for the highest share of Tier 1 costs, followed by POTW costs. In Tier 2, agricultural costs dominate total costs (41%) followed by POTW costs (27%) and urban costs (26%), but the urban sector contributes the highest share of costs in Tier 3 (37%) followed by agricultural costs (33%). Growth in agricultural costs is relatively steady–increasing by approximately $165 million from Tier 1 to Tier 2 and by $150 million from Tier 2 to Tier 3. In contrast, POTW and urban costs experience a larger increase between Tiers 2 and 3. For urban costs, the greater increase from Tier 2 to Tier 3 compared to the increase from Tier 1 to Tier 2 is attributable to the increase in implementation of storm water retrofits.

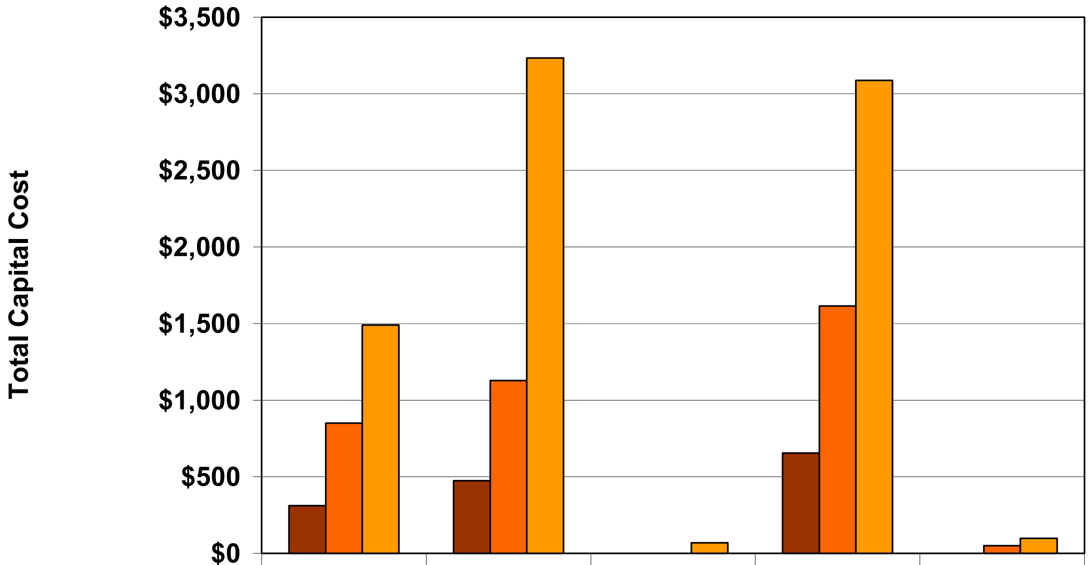


	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Forest
Tier 1 ($198)	$61	$60	$0	$53	$0	$23
Tier 2 ($555)	$226	$146	$0	$148	$8	$27
Tier 3 ($1,139)	$376	$418	$13	$286	$15	$31

Exhibit 24: Total Annual Cumulative Costs by Sector and Tier (millions of 2001$)

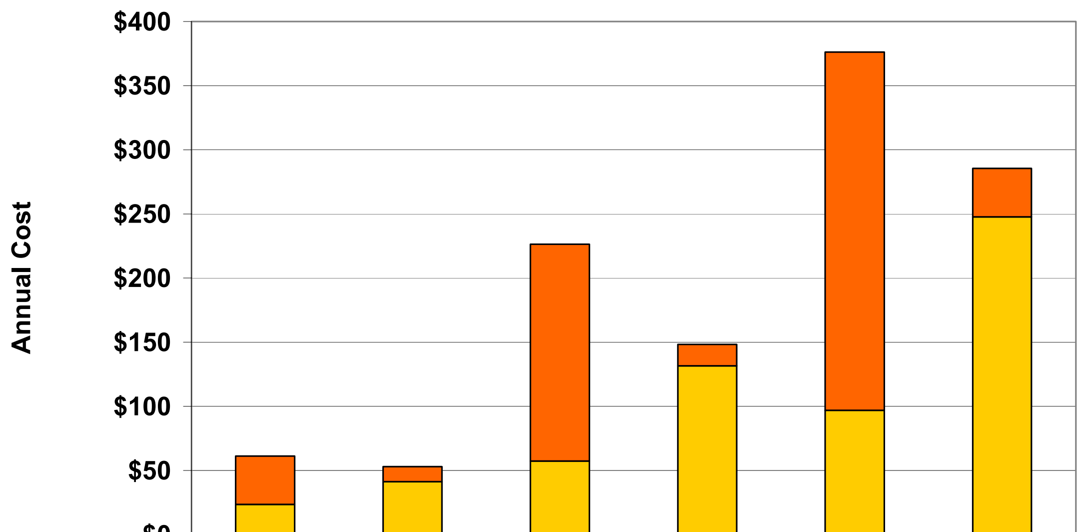
Exhibit 25 shows the breakdown of total capital costs by sector. The distribution of capital costs across sectors differs somewhat from the annual cost distribution. POTW costs account for the largest share of capital costs in Tiers 1 and 2 (45% in Tier 1 and 44% in Tier 2), followed by urban and agricultural costs. In Tier 3, urban costs account for the largest share (41%) followed by POTW and agricultural costs.

Exhibit 26 provides a comparison of estimated federal/state and local (i.e., farmer or household) annual costs for the POTW and agricultural sectors, under the cost-share assumptions described previously. The height of each bar shows the total annual cost for each of the two sectors. Each bar also shows the estimated distribution of costs between federal and state cost share programs and private farm businesses (in the case of agricultural costs) or local households (in the case of POTW costs). In the agricultural sector, federal and state cost share programs contribute a majority of the total costs for each tier (61% in Tier 1, 75% in Tier 2, and 74% in Tier 3). In the POTW sector, estimated federal and state cost sharing is lower (22% in Tier 1, 11% in Tier 2, and 13% in Tier 3) because cost sharing is only applied to facilities serving populations in Maryland and Virginia. The estimated federal and state contribution is higher in Tier 1 because the largest share of annual costs for POTWs is for facilities serving populations in Maryland, and a greater proportion of costs are shared for Maryland POTWs. In Tiers 2 and 3, a larger share of POTW costs are for facilities serving populations in other states and the District of Columbia.



	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial
Tier 1 ($1,442)	$312	$475	$0	$655	$0
Tier 2 ($3,644)	$850	$1,128	$0	$1,615	$51
Tier 3 ($7,975)	$1,490	$3,233	$68	$3,087	$98

Exhibit 25: Total Cumulative Capital Costs by Sector and Tier (millions of 2001$)



	Tier 1		Tier 2		Tier 3	
	Agriculture	POTW	Agriculture	POTW	Agriculture	POTW
Total	$61	$53	$226	$148	$376	$286
Fed./State	$38	$12	$169	$17	$279	$38
Local	$24	$41	$57	$132	$97	$248

Exhibit 26: Estimated Distribution of Annual Costs for Agriculture and POTW Sectors (millions of 2001$)

3.1.3 Cost Distribution by State and Sector

This section provides the state-level cost breakdowns for each sector. Similar to earlier sections, the annual and capital cost estimates represent cumulative costs for each tier scenario and include both state and federal cost-share amounts as well as estimated costs for private businesses and households.

3.1.3.1 POTW and Industrial Source Costs

Costs for nutrient reduction technologies among POTW and industrial sources include capital expenditures and annual O&M costs. There are no industrial control costs in Tier 1. Tiers 2 and 3 include industrial controls, but POTW control costs account for more than 90% of annual costs. Total annual costs of $156 million for Tier 2 include $148 million for POTWs and $8 million for industrial facilities. Similarly, annual Tier 3 costs of $301 million include $286 million for POTWs and $15 million for industrial facilities.

Exhibit 27 shows the breakdown of POTW costs by state. These results show the largest share of Tier 1 costs occur in Maryland, and the largest share of Tier 2 and Tier 3 costs occur in Virginia and Pennsylvania. These results show how planned (Tier 1) NRT implementation costs vary across these states. Maryland is planning expenditures of $29.5 million annually under Tier 1, which accounts for 81% of cumulative costs under Tier 2 and 35% of cumulative costs under Tier 3. In contrast, Pennsylvania's Tier 1 costs are $6.5 million, which accounts for 20% of cumulative Tier 2 costs and 11% of cumulative Tier 3 costs. Virginia's Tier 1 costs are $8.7 million, which equals 15% of cumulative Tier 2 costs and 9% of Tier 3 costs.

Exhibit 27: Summary of Total Cumulative Annual and Capital POTW Costs[1]
(millions of 2001 dollars)

Jurisdiction	Annual Costs			Capital Costs		
	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3
Delaware	$0.2	$0.6	$0.8	$3.2	$5.8	$9.0
District of Columbia	$8.3	$14.1	$25.7	$130.0	$154.3	$303.5
Maryland	$29.5	$36.2	$85.2	$356.0	$393.0	$981.6
New York	$0.0	$6.2	$10.2	$0.0	$65.2	$105.8
Pennsylvania	$6.5	$31.8	$60.0	$72.1	$352.0	$670.7
Virginia	$8.7	$57.9	$101.3	$93.9	$623.6	$984.8
West Virginia	$0.0	$1.7	$2.4	$0.0	$21.3	$31.5
Total	$53.1	$148.3	$285.5	$655.2	$1,615.1	$3,086.9

Detail may not add to total because of independent rounding. Costs for the Blue Plains WWTF are apportioned to DC, MD, and VA according to the method recommended by MWCOG (2002).

1. Includes federal and state cost shares equal to 10% of capital costs for VA, 50% of capital costs for MD, and 0% for remaining jurisdictions.

Total capital costs for POTWs and industrial dischargers are $0.7 billion for Tier 1, $1.7 billion for Tier 2, and $3.2 billion for Tier 3. This includes costs paid by households in the watershed as well as costs paid by federal and state cost-share programs. Similar to annual costs, POTW accounts for more than 90% of these costs in each tier. The distribution of POTW capital costs across states, shown in Exhibit 27, mimics the distribution of annual costs.

3.1.3.2 Agriculture Costs

The total annual costs in **Exhibit 28** include those paid by farmers and those paid by cost-share programs. Based on current implementation shares, the cost-share programs would account for approximately 75% of annual costs in Tiers 2 and 3; farmers would incur the remaining 25% of annual costs. Cost-share programs account for a smaller share of annual Tier 1 costs (60%) because BMPs with lower cost-shares such as animal waste management systems account for a larger portion of annual costs.

Exhibit 28: Summary of Total Cumulative Annual and Capital Agricultural Costs[1] (millions of 2001 dollars)

Jurisdiction	Annual Cost			Capital Cost		
	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3
Delaware	$2.2	$6.3	$9.4	$14.4	$22.3	$31.6
District of Columbia	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Maryland	$8.3	$33.8	$49.6	$49.6	$88.9	$128.3
New York	$1.8	$14.7	$28.3	$7.5	$61.9	$127.5
Pennsylvania	$22.2	$90.9	$146.6	$110.7	$313.5	$527.6
Virginia	$21.6	$67.8	$118.3	$102.1	$293.1	$539.6
West Virginia	$5.1	$12.7	$24.2	$27.9	$70.6	$135.2
Total	$61.3	$226.3	$376.3	$312.2	$850.4	$1,489.9

Detail may not add to total because of independent rounding.

1. Based on current cost share program information, federal and state cost-share programs would account for approximately 60% of annual costs in Tier 1 and 75% of costs in Tiers 2 and 3.

Annual costs are highest in Pennsylvania for all tier scenarios. Virginia has the second highest share of costs in all scenarios, followed by Maryland. Together, Pennsylvania and Virginia account for 70% of annual agricultural costs.

Total capital costs in the agricultural sector are $312 million for Tier 1, $850 million for Tier 2, and $1.5 billion for Tier 3. The distribution of capital costs across states (Exhibit 28) is similar to the annual cost distribution.

3.1.3.3 Forestry Costs

Annual costs to implement forest harvesting best management practices range from $23.5 million in Tier 1 to $30.8 million in Tier 3. Thus, baseline implementation in Tier 1 accounts for most of the costs in this sector. **Exhibit 29** provides annual cost estimates by tier scenario. This sector has the smallest share of annual costs in all tier scenarios because implementation acre estimates are small. All costs are annual because practices are assumed to be implemented on different harvest acres each year.

Exhibit 29: Summary of Cumulative Annual Forest Harvest Costs (millions of 2001 dollars)

Jurisdiction	Tier 1	Tier 2	Tier 3
Delaware	<$0.1	<$0.1	$0.1
District of Columbia	$0.0	$0.0	$0.0
Maryland	$1.6	$1.8	$2.0
New York	$3.6	$4.1	$4.5
Pennsylvania	$13.9	$15.6	$17.4
Virginia	$3.0	$4.1	$5.1
West Virginia	$1.3	$1.5	$1.7
Total	$23.5	$27.1	$30.8

Detail may not equal total because of independent rounding.

3.1.3.4 Urban BMP Costs

Exhibit 30 provides annual costs by tier and jurisdiction for urban areas. These costs are for stormwater BMPs and exclude POTW costs. Tier 1 costs are highest in Maryland and Virginia, with each accounting for 40% of annual Tier 1 costs. Maryland's share of costs declines in Tier 2 (32%) and Tier 3 (29%) while shares for other states, except Delaware, increase across the scenarios. This is indicative of Maryland's higher baseline BMP implementation rate compared to most other states. Virginia's share of total annual costs is 41% for Tiers 2 and 3. Pennsylvania's share of total annual costs increases from 15% in Tier 1 to 21% in Tier 3.

Stormwater retrofits account for over 90% of annual urban costs in all tier scenarios. Although the total number of retrofit acres is small (e.g., less than 0.4% of watershed acres in Tier 2 and 1.8% in Tier 3), the per-acre cost is high compared to other sectors. Nevertheless, the average cost per household for the 4.9 million urban households in the watershed by 2010 is expected to be small, ranging from $12 in Tier 1 to $85 in Tier 3. These estimates assume that all costs are borne by urban households. However, federal and state cost share funds or other cost-saving opportunities might reduce these costs.

Total capital costs are $0.5 billion for Tier 1, $1.1 billion for Tier 2 and $3.2 billion for Tier 3. Exhibit 30 shows that the distribution of capital costs across states is similar to the distribution of annual costs.

Exhibit 30: Summary of Cumulative Annual Urban Costs (millions of 2001 dollars)

Jurisdiction	Annual Cost			Capital Cost		
	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3
Delaware	$0.5	$1.0	$2.4	$3.6	$7.4	$18.3
District of Columbia	$0.3	$2.1	$8.3	$2.6	$16.1	$64.4
Maryland	$23.8	$47.3	$119.5	$186.3	$365.7	$924.1
New York	$1.7	$6.4	$21.6	$13.0	$48.4	$165.8
Pennsylvania	$8.8	$27.0	$87.7	$75.7	$215.1	$684.7
Virginia	$24.1	$59.3	$170.5	$186.4	$455.7	$1,317.6
West Virginia	$0.9	$2.5	$7.5	$6.8	$19.1	$57.8
Total	$60.2	$145.5	$417.6	$474.5	$1,127.6	$3,232.7

Detail may not add to total because of independent rounding.

3.1.3.5 Onsite Waste Management System Costs

OSWMS costs for Tiers 1 and 2 are zero, and costs are minimal for Tier 3 because only 1% of existing systems implement the control. The annual cost for Tier 3 is $13 million and total capital costs equal $68 million. Maryland, Pennsylvania, and Virginia account for most of the costs in the sector. The average annual cost per household implementing the BMP is $1,020.

The cost for new homes is not included because it will be rolled up in the overall cost of a home, and developers have an opportunity to offset incremental OSWMS costs with savings in other construction costs. Furthermore, new homes built in developments can use multi-home systems with lower average per-home costs. The cost for new homes implied by the single system annual unit cost is $8 million in Tier 2 and $82 million in Tier 3.

3.1.3.6 Summary

Exhibit 31 summarizes the annual cost breakdowns by state and sector. The height of each bar shows the magnitude of total annual costs for each state and tier scenario. The height of sections within each bar shows the distribution of costs among the sectors for individual states and tiers. Exhibit 31 is similar to Exhibit 22, but it also shows the relative importance of each sector within state-level costs. For example, the POTW and urban sectors dominate costs for the District of Columbia; onsite system costs are very small in comparison (and agricultural, industrial, and forestry costs are zero). Agricultural costs tend to contribute the largest portion of costs in Delaware, Pennsylvania, and West Virginia. Conversely, POTW and urban sector costs tend to dominate annual costs in Maryland and Virginia. In New York, agricultural sector costs tend to be approximately equal to the sum of POTW and urban sector costs.

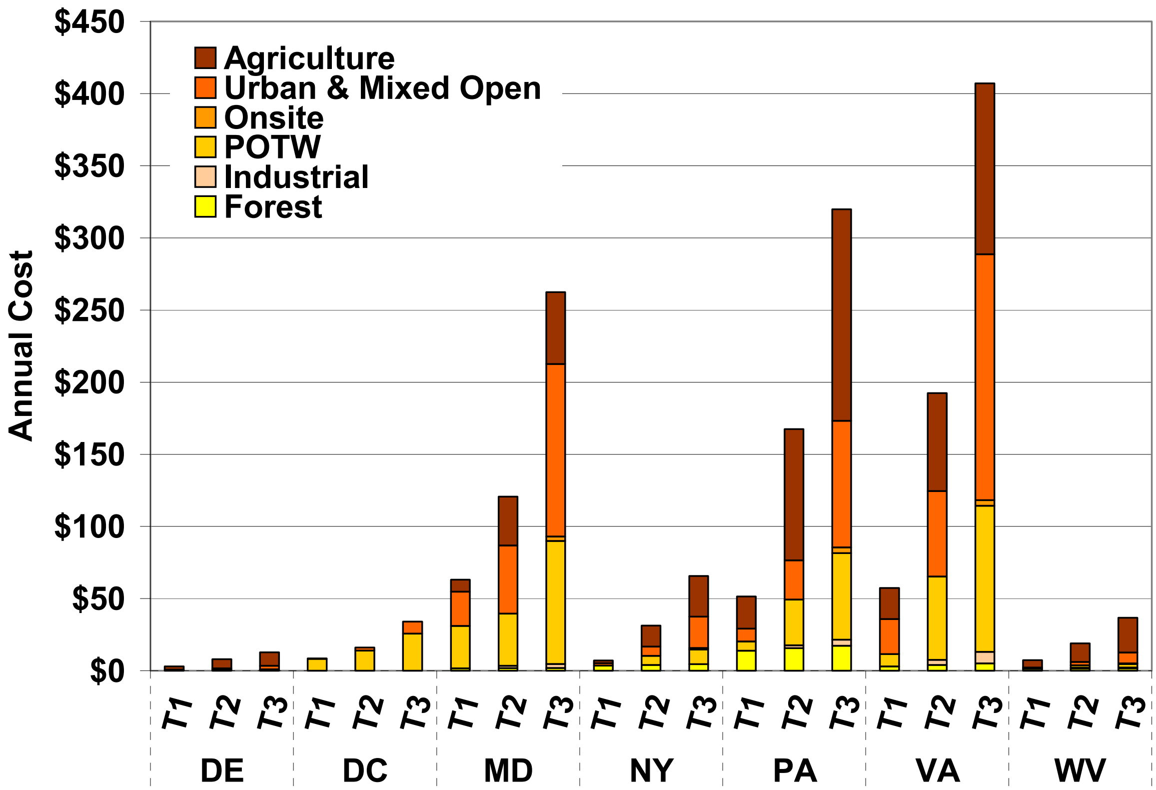


Exhibit 31: Total Annual Costs by State, Sector, and Tier (millions of 2001$)

Note: Costs for the Blue Plains WWTF are apportioned to DC, MD and VA according to the method recommended by MWCOG (2002).

Exhibit 31 also shows the relative importance of each state within sector-level costs. For example, among all the states and the District of Columbia, Pennsylvania has the highest share of agricultural and forestry costs, while urban and POTW costs are highest in Maryland and Virginia.

Within each state, the exhibit also shows which sectors contribute most to the increase in costs across the tier scenarios. For example, in Delaware and West Virginia, growth in agricultural costs dominates increases in overall costs from Tier 1 to Tier 3. In New York and Pennsylvania, growth in agricultural and urban costs contribute most to cost increases across the tier scenarios. Three sectors–agriculture, urban, and POTW–contribute roughly evenly to growth in costs for Maryland and Virginia.

A similar summary for capital costs is in **Exhibit 32**. The main difference between this chart and Exhibit 31 is that the agricultural sector's share of capital costs is much smaller. Therefore, urban and POTW capital costs tend to dominate most cost distributions. Finally, the forestry sector is not included in Exhibit 32 because there are no capital costs for that sector.

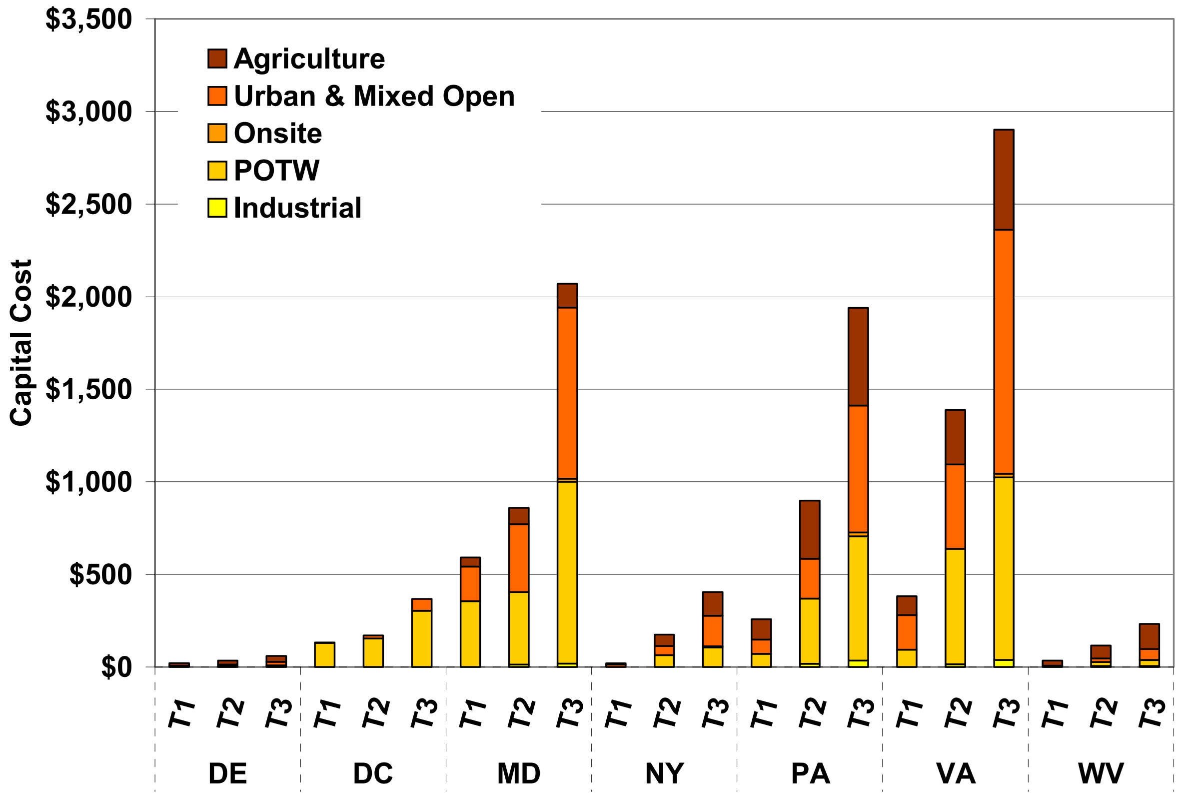


Exhibit 32: Total Capital Costs by State, Sector, and Tier (millions of 2001$)

Note: Costs for the Blue Plains WWTF are apportioned to DC, MD, and VA according to the method recommended by MWCOG (2002)

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3.1.4 Cost Distribution by State Basin

An annual cost summary by state basin (**Exhibits 33** through **35**) provides location as well as sector detail within each state.

For Tier 1, the Susquehanna and Potomac Basins each account for approximately 30% of total annual costs, which include state and federal cost shares as well as costs to private businesses and households. The Maryland West Shore accounts for 12% of total annual costs, while the James Basin accounts for 11% of total annual costs; the remaining watersheds incur 8% or less of total annual costs. The agricultural and forestry sectors dominate Tier 1 costs in the Susquehanna Basin, while agricultural and urban sector costs are highest in the Potomac Basin.

Exhibit 33: Annual Costs by State Basin for Tier 1 (millions of 2001 $)

Statebasin	Agriculture	Urban and Mixed Open	Onsite Systems	POTW	Industrial	Forest	Subtotal	Federal/ State – Agriculture[1]	Federal/ State – POTW[2]
MD-Susquehanna	0.01	0.84	0.00	0.00	0.00	0.04	0.89	0.18	0.00
NY-Susquehanna	0.62	1.68	0.00	0.00	0.00	3.64	5.94	1.19	0.00
PA-Susquehanna	8.38	8.30	0.00	5.95	0.00	12.97	35.60	11.75	0.00
Susquehanna	9.01	10.82	0.00	5.95	0.00	16.64	42.43	13.12	0
DC-Potomac	0.00	0.33	0.00	8.26	0.00	0.00	8.59	0.00	0.00
MD-Potomac	1.55	9.07	0.00	3.21	0.00	0.51	14.34	3.47	1.98
PA-Potomac	0.73	0.50	0.00	0.54	0.00	0.89	2.66	1.30	0.00
VA-Potomac	4.83	9.20	0.00	1.54	0.00	-0.35	15.22	4.93	0.13
WV-Potomac	2.38	0.89	0.00	0.00	0.00	1.32	4.58	2.71	0.00
Potomac	9.48	19.99	0.00	13.54	0.00	2.38	45.39	12.41	2.11
MD-W. Shore MD	0.01	6.24	0.00	10.71	0.00	0.15	17.12	0.44	6.48
PA-W. Shore MD	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
W. Shore MD	0.02	6.24	0.00	10.71	0.00	0.15	17.13	0.45	6.48
DE-E. Shore MD	0.71	0.48	0.00	0.24	0.00	0.01	1.44	1.54	0.00
MD-E. Shore MD	-0.11	2.47	0.00	4.46	0.00	0.79	7.61	2.77	2.63
PA-E. Shore MD	0.03	0.01	0.00	0.00	0.00	0.01	0.06	0.05	0.00
VA-E. Shore MD	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00
E. Shore MD	0.66	2.97	0.00	4.70	0.00	0.82	9.14	4.38	2.63
MD-Patuxent	-0.11	5.18	0.00	0.00	0.00	0.10	5.17	0.05	0.00
Patuxent	-0.11	5.18	0.00	0.00	0.00	0.10	5.17	0.05	0.00

Exhibit 33: Annual Costs by State Basin for Tier 1 (millions of 2001 $)

Statebasin	Agriculture	Urban and Mixed Open	Onsite Systems	POTW	Industrial	Forest	Subtotal	Federal/ State – Agriculture[1]	Federal/ State – POTW[2]
VA-Rappahannock	1.04	1.82	0.00	1.07	0.00	0.45	4.38	1.73	0.09
Rappahannock	1.04	1.82	0.00	1.07	0.00	0.45	4.38	1.73	0.09
VA-York	0.83	1.90	0.00	1.76	0.00	1.19	5.67	1.78	0.17
York	0.83	1.90	0.00	1.76	0.00	1.19	5.67	1.78	0.17
VA-James	2.48	11.17	0.00	3.60	0.00	1.74	18.99	3.39	0.29
WV-James	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.00
James	2.49	11.17	0.00	3.60	0.00	1.75	19.01	3.41	0.29
VA-E. Shore VA	0.23	0.05	0.00	0.00	0.00	-0.01	0.27	0.29	0.00
E. Shore VA	0.23	0.05	0.00	0.00	0.00	-0.01	0.27	0.29	0.00
Total	**23.64**	**60.15**	**0.00**	**41.34**	**0.00**	**23.47**	**148.60**	**37.61**	**11.78**

Detail may not add to total because of independent rounding. Costs for the Blue Plains WWTF are allocated to DC-Potomac, MD-Potomac, and VA-Potomac according to the method recommended by MWCOG (2002).

1. Includes several programs for installation and other cost-sharing.
2. POTW capital costs are shared at 50% for MD facilities, at 10% for VA facilities, and at zero for other states and the District of Columbia.

Exhibit 34: Annual Costs by State Basin for Tier 2 (millions of 2001 $)

Statebasin	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Forest	Subtotal	Federal/ State - Agriculture[1]	Federal/ State - POTW[2]
MD-Susquehanna	0.04	1.04	0.00	0.00	0.00	0.04	1.12	1.05	0.00
NY-Susquehanna	3.71	6.36	0.00	6.24	0.00	4.09	20.39	10.96	0.00
PA-Susquehanna	20.39	25.52	0.00	30.19	2.04	14.59	92.73	60.82	0.00
Susquehanna	24.13	32.91	0.00	36.42	2.04	18.73	114.23	72.84	0.00
DC-Potomac	0.00	2.10	0.00	14.07	0.00	0.00	16.17	0.00	0.00
MD-Potomac	1.80	17.70	0.00	7.91	0.83	0.57	28.82	10.87	2.79
PA-Potomac	2.24	1.44	0.00	1.60	0.00	1.00	6.28	6.87	0.00
VA-Potomac	9.10	22.82	0.00	8.12	1.04	-0.22	40.86	14.85	0.51
WV-Potomac	5.01	2.50	0.00	1.67	0.56	1.48	11.22	7.64	0.00
Potomac	18.15	46.56	0.00	33.37	2.43	2.84	103.35	40.23	3.31
MD-W. Shore MD	0.13	14.68	0.00	11.21	0.00	0.17	26.18	2.66	6.80
PA-W. Shore MD	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.07	0.00
W. Shore MD	0.15	14.68	0.00	11.21	0.00	0.17	26.21	2.73	6.80
DE-E. Shore MD	1.43	0.99	0.00	0.55	0.00	0.04	3.01	4.91	0.00
MD-E. Shore MD	0.08	4.90	0.00	4.78	0.00	0.89	10.65	16.35	2.68
PA-E. Shore MD	0.12	0.07	0.00	0.00	0.00	0.02	0.20	0.41	0.00
VA-E. Shore MD	0.05	0.01	0.00	0.00	0.00	0.00	0.06	0.16	0.00
E. Shore MD	1.67	5.98	0.00	5.34	0.00	0.95	13.93	21.82	2.68
MD-Patuxent	-0.09	8.96	0.00	0.01	0.81	0.12	9.81	0.90	0.00
Patuxent	-0.09	8.96	0.00	0.01	0.81	0.12	9.81	0.90	0.00

Exhibit 34: Annual Costs by State Basin for Tier 2 (millions of 2001 $)

Statebasin	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Forest	Subtotal	Federal/ State - Agriculture[1]	Federal/ State - POTW[2]
VA-Rappahannock	2.94	4.02	0.00	2.72	0.00	0.59	10.26	7.28	0.22
Rappahannock	2.94	4.02	0.00	2.72	0.00	0.59	10.26	7.28	0.22
VA-York	1.97	4.24	0.00	3.02	0.04	1.43	10.69	5.68	0.26
York	1.97	4.24	0.00	3.02	0.04	1.43	10.69	5.68	0.26
VA-James	7.98	27.91	0.00	38.87	2.18	2.29	79.23	15.45	3.50
WV-James	0.03	0.00	0.00	0.00	0.00	0.01	0.05	0.05	0.00
James	8.01	27.91	0.00	38.87	2.18	2.30	79.28	15.5	3.50
VA-E. Shore VA	0.41	0.26	0.00	0.59	0.15	-0.01	1.41	2.01	0.05
E. Shore VA	0.41	0.26	0.00	0.59	0.15	-0.01	1.41	2.01	0.05
Total	**57.34**	**145.52**	**0.00**	**131.54**	**7.65**	**27.11**	**369.17**	**168.98**	**16.81**

Detail may not add to total because of independent rounding. Costs for the Blue Plains WWTF are allocated to DC-Potomac, MD-Potomac, and VA-Potomac according to the method recommended by MWCOG (2002).

1. Includes several programs for installation and other cost-sharing.
2. POTW capital costs are shared at 50% for MD facilities, at 10% for VA facilities, and at zero for other states and the District of Columbia.

Exhibit 35: Annual Costs by State Basin for Tier 3 (millions of 2001 $)

Statebasin	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Forest	Subtotal	Federal/ State - Agriculture[1]	Federal/ State - POTW[2]
MD-Susquehanna	0.06	1.34	0.11	0.07	0.00	0.05	1.63	1.61	0.05
NY-Susquehanna	7.96	21.58	1.13	10.18	0.00	4.54	45.40	20.31	0.00
PA-Susquehanna	32.07	82.91	3.82	57.68	4.14	16.22	196.83	98.56	0.00
Susquehanna	40.08	105.83	5.07	67.93	4.14	20.81	243.86	120.48	0.05
DC-Potomac	0.00	8.35	0.03	25.71	0.00	0.00	34.09	0.00	0.00
MD-Potomac	1.94	44.23	1.02	18.27	1.76	0.64	67.86	15.58	9.59
PA-Potomac	3.89	4.49	0.24	2.28	0.00	1.12	12.02	11.08	0.00
VA-Potomac	13.61	66.52	1.27	21.39	1.24	-0.09	103.94	25.89	1.57
WV-Potomac	9.80	7.50	0.38	2.42	0.61	1.65	22.36	14.21	0.00
Potomac	29.24	131.09	2.94	70.07	3.62	3.31	240.27	66.76	11.16
MD-W. Shore MD	0.20	41.93	1.06	28.01	0.05	0.19	71.43	4.11	16.47
PA-W. Shore MD	0.03	0.02	0.00	0.00	0.00	0.00	0.06	0.10	0.00
W. Shore MD	0.23	41.95	1.06	28.01	0.05	0.19	71.49	4.22	16.47
DE-E. Shore MD	2.09	2.39	0.18	0.79	0.00	0.07	5.52	7.31	0.00
MD-E. Shore MD	0.15	12.14	0.61	6.62	0.00	0.99	20.51	24.58	3.76
PA-E. Shore MD	0.19	0.27	0.04	0.00	0.00	0.02	0.52	0.66	0.00
VA-E. Shore MD	0.06	0.05	0.00	0.00	0.00	0.00	0.11	0.23	0.00
E. Shore MD	2.49	14.85	0.83	7.41	0.00	1.08	26.66	32.78	3.76
MD-Patuxent	-0.07	19.91	0.44	1.54	0.87	0.13	22.81	1.45	0.84
Patuxent	-0.07	19.91	0.44	1.54	0.87	0.13	22.81	1.45	0.84

Exhibit 35: Annual Costs by State Basin for Tier 3 (millions of 2001 $)

Statebasin	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Forest	Subtotal	Federal/ State - Agriculture[1]	Federal/ State - POTW[2]
VA-Rappahannock	5.27	10.79	0.44	4.92	0.00	0.72	22.15	12.51	0.41
Rappahannock	5.27	10.79	0.44	4.92	0.00	0.72	22.15	12.51	0.41
VA-York	3.19	11.48	0.58	4.30	0.14	1.67	21.36	9.26	0.35
York	3.19	11.48	0.58	4.30	0.14	1.67	21.36	9.26	0.35
VA-James	15.86	80.69	1.6	62.82	6.30	2.84	170.10	28.85	4.76
WV-James	0.07	0.01	0.00	0.00	0.00	0.01	0.09	0.10	0.00
James	15.93	80.71	1.6	62.82	6.30	2.85	170.20	28.94	4.76
VA-E. Shore VA	0.54	0.96	0.06	0.68	0.25	0.00	2.49	2.97	0.06
E. Shore VA	0.54	0.96	0.06	0.68	0.25	0.00	2.49	2.97	0.06
Total	**96.91**	**417.57**	**13.03**	**247.67**	**15.35**	**30.75**	**821.28**	**279.37**	**37.86**

Detail may not add to total because of independent rounding. Costs for the Blue Plains WWTF are allocated to DC-Potomac, MD-Potomac, and VA-Potomac according to the method recommended by MWCOG (2002).

1. Includes several programs for installation and other cost-sharing.
2. POTW capital costs are shared at 50% for MD facilities, at 10% for VA facilities, and at zero for other states and the District of Columbia.

In Tier 2, the Susquehanna Basin's share of total annual costs increases to 34%, and the Potomac Basin's share declines slightly to 26%. The James Basin accounts for 18% of total annual costs, and for 29% of total POTW costs. Costs for the Maryland West Shore decline from 12% to 6% of total annual costs, demonstrating the effect of Maryland's relatively high Tier 1 expenditures, particularly on POTW controls. The Susquehanna Basin has 43% of total agricultural sector costs; the Potomac Basin's share is much smaller–26% of total sector costs. The Susquehanna and Potomac Basins each have 25% of the total POTW costs.

The distribution of costs for Tier 3 is similar to Tier 2. The Susquehanna Basin retains the highest share—32%—with costs dominated by agricultural costs. The Potomac Basin has the second highest share of total annual costs (28%), and the James Basin the third highest share (18%). The Potomac Basin has 31% of urban sector costs throughout the Chesapeake Bay watershed, and the James Basin has 19%. These two watersheds also have high POTW costs—the Potomac Basin has 28% of total POTW costs and the James has 24%.

Exhibits 36 through **38** provide a summary of capital costs by state basin and basin as well as sector detail, similar to Exhibits 33 through 35. There are no capital costs for the forestry BMP and, therefore, this sector is not shown. The distribution of capital costs is similar to the distribution of annual costs, with some exceptions. In Tier 1, the Potomac contributes 34% of total capital costs while the Susquehanna and Maryland West Shore Basins each contribute 18%. The James contributes 11% and the Maryland East Shore contributes 10%; all other basins have less than 5% of the capital costs. POTW capital costs dominate Tier 1 costs in the Potomac and the Maryland East and West Shore Basins, while agricultural capital costs contribute most to Tier 1 costs in the Susquehanna Basin.

In Tier 2, the Susquehanna Basin's share of total capital costs rises to 28%, while the Potomac's share drops to 27%. The James Basin contributes 22% of total capital costs, and the other basins all have less than 10% each. The Susquehanna has the highest share of agricultural costs (40%), the Potomac has the highest share of urban costs (32%), and the James contributes most to POTW capital costs (30%).

In Tier 3, the Potomac Basin once again has the highest share of total capital costs at 30%. The Susquehanna contributes 28%, the James Basin contributes 19%, the Maryland West Shore has 11%, and the remaining basins contribute less than 5% each. The Potomac has the greatest share of urban costs (31%) and POTW costs (29%), reflecting the relatively high implementation of urban storm water retrofits in the Potomac watershed. The Susquehanna contributes the highest share of agricultural capital costs (40%), which reflects the large agricultural sector in the Susquehanna watershed.

3.2 Detailed Cost Estimates

Exhibit 39 shows the BMP costs for each state for Tiers 1–3, calculated by multiplying the acres shown in Exhibit 4 and the unit costs shown in Exhibit 16 (note that the acres shown in Exhibit 4 are rounded). Negative total costs indicate a reduction in BMP acres compared to the Progress 2000 Scenario because of a change from agriculture to another land use. Negative farmer costs indicate a cost savings (i.e., that estimated state and federal contributions exceed the cost of the BMP). Capital cost-sharing does not exceed 100% of capital costs, since none of the identified cost-share programs permit this, but the sum of upfront capital cost-share, incentive payments, *and* annual maintenance payments exceeds the annual cost of the BMP when farmer costs are negative.

Exhibit 36: Capital Costs by State Basin for Tier 1 (millions of 2001 $)

Statebasin	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Total
MD-Susquehanna	1.23	6.52	0.00	0.00	0.00	7.75
NY-Susquehanna	7.47	13.00	0.00	0.00	0.00	20.48
PA-Susquehanna	99.55	71.35	0.00	65.68	0.00	236.58
Susquehanna	108.26	90.87	0.00	65.68	0.00	264.80
DC-Potomac	0.00	2.58	0.00	130.00	0.00	132.58
MD-Potomac	31.76	71.01	0.00	63.64	0.00	166.40
PA-Potomac	10.62	4.26	0.00	6.40	0.00	21.28
VA-Potomac	41.93	70.89	0.00	17.96	0.00	130.79
WV-Potomac	27.76	6.84	0.00	0.00	0.00	34.60
Potomac	112.07	155.59	0.00	218.00	0.00	485.65
MD-W. Shore MD	3.28	48.86	0.00	208.00	0.00	260.14
PA-W. Shore MD	0.09	0.01	0.00	0.00	0.00	0.10
W. Shore MD	3.37	48.87	0.00	208.00	0.00	260.24
DE-E. Shore MD	14.42	3.58	0.00	3.19	0.00	21.18
MD-E. Shore MD	13.39	19.11	0.00	84.35	0.00	116.85
PA-E. Shore MD	0.42	0.12	0.00	0.00	0.00	0.54
VA-E. Shore MD	0.39	0.02	0.00	0.00	0.00	0.41
E. Shore MD	28.61	22.83	0.00	87.54	0.00	138.97
MD-Patuxent	-0.03	40.83	0.00	0.00	0.00	40.79
Patuxent	-0.03	40.83	0.00	0.00	0.00	40.79
VA-Rappahannock	14.95	14.08	0.00	12.58	0.00	41.62
Rappahannock	14.95	14.08	0.00	12.58	0.00	41.62
VA-York	12.85	14.65	0.00	23.16	0.00	50.66
York	12.85	14.65	0.00	23.16	0.00	50.66
VA-James	28.66	86.38	0.00	40.25	0.00	155.28
WV-James	0.17	0.00	0.00	0.00	0.00	0.17
James	28.82	86.38	0.00	40.25	0.00	155.45
VA-E. Shore VA	3.33	0.41	0.00	0.00	0.00	3.74
E. Shore VA	3.33	0.41	0.00	0.00	0.00	3.74
Total	**312.23**	**474.50**	**0.00**	**655.20**	**0.00**	**1,441.93**

Detail may not add to total because of independent rounding. Costs for the Blue Plains WWTF are allocated to DC-Potomac, MD-Potomac, and VA-Potomac according to the method recommended by MWCOG (2002).

Exhibit 37: Capital Costs by State Basin for Tier 2 (millions of 2001 $)

Statebasin	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Total
MD-Susquehanna	2.08	8.01	0.00	0.00	0.00	10.10
NY-Susquehanna	61.95	48.37	0.00	65.16	0.00	175.48
PA-Susquehanna	279.08	203.10	0.00	334.65	18.12	834.96
Susquehanna	343.11	259.49	0.00	399.81	18.12	1,020.53
DC-Potomac	0.00	16.14	0.00	154.26	0.00	170.40
MD-Potomac	46.56	136.87	0.00	89.14	5.00	277.56
PA-Potomac	32.36	11.41	0.00	17.37	0.00	61.13
VA-Potomac	102.41	175.10	0.00	71.04	9.29	357.85
WV-Potomac	70.17	19.11	0.00	21.30	5.29	115.86
Potomac	251.50	358.63	0.00	353.10	19.58	982.81
MD-W. Shore MD	6.54	113.57	0.00	218.00	0.00	338.12
PA-W. Shore MD	0.23	0.05	0.00	0.00	0.00	0.28
W. Shore MD	6.77	113.62	0.00	218.00	0.00	338.39
DE-E. Shore MD	22.29	7.40	0.00	5.82	0.00	35.51
MD-E. Shore MD	32.42	37.65	0.00	85.86	0.00	155.93
PA-E. Shore MD	1.82	0.56	0.00	0.00	0.00	2.38
VA-E. Shore MD	0.67	0.10	0.00	0.00	0.00	0.77
E. Shore MD	57.19	45.72	0.00	91.67	0.00	194.58
MD-Patuxent	1.31	69.64	0.00	0.00	7.35	78.30
Patuxent	1.31	69.64	0.00	0.00	7.35	78.30
VA-Rappahannock	42.14	30.72	0.00	30.59	0.00	103.45
Rappahannock	42.14	30.72	0.00	30.59	0.00	103.45
VA-York	29.52	32.56	0.00	35.88	0.00	97.96
York	29.52	32.56	0.00	35.88	0.00	97.96
VA-James	111.50	215.21	0.00	479.32	5.75	811.78
WV-James	0.47	0.02	0.00	0.00	0.00	0.50
James	111.98	215.23	0.00	479.32	5.75	812.28
VA-E. Shore VA	6.85	2.02	0.00	6.75	0.01	15.63
E. Shore VA	6.85	2.02	0.00	6.75	0.01	15.63
Total	**850.38**	**1,127.63**	**0.00**	**1,615.12**	**50.81**	**3,643.93**

Detail may not add to total because of independent rounding. Costs for the Blue Plains WWTF are allocated to DC-Potomac, MD-Potomac, and VA-Potomac according to the method recommended by MWCOG (2002).

Exhibit 38: Capital Costs by State Basin for Tier 3 (millions of 2001 $)

Statebasin	Agriculture	Urban & Mixed Open	Onsite Systems	POTW	Industrial	Total
MD-Susquehanna	3.24	10.28	0.59	1.50	0.00	15.61
NY-Susquehanna	127.49	165.82	5.94	105.76	0.00	405.01
PA-Susquehanna	469.27	647.43	20.07	646.11	35.08	1,817.96
Susquehanna	600.00	823.53	26.60	753.37	35.08	2,238.58
DC-Potomac	0.00	64.40	0.17	303.51	0.00	368.08
MD-Potomac	60.35	341.70	5.37	304.15	10.00	721.58
PA-Potomac	54.92	35.05	1.27	24.61	0.00	115.85
VA-Potomac	182.08	512.67	6.65	219.91	10.76	932.06
WV-Potomac	134.28	57.69	1.98	31.50	5.74	231.19
Potomac	431.64	1,011.51	15.45	883.68	26.49	2,368.77
MD-W. Shore MD	10.16	324.25	5.55	528.46	0.40	868.81
PA-W. Shore MD	0.37	0.17	0.01	0.00	0.00	0.55
W. Shore MD	10.52	324.42	5.56	528.46	0.40	869.36
DE-E. Shore MD	31.60	18.26	0.95	9.00	0.00	59.81
MD-E. Shore MD	51.89	93.70	3.22	120.68	0.00	269.49
PA-E. Shore MD	3.08	2.09	0.19	0.00	0.00	5.37
VA-E. Shore MD	0.87	0.39	0.02	0.00	0.00	1.28
E. Shore MD	87.45	114.44	4.37	129.68	0.00	335.95
MD-Patuxent	2.68	154.19	2.33	26.82	7.84	193.86
Patuxent	2.68	154.19	2.33	26.82	7.84	193.86
VA-Rappahannock	76.35	83.06	2.30	56.39	0.00	218.11
Rappahannock	76.35	83.06	2.30	56.39	0.00	218.11
VA-York	48.86	88.78	3.02	48.67	0.00	189.34
York	48.86	88.78	3.02	48.67	0.00	189.34
VA-James	221.89	625.25	8.39	652.03	27.19	1,534.74
WV-James	0.97	0.08	0.01	0.00	0.00	1.05
James	222.85	625.33	8.39	652.03	27.19	1,535.79
VA-E. Shore VA	9.55	7.46	0.32	7.76	0.63	25.72
E. Shore VA	9.55	7.46	0.32	7.76	0.63	25.72
Total	**1,489.91**	**3,232.72**	**68.35**	**3,086.87**	**97.63**	**7,975.47**

Detail may not add to total because of independent rounding. Costs for the Blue Plains WWTF are allocated to DC-Potomac, MD-Potomac, and VA-Potomac according to the method recommended by MWCOG (2002).

Exhibit 39: Estimated Costs of Tier 1: Delaware (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	234	2,797	234
Grass Buffers	9,605	74,167	9,605
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	79,964	617,844	79,964
Storm Water Management on New Dev.	361,963	2,796,733	361,963
Nutrient Management	31,612	86,086	31,612
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	483,377	3,577,627	483,377

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	650,607	3,304,451	41,375	374,773	57,912	592,695
Grass Buffers	127,076	141,013	0	108,814	-3,088	130,164
Wetland Restoration	39,577	234,091	7,166	17,183	8,104	31,472
Retirement of Highly Erodible Land	0	0	0	0	0	0
Tree Planting	0	0	0	0	0	0
Farm Plans	0	0	0	0	0	0
Cover Crops	0	0	0	0	0	0
Stream Protection w/ Fencing	0	0	0	0	0	0
Stream Protection w/o Fencing	0	0	0	0	0	0
Nutrient Management Plan Implementation[4]	1,167,989	10,602,410	0	0	622,371	545,618
Grazing Land Protection	0	0	0	0	0	0
Animal Waste Management Systems	31,905	137,963	14,038	0	18,505	13,400
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	221,702	0	221,702	0	0	221,702
Conservation Tillage	1,962	0	1,962	0	1,962	0
Total	2,240,817	14,419,927	286,243	500,770	705,766	1,535,051

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	14,685

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	239,875	3,187,400	63,244
Industrial	0	0	0
Total	239,875	3,187,400	63,244

All Sources	Total Annual	Capital	Annual O&M
Total	2,978,754	21,184,954	832,863

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 1: District of Columbia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	60	714	60
Grass Buffers	2,451	18,924	2,451
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	331,687	2,562,806	331,687
Storm Water Management on New Dev.	0	0	0
Nutrient Management	0	0	0
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	334,198	2,582,444	334,198

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	0	0	0	0	0	0
Grass Buffers	0	0	0	0	0	0
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	0	0	0	0	0	0
Tree Planting	0	0	0	0	0	0
Farm Plans	0	0	0	0	0	0
Cover Crops	0	0	0	0	0	0
Stream Protection w/ Fencing	0	0	0	0	0	0
Stream Protection w/o Fencing	0	0	0	0	0	0
Nutrient Management Plan Implementation[4]	0	0	0	0	0	0
Grazing Land Protection	0	0	0	0	0	0
Animal Waste Management Systems	0	0	0	0	0	0
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	0	0	0	0	0	0
Total	0	0	0	0	0	0

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	0

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	8,260,558	130,000,000	0
Industrial	0	0	0
Total	8,260,558	130,000,000	0

All Sources	Total Annual	Capital	Annual O&M
Total	8,594,755	132,582,444	334,198

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002). Costs for the District of Columbia include CSO controls.

Exhibit 39: Estimated Costs of Tier 1: Maryland (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	572,384	6,857,076	572,384
Grass Buffers	340,710	2,630,870	340,710
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	4,195,385	32,415,941	4,195,385
Storm Water Management on New Dev.	18,691,867	144,424,027	18,691,867
Nutrient Management	0	0	0
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	23,800,346	186,327,914	23,800,346

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	3,891,132	23,075,131	288,924	1,964,971	-140,342	4,031,475
Grass Buffers	1,024,591	1,011,164	0	893,640	-99,176	1,123,766
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	157,261	180,675	0	133,863	-17,721	174,982
Tree Planting	0	0	0	0	0	0
Farm Plans	830,139	4,481,575	249,755	0	322,303	507,836
Cover Crops	-862,958	0	-862,958	0	-223,730	-639,228
Stream Protection w/ Fencing	1,504,720	8,365,718	421,322	0	556,747	947,974
Stream Protection w/o Fencing	222,346	1,236,169	62,257	0	82,268	140,078
Nutrient Management Plan Implementation[4]	872,566	7,920,713	0	0	623,261	249,305
Grazing Land Protection	0	0	0	0	0	0
Animal Waste Management Systems	772,924	3,342,256	340,087	0	394,191	378,733
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	-13,153	0	-13,153	0	0	-13,153
Conservation Tillage	-145,758	0	-145,758	0	-145,758	0
Total	8,253,812	49,613,399	340,476	2,992,474	1,352,044	6,901,768

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	1,592,527

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	29,478,054	355,985,619	7,284,694
Industrial	0	0	0
Total	29,478,054	355,985,619	7,284,694

All Sources	Total Annual	Capital	Annual O&M
Total	63,124,740	591,926,932	31,425,516

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.

1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002).

Exhibit 39: Estimated Costs of Tier 1: New York (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	1,965	23,545	1,965
Grass Buffers	80,840	624,228	80,840
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	806,622	6,232,423	806,622
Storm Water Management on New Dev.	792,426	6,122,733	792,426
Nutrient Management	0	0	0
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	1,681,854	13,002,928	1,681,854

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	0	0	0	0	0	0
Grass Buffers	0	0	0	0	0	0
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	433,622	789,762	0	331,345	-17,297	450,919
Tree Planting	0	0	0	0	0	0
Farm Plans	0	0	0	0	0	0
Cover Crops	0	0	0	0	0	0
Stream Protection w/ Fencing	0	0	0	0	0	0
Stream Protection w/o Fencing	0	0	0	0	0	0
Nutrient Management Plan Implementation[4]	126,281	1,146,315	0	0	15,785	110,496
Grazing Land Protection	209,254	1,163,380	58,591	0	77,424	131,830
Animal Waste Management Systems	1,011,757	4,375,012	445,173	0	515,996	495,761
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	29,853	0	29,853	0	29,853	0
Total	1,810,767	7,474,468	533,617	331,345	621,761	1,189,006

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	3,635,376

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	0	0	0
Industrial	0	0	0
Total	0	0	0

All Sources	Total Annual	Capital	Annual O&M
Total	7,127,997	20,477,397	2,215,471

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.

1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 1: Pennsylvania (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	1,787,376	21,412,504	1,787,376
Grass Buffers	393,284	3,036,834	393,284
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	3,227,571	24,938,052	3,227,571
Storm Water Management on New Dev.	3,409,722	26,345,454	3,409,722
Nutrient Management	0	0	0
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	8,817,952	75,732,844	8,817,952

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	223,036	1,312,681	16,436	113,462	11,363	211,673
Grass Buffers	37,194	34,236	0	32,760	-1,304	38,498
Wetland Restoration	81,106	489,136	14,974	34,313	12,957	68,149
Retirement of Highly Erodible Land	537,128	687,003	0	448,158	-26,168	563,295
Tree Planting	0	0	0	0	0	0
Farm Plans	7,988,447	43,146,864	2,400,731	0	2,400,731	5,587,716
Cover Crops	0	0	0	0	0	0
Stream Protection w/ Fencing	713,633	3,967,546	199,817	0	199,817	513,815
Stream Protection w/o Fencing	55,927	310,933	15,659	0	23,713	32,214
Nutrient Management Plan Implementation[4]	1,434,155	13,018,531	0	0	286,831	1,147,324
Grazing Land Protection	86,218	479,342	24,141	0	36,556	49,662
Animal Waste Management Systems	10,923,744	47,236,144	4,806,447	0	6,029,907	4,893,837
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	9,617	0	9,617	0	9,617	0
Conservation Tillage	158,920	0	158,920	0	158,920	0
Total	22,249,124	110,682,417	7,646,743	628,693	9,142,941	13,106,184

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	13,880,287

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	6,490,146	72,079,813	1,866,433
Industrial	0	0	0
Total	6,490,146	72,079,813	1,866,433

All Sources	Total Annual	Capital	Annual O&M
Total	51,437,510	258,495,073	18,331,128

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 1: Virginia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	18,367	220,036	18,367
Grass Buffers	755,486	5,833,663	755,486
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	6,158,798	47,586,385	6,158,798
Storm Water Management on New Dev.	17,170,631	132,670,093	17,170,631
Nutrient Management	45,366	123,542	45,366
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	24,148,648	186,433,719	24,148,648

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	847,877	5,349,858	66,986	401,306	115,364	732,513
Grass Buffers	162,030	181,989	0	138,462	-9,705	171,735
Wetland Restoration	201,687	1,214,791	37,188	85,476	45,673	156,014
Retirement of Highly Erodible Land	3,383,002	4,119,205	0	2,849,546	-219,658	3,602,660
Tree Planting	0	0	0	0	0	0
Farm Plans	9,073,602	48,538,411	2,787,656	0	4,359,143	4,714,460
Cover Crops	-946,558	0	-946,558	0	-236,639	-709,918
Stream Protection w/ Fencing	1,057,642	5,880,117	296,140	0	486,515	571,127
Stream Protection w/o Fencing	0	0	0	0	0	0
Nutrient Management Plan Implementation[4]	1,467,264	13,319,083	0	0	838,437	628,828
Grazing Land Protection	2,881,677	16,021,111	806,869	0	1,325,571	1,556,105
Animal Waste Management Systems	1,730,494	7,482,955	761,418	0	1,003,687	726,808
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	1,827,469	0	1,827,469	0	1,827,469	0
Conservation Tillage	-105,986	0	-105,986	0	-105,986	0
Total	21,580,201	102,107,520	5,531,181	3,474,789	9,429,871	12,150,330

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	3,019,242

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	8,650,293	93,947,837	1,798,521
Industrial	0	0	0
Total	8,650,293	93,947,837	1,798,521

All Sources	Total Annual	Capital	Annual O&M
Total	57,398,385	382,489,077	31,478,351

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002).

Exhibit 39: Estimated Costs of Tier 1: West Virginia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	802	9,612	802
Grass Buffers	33,004	254,845	33,004
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	270,464	2,089,761	270,464
Storm Water Management on New Dev.	581,455	4,492,653	581,455
Nutrient Management	0	0	0
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	885,725	6,846,872	885,725

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	39,340	321,293	4,023	12,520	8,480	30,859
Grass Buffers	25,004	48,685	0	18,699	-278	25,282
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	21,921	48,760	0	15,606	-279	22,200
Tree Planting	0	0	0	0	0	0
Farm Plans	3,041,942	16,227,374	940,423	0	1,465,803	1,576,139
Cover Crops	-9,421	0	-9,421	0	-2,355	-7,065
Stream Protection w/ Fencing	62,432	347,103	17,481	0	28,719	33,714
Stream Protection w/o Fencing	275	1,531	77	0	127	149
Nutrient Management Plan Implementation[4]	113,956	1,034,433	0	0	28,489	85,467
Grazing Land Protection	1,544,232	8,585,385	432,385	0	710,346	833,885
Animal Waste Management Systems	303,591	1,312,778	133,580	0	176,083	127,508
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	-25,815	0	-25,815	0	-25,815	0
Total	5,117,457	27,927,343	1,492,733	46,825	2,389,320	2,728,137

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	1,328,544

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	0	0	0
Industrial	0	0	0
Total	0	0	0

All Sources	Total Annual	Capital	Annual O&M
Total	7,331,726	34,774,215	2,378,458

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 2: Delaware (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	12,439	149,013	12,439
Grass Buffers	8,644	66,749	8,644
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	499,772	3,861,523	499,772
Storm Water Management on New Dev.	411,322	3,178,105	411,322
Nutrient Management	54,452	148,286	54,452
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	986,628	7,403,677	986,628

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	1,083,343	5,522,386	69,146	622,370	96,783	986,560
Grass Buffers	254,741	275,772	0	219,028	-6,040	260,781
Wetland Restoration	39,577	234,091	7,166	17,183	8,104	31,472
Retirement of Highly Erodible Land	1,059,660	1,676,070	0	842,601	-36,708	1,096,368
Tree Planting	0	0	0	0	0	0
Farm Plans	829,226	4,479,396	249,124	0	321,637	507,590
Cover Crops	1,679,761	0	1,679,761	0	419,940	1,259,821
Stream Protection w/ Fencing	17,447	97,000	4,885	0	8,026	9,421
Stream Protection w/o Fencing	7,130	39,639	1,996	0	3,280	3,850
Nutrient Management Plan Implementation[4]	1,061,261	9,633,587	0	0	565,500	495,760
Grazing Land Protection	30,401	169,019	8,512	0	13,984	16,417
Animal Waste Management Systems	37,044	160,183	16,299	0	21,485	15,558
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	221,972	0	221,972	0	0	221,972
Conservation Tillage	13,249	0	13,249	0	13,249	0
Total	6,334,812	22,287,143	2,272,111	1,701,181	1,429,241	4,905,571

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	44,020

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	552,811	5,815,797	230,527
Industrial	0	0	0
Total	552,811	5,815,797	230,527

All Sources	Total Annual	Capital	Annual O&M
Total	7,918,271	35,506,616	3,489,266

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 2: District of Columbia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	3,174	38,021	3,174
Grass Buffers	2,206	17,031	2,206
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	2,076,376	16,043,269	2,076,376
Storm Water Management on New Dev.	0	0	0
Nutrient Management	14,385	39,173	14,385
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	2,096,140	16,137,494	2,096,140

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	0	0	0	0	0	0
Grass Buffers	0	0	0	0	0	0
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	0	0	0	0	0	0
Tree Planting	0	0	0	0	0	0
Farm Plans	0	0	0	0	0	0
Cover Crops	0	0	0	0	0	0
Stream Protection w/ Fencing	0	0	0	0	0	0
Stream Protection w/o Fencing	0	0	0	0	0	0
Nutrient Management Plan Implementation[4]	0	0	0	0	0	0
Grazing Land Protection	0	0	0	0	0	0
Animal Waste Management Systems	0	0	0	0	0	0
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	0	0	0	0	0	0
Total	0	0	0	0	0	0

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	0

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	14,069,871	154,263,400	4,267,550
Industrial	0	0	0
Total	14,069,871	154,263,400	4,267,550

All Sources	Total Annual	Capital	Annual O&M
Total	16,166,011	170,400,894	6,363,690

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002). Costs for the District of Columbia include CSO controls.

Exhibit 39: Estimated Costs of Tier 2: Maryland (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	1,039,840	12,457,130	1,039,840
Grass Buffers	303,006	2,339,734	303,006
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	26,216,002	202,559,788	26,216,002
Storm Water Management on New Dev.	18,922,461	146,205,730	18,922,461
Nutrient Management	800,481	2,179,909	800,481
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	47,281,791	365,742,292	47,281,791

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	8,805,605	52,510,649	657,487	4,422,358	-319,368	9,124,973
Grass Buffers	2,412,068	2,589,720	0	2,076,687	-254,001	2,666,069
Wetland Restoration	961,043	6,002,266	183,744	386,843	158,301	802,742
Retirement of Highly Erodible Land	9,858,895	11,539,825	0	8,364,435	-1,131,834	10,990,729
Tree Planting	0	0	0	0	0	0
Farm Plans	-984,682	-5,313,725	-296,530	0	-382,549	-602,133
Cover Crops	8,699,357	0	8,699,357	0	2,255,389	6,443,968
Stream Protection w/ Fencing	1,739,112	9,668,850	486,951	0	643,471	1,095,640
Stream Protection w/o Fencing	227,298	1,263,699	63,644	0	84,100	143,198
Nutrient Management Plan Implementation[4]	43,723	396,894	0	0	31,231	12,492
Grazing Land Protection	1,213,802	6,748,311	339,864	0	449,107	764,695
Animal Waste Management Systems	810,839	3,506,205	356,769	0	413,528	397,311
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	-14,655	0	-14,655	0	0	-14,655
Conservation Tillage	9,974	0	9,974	0	9,974	0
Total	33,782,377	88,912,693	10,486,604	15,250,323	1,957,348	31,825,029

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	1,791,593

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	36,180,908	392,994,846	11,651,128
Industrial	1,637,472	12,350,911	581,548
Total	37,818,381	405,345,756	12,232,676

All Sources	Total Annual	Capital	Annual O&M
Total	120,674,142	860,000,742	70,001,072

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002).

Exhibit 39: Estimated Costs of Tier 2: New York (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	104,690	1,254,168	104,690
Grass Buffers	72,755	561,792	72,755
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	5,041,389	38,952,644	5,041,389
Storm Water Management on New Dev.	900,484	6,957,651	900,484
Nutrient Management	235,687	641,833	235,687
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	6,355,003	48,368,088	6,355,003

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	1,584,359	12,404,134	155,312	548,943	217,389	1,366,969
Grass Buffers	237,642	408,479	0	184,742	-8,946	246,588
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	2,321,127	3,954,102	0	1,809,053	-86,601	2,407,728
Tree Planting	0	0	0	0	0	0
Farm Plans	2,621,314	14,048,270	801,998	0	1,029,413	1,591,901
Cover Crops	2,246,571	0	2,246,571	0	280,821	1,965,750
Stream Protection w/ Fencing	782,184	4,348,670	219,012	0	289,408	492,776
Stream Protection w/o Fencing	319,643	1,777,101	89,500	0	118,268	201,375
Nutrient Management Plan Implementation[4]	941,937	8,550,427	0	0	117,742	824,195
Grazing Land Protection	1,262,326	7,018,088	353,451	0	467,060	795,265
Animal Waste Management Systems	2,182,852	9,439,027	960,455	0	1,113,255	1,069,598
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	167,524	0	167,524	0	167,524	0
Total	14,667,478	61,948,298	4,993,823	2,542,738	3,705,333	10,962,145

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	4,089,798

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	6,235,642	65,159,566	2,055,843
Industrial	0	0	0
Total	6,235,642	65,159,566	2,055,843

All Sources	Total Annual	Capital	Annual O&M
Total	31,347,921	175,475,952	13,404,669

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 2: Pennsylvania (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	2,351,317	28,168,437	2,351,317
Grass Buffers	352,798	2,724,214	352,798
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	20,166,570	155,818,424	20,166,570
Storm Water Management on New Dev.	3,412,988	26,370,696	3,412,988
Nutrient Management	747,517	2,035,675	747,517
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	27,031,192	215,117,445	27,031,192

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	12,529,675	75,215,200	941,771	6,251,200	651,101	11,878,574
Grass Buffers	3,657,998	3,727,866	0	3,175,222	-141,993	3,799,991
Wetland Restoration	303,268	1,797,060	55,012	131,355	47,602	255,666
Retirement of Highly Erodible Land	19,254,172	23,661,964	0	16,189,839	-901,274	20,155,446
Tree Planting	0	0	0	0	0	0
Farm Plans	11,140,394	59,484,892	3,436,828	0	3,436,828	7,703,566
Cover Crops	16,610,845	0	16,610,845	0	7,382,598	9,228,247
Stream Protection w/ Fencing	3,097,505	17,221,042	867,301	0	867,301	2,230,204
Stream Protection w/o Fencing	1,022,835	5,686,604	286,394	0	433,682	589,153
Nutrient Management Plan Implementation[4]	5,639,185	51,189,665	0	0	1,127,837	4,511,348
Grazing Land Protection	3,238,242	18,003,488	906,708	0	1,373,014	1,865,227
Animal Waste Management Systems	13,298,399	57,504,561	5,851,296	0	7,340,717	5,957,683
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	406,072	0	406,072	0	406,072	0
Conservation Tillage	734,105	0	734,105	0	734,105	0
Total	90,932,696	313,492,341	30,096,333	25,747,616	22,757,591	68,175,104

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	15,615,323

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	31,784,614	352,016,372	9,203,774
Industrial	2,043,399	18,123,358	493,968
Total	33,828,013	370,139,730	9,697,742

All Sources	Total Annual	Capital	Annual O&M
Total	167,407,224	898,749,516	66,825,267

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 2: Virginia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	972,497	11,650,369	972,497
Grass Buffers	675,841	5,218,663	675,841
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	38,488,376	297,383,150	38,488,376
Storm Water Management on New Dev.	17,864,470	138,031,087	17,864,470
Nutrient Management	1,264,150	3,442,593	1,264,150
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	59,265,334	455,725,862	59,265,334

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	9,758,239	63,154,108	790,754	4,486,546	1,361,854	8,396,385
Grass Buffers	1,494,822	1,780,341	0	1,264,260	-94,937	1,589,760
Wetland Restoration	479,241	2,939,844	89,996	198,004	110,531	368,710
Retirement of Highly Erodible Land	10,418,034	12,811,532	0	8,758,882	-683,180	11,101,214
Tree Planting	0	0	0	0	0	0
Farm Plans	13,403,197	71,609,558	4,129,431	0	6,447,873	6,955,324
Cover Crops	6,197,876	0	6,197,876	0	1,549,469	4,648,407
Stream Protection w/ Fencing	6,274,538	34,884,232	1,756,871	0	2,886,288	3,388,251
Stream Protection w/o Fencing	2,140,090	11,898,149	599,225	0	984,441	1,155,649
Nutrient Management Plan Implementation[4]	2,900,010	26,324,820	0	0	1,657,148	1,242,861
Grazing Land Protection	10,477,739	58,252,555	2,933,767	0	4,819,760	5,657,979
Animal Waste Management Systems	2,183,733	9,442,837	960,843	0	1,266,565	917,168
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	2,108,290	0	2,108,290	0	2,108,290	0
Conservation Tillage	36,521	0	36,521	0	36,521	0
Total	67,872,330	293,097,977	19,603,573	14,707,692	22,450,623	45,421,708

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	4,077,351

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	57,856,930	623,564,696	12,421,018
Industrial	3,411,858	15,051,365	2,125,063
Total	61,268,788	638,616,061	14,546,080

All Sources	Total Annual	Capital	Annual O&M
Total	192,483,803	1,387,439,899	93,414,987

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002).

Exhibit 39: Estimated Costs of Tier 2: West Virginia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	42,740	512,023	42,740
Grass Buffers	29,703	229,355	29,703
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	1,690,402	13,061,008	1,690,402
Storm Water Management on New Dev.	660,744	5,105,287	660,744
Nutrient Management	81,873	222,961	81,873
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	2,505,462	19,130,634	2,505,462

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	1,553,131	13,167,381	164,869	454,004	347,548	1,205,583
Grass Buffers	55,979	108,997	0	41,863	-623	56,602
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	825,639	1,836,510	0	587,803	-10,493	836,132
Tree Planting	0	0	0	0	0	0
Farm Plans	2,779,769	14,825,029	859,860	0	1,339,837	1,439,932
Cover Crops	327,115	0	327,115	0	81,779	245,337
Stream Protection w/ Fencing	2,091,315	11,626,979	585,568	0	962,005	1,129,310
Stream Protection w/o Fencing	829,179	4,609,942	232,170	0	381,422	447,756
Nutrient Management Plan Implementation[4]	381,612	3,464,082	0	0	95,403	286,209
Grazing Land Protection	3,324,960	18,485,609	930,989	0	1,529,481	1,795,478
Animal Waste Management Systems	582,122	2,517,194	256,134	0	337,631	244,491
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	-19,807	0	-19,807	0	-19,807	0
Total	12,731,013	70,641,723	3,336,897	1,083,670	5,044,183	7,686,830

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	1,494,612

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	0	0	0

Point Sources	Total Annual	Capital	Annual O&M
Municipal	1,667,872	21,301,901	522,764
Industrial	559,099	5,286,279	107,156
Total	2,226,971	26,588,180	629,920

All Sources	Total Annual	Capital	Annual O&M
Total	18,958,057	116,360,538	6,472,279

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 3: Delaware (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	36,847	441,417	36,847
Grass Buffers	6,723	51,915	6,723
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	1,999,088	15,446,093	1,999,088
Storm Water Management on New Dev.	274,214	2,118,737	274,214
Nutrient Management	72,586	197,669	72,586
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	2,389,458	18,255,831	2,389,458

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	1,274,902	6,494,628	81,319	732,773	113,822	1,161,080
Grass Buffers	341,376	366,849	0	293,868	-8,035	349,411
Wetland Restoration	39,594	234,183	7,169	17,191	8,108	31,486
Retirement of Highly Erodible Land	1,747,278	2,764,430	0	1,389,271	-60,545	1,807,823
Tree Planting	0	0	0	0	0	0
Farm Plans	1,758,609	9,484,031	530,383	0	683,912	1,074,697
Cover Crops	2,514,479	0	2,514,479	0	628,620	1,885,859
Stream Protection w/ Fencing	87,236	485,000	24,426	0	40,128	47,107
Stream Protection w/o Fencing	5,243	29,147	1,468	0	2,412	2,831
Nutrient Management Plan Implementation[4]	677,137	6,146,711	0	0	360,818	316,320
Grazing Land Protection	60,802	338,038	17,025	0	27,969	32,833
Animal Waste Management Systems	44,238	191,292	19,465	0	25,658	18,580
Yield Reserve[4]	316,092	2,869,325	0	0	0	316,092
Carbon Sequestration	285,037	2,200,976	0	0	285,037	0
Excess Manure Removal	262,177	0	262,177	0	0	262,177
Conservation Tillage	-22,371	0	-22,371	0	-22,371	0
Total	9,391,828	31,604,611	3,435,539	2,433,103	2,085,531	7,306,297

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	73,355

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	181,326	951,419	181,326

Point Sources	Total Annual	Capital	Annual O&M
Municipal	785,664	8,998,705	286,998
Industrial	0	0	0
Total	785,664	8,998,705	286,998

All Sources	Total Annual	Capital	Annual O&M
Total	12,821,630	59,810,566	6,293,321

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.

1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 3: District of Columbia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	9,401	112,628	9,401
Grass Buffers	1,715	13,246	1,715
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	8,308,836	64,198,805	8,308,836
Storm Water Management on New Dev.	0	0	0
Nutrient Management	26,949	73,388	26,949
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	8,346,901	64,398,067	8,346,901

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	0	0	0	0	0	0
Grass Buffers	0	0	0	0	0	0
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	0	0	0	0	0	0
Tree Planting	0	0	0	0	0	0
Farm Plans	0	0	0	0	0	0
Cover Crops	0	0	0	0	0	0
Stream Protection w/ Fencing	0	0	0	0	0	0
Stream Protection w/o Fencing	0	0	0	0	0	0
Nutrient Management Plan Implementation[4]	0	0	0	0	0	0
Grazing Land Protection	0	0	0	0	0	0
Animal Waste Management Systems	0	0	0	0	0	0
Yield Reserve[4]	0	0	0	0	0	0
Carbon Sequestration	0	0	0	0	0	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	0	0	0	0	0	0
Total	0	0	0	0	0	0

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	0

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	33,087	173,609	33,087

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	25,710,919	303,506,200	6,425,300
Industrial	0	0	0
Total	25,710,919	303,506,200	6,425,300

All Sources	Total Annual	Capital	Annual O&M
Total	34,090,908	368,077,876	14,805,289

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002). Costs for the District of Columbia include CSO controls.

Exhibit 39: Estimated Costs of Tier 3: Maryland (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	1,886,731	22,602,757	1,886,731
Grass Buffers	232,846	1,797,978	232,846
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	104,843,384	810,079,790	104,843,384
Storm Water Management on New Dev.	11,069,443	85,528,832	11,069,443
Nutrient Management	1,507,955	4,106,536	1,507,955
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	119,540,360	924,115,893	119,540,360

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	10,880,555	64,813,373	811,530	5,470,358	-394,193	11,274,748
Grass Buffers	3,370,826	3,692,917	0	2,892,576	-362,204	3,733,029
Wetland Restoration	1,922,412	12,004,531	367,488	774,012	316,602	1,605,810
Retirement of Highly Erodible Land	15,681,537	18,382,523	0	13,300,917	-1,802,970	17,484,508
Tree Planting	0	0	0	0	0	0
Farm Plans	-2,704,391	-14,744,417	-794,922	0	-1,033,605	-1,670,786
Cover Crops	12,885,030	0	12,885,030	0	3,340,563	9,544,467
Stream Protection w/ Fencing	2,873,335	15,974,733	804,534	0	1,063,134	1,810,201
Stream Protection w/o Fencing	163,730	910,283	45,844	0	60,580	103,150
Nutrient Management Plan Implementation[4]	-2,764,411	-25,093,921	0	0	-1,974,579	-789,832
Grazing Land Protection	2,428,946	13,504,087	680,105	0	898,710	1,530,236
Animal Waste Management Systems	863,919	3,735,733	380,124	0	440,599	423,320
Yield Reserve[4]	2,296,770	20,848,914	0	0	0	2,296,770
Carbon Sequestration	1,850,941	14,292,475	0	0	1,850,941	0
Excess Manure Removal	-8,577	0	-8,577	0	0	-8,577
Conservation Tillage	-132,705	0	-132,705	0	-132,705	0
Total	49,607,917	128,321,230	15,038,451	22,437,863	2,270,873	47,337,045

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	1,990,659

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	3,250,804	17,057,048	3,250,804

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	85,214,328	981,622,772	23,808,244
Industrial	2,676,421	18,239,006	1,117,102
Total	87,890,748	999,861,778	24,925,346

All Sources	Total Annual	Capital	Annual O&M
Total	262,280,488	2,069,355,949	162,754,961

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002).

Exhibit 39: Estimated Costs of Tier 3: New York (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	310,119	3,715,185	310,119
Grass Buffers	56,586	436,939	56,586
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	20,165,554	155,810,576	20,165,554
Storm Water Management on New Dev.	600,322	4,638,434	600,322
Nutrient Management	449,237	1,223,383	449,237
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	21,581,819	165,824,517	21,581,819

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	2,715,428	21,232,593	265,854	943,070	372,113	2,343,315
Grass Buffers	415,873	714,838	0	323,298	-15,656	431,529
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	3,722,815	6,389,951	0	2,895,287	-139,950	3,862,765
Tree Planting	0	0	0	0	0	0
Farm Plans	5,747,569	30,775,278	1,762,030	0	2,260,222	3,487,347
Cover Crops	3,355,143	0	3,355,143	0	419,393	2,935,750
Stream Protection w/ Fencing	3,884,525	21,596,594	1,087,667	0	1,437,274	2,447,250
Stream Protection w/o Fencing	233,445	1,297,872	65,365	0	86,375	147,070
Nutrient Management Plan Implementation[4]	974,582	8,846,765	0	0	121,823	852,760
Grazing Land Protection	2,300,132	12,787,924	644,037	0	851,049	1,449,083
Animal Waste Management Systems	3,822,385	16,528,648	1,681,849	0	1,949,416	1,872,969
Yield Reserve[4]	483,087	4,385,221	0	0	0	483,087
Carbon Sequestration	380,103	2,935,057	0	0	380,103	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	237,254	0	237,254	0	237,254	0
Total	28,272,341	127,490,741	9,099,198	4,161,655	7,959,416	20,312,925

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	4,544,220

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	1,131,503	5,937,023	1,131,503

Point Sources	Total Annual	Capital	Annual O&M
Municipal	10,184,157	105,760,184	3,399,944
Industrial	0	0	0
Total	10,184,157	105,760,184	3,399,944

All Sources	Total Annual	Capital	Annual O&M
Total	65,714,039	405,012,465	35,212,464

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 3: Pennsylvania (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	3,372,590	40,403,133	3,372,590
Grass Buffers	273,498	2,111,882	273,498
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	80,640,209	623,072,254	80,640,209
Storm Water Management on New Dev.	1,971,034	15,229,335	1,971,034
Nutrient Management	1,442,580	3,928,502	1,442,580
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	87,699,911	684,745,106	87,699,911

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	21,111,400	126,820,710	1,587,925	10,525,234	1,097,825	20,013,575
Grass Buffers	6,371,405	6,496,114	0	5,530,128	-247,434	6,618,839
Wetland Restoration	528,432	3,122,939	95,601	229,680	82,724	445,709
Retirement of Highly Erodible Land	30,058,820	36,977,925	0	25,270,009	-1,408,474	31,467,293
Tree Planting	0	0	0	0	0	0
Farm Plans	15,876,265	84,680,815	4,909,712	0	4,909,712	10,966,553
Cover Crops	24,719,849	0	24,719,849	0	10,986,599	13,733,249
Stream Protection w/ Fencing	12,508,191	69,541,155	3,502,294	0	3,502,294	9,005,898
Stream Protection w/o Fencing	746,558	4,150,602	209,036	0	316,541	430,018
Nutrient Management Plan Implementation[4]	3,849,996	34,948,310	0	0	769,999	3,079,996
Grazing Land Protection	6,335,106	35,220,968	1,773,830	0	2,686,085	3,649,021
Animal Waste Management Systems	16,622,917	71,880,344	7,314,083	0	9,175,850	7,447,067
Yield Reserve[4]	3,544,743	32,177,379	0	0	0	3,544,743
Carbon Sequestration	2,800,506	21,624,763	0	0	2,800,506	0
Excess Manure Removal	685,345	0	685,345	0	685,345	0
Conservation Tillage	821,257	0	821,257	0	821,257	0
Total	146,580,789	527,642,024	45,618,932	41,555,051	36,178,828	110,401,961

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	17,350,359

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	4,106,021	21,544,394	4,106,021

Point Sources	Total Annual	Capital	Annual O&M
Municipal	59,952,609	670,716,278	16,928,086
Industrial	4,136,284	35,078,315	1,137,311
Total	64,088,893	705,794,593	18,065,397

All Sources	Total Annual	Capital	Annual O&M
Total	319,825,974	1,939,726,117	155,490,261

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.

1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

Exhibit 39: Estimated Costs of Tier 3: Virginia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	2,863,404	34,303,155	2,863,404
Grass Buffers	522,468	4,034,356	522,468
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	153,911,083	1,189,204,823	153,911,083
Storm Water Management on New Dev.	10,814,275	83,557,256	10,814,275
Nutrient Management	2,391,345	6,512,225	2,391,345
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	170,502,574	1,317,611,815	170,502,574

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	15,165,870	97,987,186	1,226,900	6,986,538	2,112,994	13,052,876
Grass Buffers	2,483,348	2,966,709	0	2,099,145	-158,201	2,641,549
Wetland Restoration	764,019	4,708,912	144,151	313,546	177,044	586,975
Retirement of Highly Erodible Land	16,416,047	20,185,401	0	13,801,946	-1,076,395	17,492,442
Tree Planting	0	0	0	0	0	0
Farm Plans	18,557,806	98,973,867	5,740,238	0	8,944,630	9,613,176
Cover Crops	9,605,252	0	9,605,252	0	2,401,313	7,203,939
Stream Protection w/ Fencing	27,030,520	150,280,207	7,568,546	0	12,434,039	14,596,481
Stream Protection w/o Fencing	1,562,660	8,687,842	437,545	0	718,824	843,836
Nutrient Management Plan Implementation[4]	1,710,724	15,529,089	0	0	977,557	733,168
Grazing Land Protection	17,968,738	99,899,881	5,031,247	0	8,265,620	9,703,119
Animal Waste Management Systems	2,818,268	12,186,672	1,240,038	0	1,634,595	1,183,672
Yield Reserve[4]	2,056,859	18,671,127	0	0	0	2,056,859
Carbon Sequestration	1,233,866	9,527,582	0	0	1,233,866	0
Excess Manure Removal	926,890	0	926,890	0	926,890	0
Conservation Tillage	-48,363	0	-48,363	0	-48,363	0
Total	118,252,504	539,604,475	31,872,443	23,201,175	38,544,411	79,708,093

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	5,135,459

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	3,944,432	20,696,534	3,944,432

Point Sources	Total Annual	Capital	Annual O&M
Municipal[5]	101,254,416	984,760,302	29,732,400
Industrial	7,923,629	38,575,094	4,625,704
Total	109,178,044	1,023,335,396	34,358,104

All Sources	Total Annual	Capital	Annual O&M
Total	407,013,014	2,901,248,220	240,677,554

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.
1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.
5. Costs for Blue Plains WWTF are allocated to Maryland, Virginia, and the District of Columbia as recommended by MWCOG (2002).

Exhibit 39: Estimated Costs of Tier 3: West Virginia (2001 $)

Urban	Total Annual	Capital	Annual O&M
Forest Buffers	126,608	1,516,750	126,608
Grass Buffers	23,101	178,383	23,101
Environmental Site Design / Low-Impact Dev.	0	0	0
Storm Water Retrofits	6,761,607	52,244,033	6,761,607
Storm Water Management on New Dev.	440,496	3,403,525	440,496
Nutrient Management	155,724	424,074	155,724
Urban Land Conversion	0	0	0
Forest Conservation	0	0	0
Total	7,507,537	57,766,765	7,507,537

Agriculture	Total Annual[1]	Capital	Annual O&M	Annual Land Rental[2]	Farmer Share of Annual Cost[3]	Federal/State Share of Annual Cost
Forest Buffers	2,497,590	21,113,284	264,360	735,191	557,277	1,940,313
Grass Buffers	77,029	149,985	0	57,606	-857	77,886
Wetland Restoration	0	0	0	0	0	0
Retirement of Highly Erodible Land	1,187,708	2,641,877	0	845,573	-15,094	1,202,802
Tree Planting	0	0	0	0	0	0
Farm Plans	2,600,177	13,857,990	805,504	0	1,254,172	1,346,005
Cover Crops	462,929	0	462,929	0	115,732	347,196
Stream Protection w/ Fencing	10,114,560	56,233,407	2,832,077	0	4,652,698	5,461,863
Stream Protection w/o Fencing	603,851	3,357,199	169,078	0	277,771	326,079
Nutrient Management Plan Implementation[4]	343,079	3,114,295	0	0	85,770	257,309
Grazing Land Protection	5,063,244	28,149,858	1,417,708	0	2,329,092	2,734,152
Animal Waste Management Systems	972,065	4,203,377	427,709	0	563,798	408,267
Yield Reserve[4]	206,059	1,870,497	0	0	0	206,059
Carbon Sequestration	72,145	557,087	0	0	72,145	0
Excess Manure Removal	0	0	0	0	0	0
Conservation Tillage	-24,525	0	-24,525	0	-24,525	0
Total	24,175,910	135,248,854	6,354,839	1,638,369	9,867,979	14,307,931

Forest	Total Annual
Forest Harvesting Practices (Erosion Control)	1,660,679

Onsite Wastewater Management Systems	Total Annual	Capital	Annual O&M
Denitrification w/ Pumping	379,196	1,989,648	379,196

Point Sources	Total Annual	Capital	Annual O&M
Municipal	2,424,046	31,501,539	730,645
Industrial	611,642	5,736,257	121,229
Total	3,035,688	37,237,795	851,873

All Sources	Total Annual	Capital	Annual O&M
Total	36,759,010	232,243,063	15,093,444

Notes: Totals may not add due to rounding. Federal and State cost estimates reflect potential cost sharing through identified programs. Annual cost is calculated as annualized capital cost, plus annual O&M and land rental where applicable.

1. Total annual cost equals annual farmer cost plus annual Federal/State cost. Negative values for total annual cost reflect the conversion of land from agriculture to another use.
2. Total annual cost includes land rental payments paid to farmers by Federal/State cost share programs.
3. Negative values for farmer costs reflect that agricultural producers experience a cost savings due to Federal/State contributions.
4. Capital costs for nutrient management plans and yield reserve are multiplied by 10/3 to represent capital costs over 10 years.

The Blue Plains facility treats wastewater from Maryland, Virginia, and the District of Columbia. Thus, in Exhibit 39, NRT costs for the Blue Plains WWTF are allocated to each of the jurisdictions according to their corresponding percentage of flow treated by Blue Plains (see MWCOG, 2002). Costs for CSO controls in the District of Columbia are allocated to the District.

Exhibit 40 summarizes the capital, O&M, and total annual (i.e., annualized capital plus annual O&M) costs for each significant municipal and industrial facility in the watershed. Since Exhibit 40 shows facility-level costs, the costs for the Blue Plains WWTF are not distinguished by the jurisdictions it serves. The costs in the exhibit represent the total cumulative cost of achieving each tier, including cost-share funds that offset the cost of NRT at municipal facilities.

Note that Exhibit 40 does not include federal facilities that are in the watershed. Households in the watershed will not incur direct costs for these facilities and, therefore, they are excluded from analyses.

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Municipal Facilities										
Blue Plains[2]	DC0021199	$0	$0	$0	$53,000,000	$8,900,000	$12,267,766	$379,000,000	$13,400,000	$37,482,703
DC Combined Sewer Overflow	NA	$130,000,000	$0	$8,260,558	$130,000,000	$0	$8,260,558	$130,000,000	$0	$8,260,558
DC Subtotal		**$130,000,000**	**$0**	**$8,260,558**	**$183,000,000**	**$8,900,000**	**$20,528,323**	**$509,000,000**	**$13,400,000**	**$45,743,260**
Bridgeville	DE0020249	$3,187,400	$63,244	$239,875	$3,328,511	$74,132	$258,583	$4,246,599	$82,065	$317,392
Laurel	DE0020125	$0	$0	$0	$2,487,286	$155,049	$292,882	$3,115,256	$167,481	$340,114
Seaford	DE0020265	$0	$0	$0	$0	$1,346	$1,346	$1,636,850	$37,452	$128,158
DE Subtotal		**$3,187,400**	**$63,244**	**$239,875**	**$5,815,797**	**$230,527**	**$552,811**	**$8,998,705**	**$286,998**	**$785,664**
Aberdeen	MD0021563	$0	$0	$0	$0	$0	$0	$2,408,870	$31,281	$181,458
Aberdeen Proving Grounds-Aberdeen	MD0021237	$8,000,000	$159,146	$657,893	$8,000,000	$159,146	$657,893	$9,945,658	$177,594	$797,640
Annapolis	MD0021814	$0	$0	$0	$0	$0	$0	$5,882,960	$111,936	$478,700
Back River	MD0021555	$0	$0	$0	$10,000,000	$141,129	$764,564	$253,600,000	$5,141,129	$20,951,420
Ballenger Creek	MD0021822	$0	$0	$0	$0	$0	$0	$3,180,890	$68,203	$266,511
Bowie	MD0021628	$0	$0	$0	$0	$0	$0	$2,138,663	$39,949	$173,280
Broadneck	MD0021644	$0	$0	$0	$0	$0	$0	$3,180,890	$86,565	$284,873
Broadwater	MD0024350	$0	$0	$0	$0	$0	$0	$1,636,850	$29,571	$131,618
Brunswick	MD0020958	$2,000,000	$10,928	$135,615	$2,131,667	$26,158	$159,054	$2,953,049	$54,031	$238,135
Cambridge	MD0021636	$6,904,964	$137,789	$568,268	$7,172,685	$215,921	$663,090	$11,164,196	$323,912	$1,019,927
Celanese	MD0063878	$5,791,500	$116,260	$477,322	$5,966,672	$132,516	$504,499	$7,603,522	$161,265	$635,295
Centreville	MD0020834	$5,065,400	$101,583	$417,378	$5,201,789	$109,536	$433,834	$6,071,524	$122,276	$500,795
Chesapeake Beach	MD0020281	$0	$0	$0	$0	$0	$0	$1,320,322	$27,209	$109,522
Chestertown	MD0020010	$2,600,000	$51,782	$213,875	$2,750,556	$72,832	$244,311	$3,765,350	$95,782	$330,526
Conococheague	MD0063509	$0	$0	$0	$0	$1,696	$1,696	$2,447,471	$27,266	$179,850
Cox Creek	MD0021661	$0	$0	$0	$0	$28,172	$28,172	$6,654,980	$274,756	$689,650
Crisfield	MD0020001	$4,052,200	$80,139	$332,767	$4,212,200	$89,073	$351,676	$5,323,700	$112,586	$444,484
Cumberland	MD0021598	$0	$0	$0	$0	$58,071	$58,071	$6,654,980	$250,533	$665,428
Damascus	MD0020982	$0	$0	$0	$0	$830	$830	$1,443,845	$27,892	$117,906
Delmar	MD0020532	$1,686,000	$19,833	$124,944	$1,686,000	$19,833	$124,944	$2,459,029	$38,128	$191,433
Denton	MD0020494	$0	$0	$0	$0	$1,268	$1,268	$918,088	$15,878	$73,114

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Dorsey Run	MD0063207	$0	$0	$0	$0	$0	$0	$1,636,850	$33,574	$135,621
Easton	MD0020273	$0	$0	$0	$205,516	$29,520	$42,333	$2,614,386	$74,906	$237,896
Elkton	MD0020681	$6,000,000	$128,234	$502,295	$6,000,000	$129,486	$503,547	$7,907,057	$174,147	$667,100
Emmitsburg	MD0020257	$0	$0	$0	$0	$4,669	$4,669	$869,735	$25,569	$79,791
Federalsburg	MD0020249	$1,300,000	$29,282	$110,329	$1,300,000	$29,282	$110,329	$2,169,735	$41,099	$176,367
Frederick	MD0021610	$0	$0	$0	$266,204	$210,251	$226,847	$4,219,114	$374,508	$637,542
Freedom District	MD0021512	$0	$0	$0	$0	$0	$0	$2,215,865	$59,144	$197,288
Fruitland	MD0052990	$0	$0	$0	$141,111	$11,381	$20,178	$1,059,199	$29,895	$95,929
Georges Creek	MD0060071	$2,000,000	$40,709	$165,396	$2,122,222	$54,211	$186,517	$2,846,898	$79,406	$256,891
Hagerstown	MD0021776	$0	$0	$0	$266,204	$97,440	$114,036	$4,219,114	$276,630	$539,664
Havre De Grace	MD0021750	$0	$0	$0	$0	$0	$0	$1,594,389	$38,674	$138,073
Hurlock	MD0022730	$4,600,000	$103,378	$390,158	$4,769,862	$160,897	$458,266	$6,271,609	$193,076	$584,069
Indian Head	MD0020052	$676,000	$12,603	$54,747	$788,778	$19,317	$68,492	$1,416,748	$33,133	$121,458
Joppatowne	MD0022535	$0	$0	$0	$0	$0	$0	$1,063,147	$28,048	$94,328
Kent Island	MD0023485	$20,742,570	$415,470	$1,708,632	$20,742,570	$415,470	$1,708,632	$22,765,430	$451,692	$1,870,966
La Plata	MD0020524	$0	$0	$0	$0	$4,030	$4,030	$1,443,845	$29,970	$119,984
Leonardtown	MD0024767	$2,511,529	$50,596	$207,173	$2,641,307	$61,044	$225,712	$3,443,348	$78,751	$293,421
Little Patuxent	MD0055174	$0	$0	$0	$0	$0	$0	$10,515,080	$291,813	$947,359
Maryland City	MD0062596	$0	$0	$0	$0	$0	$0	$1,829,855	$22,344	$136,423
Maryland Correctional Institute	MD0023957	$0	$0	$0	$0	$0	$0	$1,339,622	$27,220	$110,736
Mattawoman	MD0021865	$19,479,986	$397,854	$1,612,303	$19,479,986	$397,854	$1,612,303	$28,065,016	$514,993	$2,264,662
Mount Airy	MD0022527	$0	$0	$0	$0	$0	$0	$1,328,042	$19,228	$102,023
Northeast River	MD0052027	$2,718,000	$53,912	$223,361	$2,718,000	$53,912	$223,361	$4,354,850	$71,294	$342,790
Parkway	MD0021725	$0	$0	$0	$0	$0	$0	$3,759,905	$98,699	$333,104
Patapsco	MD0021601	$200,000,000	$4,067,523	$16,536,207	$200,000,000	$4,067,523	$16,536,207	$229,043,560	$5,248,210	$19,527,569
Patuxent	MD0021652	$0	$0	$0	$0	$0	$0	$3,759,905	$77,129	$311,535
Perryville	MD0020613	$0	$0	$0	$0	$0	$0	$1,501,746	$23,358	$116,982
Pine Hill Run	MD0021679	$0	$0	$0	$0	$11,611	$11,611	$3,180,890	$97,071	$295,379
Piscataway	MD0021539	$0	$0	$0	$0	$0	$0	$12,445,130	$354,631	$1,130,503
Pocomoke City	MD0022551	$3,529,470	$200,000	$420,039	$3,695,539	$229,233	$459,626	$5,100,783	$260,371	$578,371

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Poolesville	MD0023001	$1,658,000	$33,147	$136,513	$1,658,000	$33,147	$136,513	$2,527,735	$56,178	$213,766
Princess Anne	MD0020656	$0	$0	$0	$0	$0	$0	$1,351,203	$17,650	$101,889
Salisbury	MD0021571	$23,550,000	$476,487	$1,944,675	$23,550,000	$495,600	$1,963,788	$27,695,915	$619,540	$2,346,199
Seneca Creek	MD0021491	$29,520,000	$566,020	$2,406,398	$29,520,000	$611,888	$2,452,266	$38,105,030	$982,954	$3,358,552
Snow Hill	MD0022764	$1,600,000	$32,017	$131,767	$1,712,778	$44,864	$151,645	$2,340,748	$63,097	$209,027
Sod Run	MD0056545	$0	$0	$0	$0	$17,662	$17,662	$8,585,030	$266,222	$801,442
Talbot County Regional	MD0023604	$0	$0	$0	$0	$0	$0	$7,352,000	$154,586	$612,935
Taneytown	MD0020672	$0	$0	$0	$0	$5,741	$5,741	$1,289,441	$38,594	$118,982
Thurmont	MD0021121	$0	$0	$0	$0	$0	$0	$1,111,500	$31,478	$100,773
Western Branch	MD0021741	$0	$0	$0	$0	$0	$0	$0	$39,020	$39,020
Westminster	MD0021831	$0	$0	$0	$0	$0	$0	$2,794,880	$75,140	$249,382
MD Subtotal		**$355,985,619**	**$7,284,694**	**$29,478,054**	**$368,699,646**	**$8,252,218**	**$31,238,214**	**$807,889,172**	**$18,690,784**	**$69,057,357**
Addison (V)	NY0020320	$0	$0	$0	$2,423,823	$55,047	$210,528	$2,974,428	$64,674	$255,475
Bath (V)	NY0021431	$0	$0	$0	$2,882,193	$69,643	$254,528	$3,993,693	$95,930	$352,114
Binghamton-Johnson City Joint Borough	NY0024414	$0	$0	$0	$448,268	$175,305	$204,060	$9,033,298	$560,856	$1,140,316
Cooperstown	NY0023591	$0	$0	$0	$2,503,139	$59,398	$219,967	$3,150,451	$84,551	$286,643
Corning (C)	NY0025721	$0	$0	$0	$3,674,079	$92,485	$328,166	$5,361,111	$128,446	$472,346
Cortland (C)	NY0027561	$0	$0	$0	$0	$21,404	$21,404	$4,724,930	$197,711	$500,802
Elmira / Chemung Co. SD #2	NY0035742	$0	$0	$0	$9,940,841	$306,780	$944,457	$15,437,791	$453,234	$1,443,524
Endicott (V)	NY0027669	$0	$0	$0	$6,952,548	$264,880	$710,866	$6,952,548	$305,815	$751,801
Hamilton (V)	NY0020672	$0	$0	$0	$2,764,035	$61,060	$238,365	$3,730,476	$76,967	$316,266
Hornell (C)	NY0023647	$0	$0	$0	$4,950,960	$143,886	$461,476	$7,359,830	$214,750	$686,862
Lake Street/Chemung County SD #1	NY0036986	$0	$0	$0	$8,463,821	$271,098	$814,028	$12,995,746	$419,040	$1,252,680
Norwich	NY0021423	$0	$0	$0	$3,722,631	$108,573	$347,369	$5,436,683	$182,064	$530,812
Oneonta (C)	NY0031151	$0	$0	$0	$4,950,960	$117,700	$435,290	$7,359,830	$188,494	$660,606
Owego #2	NY0025798	$0	$0	$0	$175,172	$16,282	$27,519	$1,812,022	$45,739	$161,975
Owego (V)	NY0029262	$0	$0	$0	$2,882,193	$66,970	$251,854	$3,993,693	$88,561	$344,744
Richfield Springs (V)	NY0031411	$0	$0	$0	$2,444,284	$48,320	$205,114	$3,168,960	$58,719	$261,999

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Sidney (V)	NY0029271	$0	$0	$0	$3,374,544	$107,065	$323,532	$4,895,591	$127,000	$441,038
Waverly (V)	NY0031089	$0	$0	$0	$2,606,072	$69,949	$237,121	$3,379,101	$107,394	$324,154
NY Subtotal		**$0**	**$0**	**$0**	**$65,159,566**	**$2,055,843**	**$6,235,642**	**$105,760,184**	**$3,399,944**	**$10,184,157**
Altoona City Authority-East	PA0027014	$0	$0	$0	$1,428,274	$184,710	$276,329	$9,758,274	$500,170	$1,126,136
Altoona City Authority-West	PA0027022	$0	$0	$0	$1,481,376	$188,463	$283,489	$13,011,376	$479,656	$1,314,298
Annville Township	PA0021806	$0	$0	$0	$2,548,725	$51,066	$214,559	$3,418,460	$68,242	$287,526
Antrim Township	PA0080519	$0	$0	$0	$160,759	$7,913	$18,225	$1,430,899	$26,204	$117,992
Ashland MA	PA0023558	$0	$0	$0	$3,093,919	$75,810	$274,276	$4,460,562	$99,958	$386,090
Bedford Borough MA	PA0022209	$0	$0	$0	$2,860,429	$61,420	$244,909	$4,188,471	$95,308	$363,986
Bellefonte Borough	PA0020486	$0	$0	$0	$4,229,766	$81,123	$352,451	$6,337,548	$125,378	$531,914
Berwick MA	PA0023248	$0	$0	$0	$4,715,157	$137,740	$440,204	$6,988,924	$173,400	$621,720
Bloomsburg MA	PA0027171	$0	$0	$0	$4,935,313	$110,171	$426,757	$7,456,126	$171,969	$650,258
Blossburg	PA0020036	$0	$0	$0	$2,444,284	$49,624	$206,418	$3,168,960	$57,466	$260,746
Brown Township MA	PA0028088	$0	$0	$0	$2,444,284	$49,450	$206,244	$3,168,960	$61,882	$265,161
Burnham Borough	PA0038920	$0	$0	$0	$2,472,161	$52,432	$211,014	$3,235,520	$74,538	$282,088
Carlisle Borough	PA0026077	$0	$0	$0	$6,660,935	$136,597	$563,877	$10,227,835	$192,078	$848,164
Carlisle Suburban Authority	PA0024384	$0	$0	$0	$0	$0	$0	$1,038,971	$21,947	$88,594
Chambersburg Borough	PA0026051	$6,400,000	$124,868	$535,409	$6,623,722	$194,641	$619,534	$6,623,722	$220,445	$645,338
Clarks Summit-S. Abington JA	PA0028576	$0	$0	$0	$3,583,756	$107,432	$337,319	$5,220,606	$171,843	$506,730
Clearfield	PA0026310	$0	$0	$0	$5,072,176	$104,021	$429,386	$7,674,051	$158,103	$650,372
Columbia	PA0026123	$0	$0	$0	$3,408,584	$69,207	$287,858	$5,045,434	$89,924	$413,574
Curwensville MA	PA0024759	$0	$0	$0	$2,374,508	$51,188	$203,506	$3,002,478	$68,728	$261,329
Danville MA	PA0023531	$0	$0	$0	$4,229,766	$91,402	$362,729	$6,337,548	$144,517	$551,052
Derry Township MA	PA0026484	$0	$0	$0	$1,983,000	$120,430	$247,634	$3,223,000	$165,702	$372,448
Dillsburg Borough Authority	PA0024431	$0	$0	$0	$2,722,193	$55,091	$229,712	$3,833,693	$77,032	$322,953
Dover Township Sewer Authority	PA0020826	$0	$0	$0	$0	$11,171	$11,171	$2,408,870	$98,381	$252,903
Duncansville	PA0032883	$0	$0	$0	$3,035,449	$65,860	$260,575	$4,370,054	$86,837	$367,163
East Pennsboro South Treatment Plant	PA0038415	$0	$0	$0	$4,748,933	$140,287	$444,917	$7,042,000	$198,298	$650,022

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Eastern Snyder County Regional Auth	PA0110582	$3,000,000	$61,856	$254,297	$3,187,310	$104,746	$309,203	$3,187,310	$113,409	$317,866
Elizabethtown Borough	PA0023108	$4,083,001	$86,431	$348,344	$4,083,001	$86,431	$348,344	$6,105,861	$142,054	$533,727
Elkland MA	PA0113298	$0	$0	$0	$2,409,411	$47,203	$201,760	$3,085,734	$63,310	$261,251
Emporium Borough (Mid-Cameron Authority)	PA0028631	$0	$0	$0	$2,503,139	$56,125	$216,694	$3,150,451	$74,822	$276,914
Ephrata Borough WWTP	PA0027405	$0	$0	$0	$4,613,914	$105,209	$401,178	$6,945,582	$171,283	$616,822
Fairview Township	PA0081868	$0	$0	$0	$2,374,508	$47,883	$200,201	$3,002,478	$62,016	$254,617
Franklin County Authority-Greencastle	PA0020834	$0	$0	$0	$2,304,611	$46,741	$194,575	$2,835,875	$87,706	$269,619
Gettysburg MA	PA0021563	$0	$0	$0	$0	$0	$0	$1,494,026	$40,756	$136,594
Greater Hazelton	PA0026921	$0	$0	$0	$7,840,000	$163,170	$666,083	$24,090,000	$586,537	$2,131,842
Gregg Township	PA0114821	$0	$0	$0	$0	$1,822	$1,822	$918,088	$25,596	$84,489
Hampden Township	PA0028746	$0	$0	$0	$0	$641	$641	$1,544,208	$38,981	$138,037
Hampden Township SA	PA0080314	$0	$0	$0	$3,747,289	$73,618	$313,996	$5,577,144	$120,181	$477,938
Hanover Borough	PA0026875	$0	$0	$0	$60,000	$0	$3,849	$5,190,000	$181,365	$514,289
Harrisburg SA	PA0027197	$22,682,000	$865,000	$2,319,985	$22,682,000	$947,263	$2,402,248	$22,682,000	$1,089,046	$2,544,031
Highspire	PA0024040	$0	$0	$0	$3,408,584	$74,472	$293,123	$5,045,434	$104,127	$427,777
Hollidaysburg Regional	PA0043273	$0	$0	$0	$3,408,584	$84,480	$303,130	$5,045,434	$168,669	$492,319
Houtzdale Borough Municipal	PA0046159	$0	$0	$0	$0	$0	$0	$434,558	$5,125	$33,001
Huntingdon Borough	PA0026191	$0	$0	$0	$4,580,956	$99,010	$392,865	$6,893,324	$149,919	$592,106
Hyndman Borough	PA0020851	$0	$0	$0	$2,097,017	$42,091	$176,609	$2,342,031	$48,261	$198,495
Jersey Shore Borough	PA0028665	$0	$0	$0	$2,724,589	$85,654	$260,428	$3,642,677	$111,308	$344,976
Kelly Township MA	PA0028681	$0	$0	$0	$0	$0	$0	$1,926,358	$42,475	$166,045
Lackawanna River Basin SA	PA0027065	$0	$0	$0	$6,034,411	$133,365	$520,455	$9,215,301	$187,093	$778,228
Lackawanna River Basin SA	PA0027081	$2,513,941	$55,025	$216,287	$2,513,941	$55,521	$216,784	$3,335,323	$73,517	$287,468
Lackawanna River Basin SA	PA0027090	$0	$0	$0	$6,660,935	$128,655	$555,935	$13,580,935	$309,619	$1,180,797
Lancaster Area SA	PA0042269	$4,249,333	$93,253	$365,835	$4,249,333	$93,253	$365,835	$14,709,333	$293,204	$1,236,766
Lancaster City	PA0026743	$1,077,000	$8,461	$77,547	$1,077,000	$8,461	$77,547	$24,157,000	$620,831	$2,170,434
Lebanon City Authority	PA0027316	$0	$0	$0	$4,039,000	$139,109	$398,199	$11,659,000	$336,057	$1,083,948
Lemoyne Borough MA	PA0026441	$0	$0	$0	$3,468,413	$77,654	$300,143	$5,139,232	$123,963	$453,630

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Lewisburg Area JSA	PA0044661	$3,693,297	$75,717	$312,631	$3,693,297	$78,960	$315,874	$7,323,297	$136,768	$606,537
Lewistown Borough	PA0026280	$0	$0	$0	$3,679,787	$80,393	$316,441	$5,471,041	$131,005	$481,957
Lititz Sewage Authority	PA0020320	$0	$0	$0	$4,415,719	$94,250	$377,506	$6,631,584	$167,511	$592,908
Littlestown Borough	PA0021229	$0	$0	$0	$2,722,193	$57,995	$232,616	$3,833,693	$75,566	$321,486
Lock Haven	PA0025933	$4,580,956	$94,176	$388,031	$4,782,679	$123,736	$430,531	$9,372,679	$215,398	$816,628
Logan Township-Greenwood Area	PA0032557	$2,444,284	$49,316	$206,110	$2,566,507	$56,881	$221,515	$3,291,183	$70,668	$281,788
Lower Allen Township Authority	PA0027189	$0	$0	$0	$6,002,771	$136,328	$521,389	$9,164,360	$211,154	$799,021
Lower Lackawanna Valley	PA0026361	$0	$0	$0	$6,034,411	$141,695	$528,785	$9,215,301	$218,538	$809,673
Lykens Borough	PA0043575	$0	$0	$0	$2,311,606	$47,089	$195,372	$2,852,541	$57,051	$240,033
Mahanoy City	PA0070041	$0	$0	$0	$165,765	$11,192	$21,825	$1,563,289	$29,810	$130,091
Manheim Borough Authority	PA0020893	$0	$0	$0	$2,722,193	$57,468	$232,089	$3,833,693	$84,969	$330,889
Mansfield Borough	PA0021814	$0	$0	$0	$2,882,193	$64,115	$248,999	$3,993,693	$84,049	$340,233
Marietta-Donegal JA	PA0021717	$0	$0	$0	$2,444,284	$49,379	$206,172	$3,168,960	$66,373	$269,653
Martinsburg	PA0028347	$0	$0	$0	$2,374,508	$49,549	$201,867	$3,002,478	$65,572	$258,172
Marysville MA	PA0021571	$0	$0	$0	$2,374,508	$48,576	$200,894	$3,002,478	$85,887	$278,488
Mechanicsburg Borough Municipal	PA0020885	$0	$0	$0	$3,462,978	$67,602	$289,743	$5,130,708	$90,753	$419,874
Middletown	PA0020664	$0	$0	$0	$3,544,425	$72,505	$299,870	$5,258,477	$101,333	$438,649
Mifflinburg Borough Municipal	PA0028461	$0	$0	$0	$0	$0	$0	$639,575	$25,758	$66,785
Millersburg Borough Authority	PA0022535	$0	$0	$0	$2,722,193	$56,923	$231,544	$3,833,693	$81,131	$327,051
Millersville Borough	PA0026620	$0	$0	$0	$2,722,193	$56,514	$231,135	$3,833,693	$80,385	$326,305
Milton MA	PA0020273	$0	$0	$0	$3,814,671	$76,696	$321,396	$5,683,127	$112,144	$476,700
Montgomery Borough	PA0020699	$0	$0	$0	$2,566,507	$57,984	$222,618	$3,291,183	$77,453	$288,573
Moshannon Valley JSA	PA0037966	$0	$0	$0	$3,066,885	$62,920	$259,652	$4,510,730	$100,067	$389,418
Mount Joy	PA0021067	$0	$0	$0	$2,929,367	$56,610	$244,521	$4,296,010	$77,537	$353,114
Mount Union Borough	PA0020214	$0	$0	$0	$2,465,194	$50,502	$208,638	$3,218,882	$63,113	$269,595
Mountaintop Area	PA0045985	$0	$0	$0	$181,241	$64,537	$76,163	$1,972,495	$137,919	$264,449
Mt. Carmel Municipal Sewage Authority	PA0024406	$0	$0	$0	$3,234,471	$79,778	$287,260	$4,678,316	$109,540	$409,641
Mt. Holly Springs Borough Authority	PA0023183	$0	$0	$0	$2,444,284	$48,311	$205,104	$3,168,960	$61,362	$264,641

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Muncy Borough MA	PA0024325	$0	$0	$0	$2,998,186	$62,575	$254,900	$4,403,430	$83,305	$365,772
New Cumberland Borough Authority	PA0026654	$0	$0	$0	$2,894,913	$58,383	$244,083	$4,242,256	$72,483	$344,611
New Freedom WWTP	PA0043257	$0	$0	$0	$2,929,367	$61,546	$249,456	$4,296,010	$99,960	$375,537
New Holland Borough Authority	PA0021890	$0	$0	$0	$2,819,009	$58,751	$239,582	$4,123,890	$97,876	$362,411
New Oxford Municipal Facility	PA0020923	$0	$0	$0	$0	$0	$0	$942,264	$37,444	$97,888
Newberry Township	PA0083011	$0	$0	$0	$2,304,611	$48,327	$196,161	$2,835,875	$65,488	$247,402
Northeastern York Country	PA0023744	$0	$0	$0	$3,203,924	$66,014	$271,537	$4,724,971	$85,380	$388,473
Northumberland Borough	PA0020567	$0	$0	$0	$2,548,725	$51,570	$215,063	$3,418,460	$66,052	$285,336
Palmyra Borough Authority	PA0024287	$0	$0	$0	$3,011,935	$60,600	$253,807	$4,424,900	$86,841	$370,685
Penn Township	PA0037150	$0	$0	$0	$4,876,496	$97,677	$410,490	$7,362,568	$136,468	$608,755
Pine Creek MA	PA0027553	$0	$0	$0	$2,929,367	$62,319	$250,230	$4,296,010	$83,751	$359,328
Pine Grove Borough Authority	PA0020915	$0	$0	$0	$2,566,507	$58,279	$222,914	$3,291,183	$75,241	$286,361
Porter Tower Joint MA	PA0046272	$0	$0	$0	$0	$1,395	$1,395	$560,276	$24,286	$60,226
Roaring Spring Borough	PA0020249	$0	$0	$0	$0	$3,041	$3,041	$821,382	$27,964	$80,653
Sayre	PA0043681	$0	$0	$0	$3,367,738	$68,131	$284,162	$4,981,427	$83,309	$402,854
Scranton Sewer Authority	PA0026492	$0	$0	$0	$0	$85,177	$85,177	$11,673,110	$341,203	$1,089,999
Shamokin-Coal Township JSA	PA0027324	$0	$0	$0	$6,660,935	$163,547	$590,827	$10,227,835	$240,030	$896,117
Shenandoah Municipal SA	PA0070386	$0	$0	$0	$3,408,584	$69,167	$287,818	$5,045,434	$96,397	$420,047
Shippensburg Borough Authority	PA0030643	$0	$0	$0	$3,915,519	$80,883	$332,053	$5,841,877	$127,231	$501,970
Silver Spring Township	PA0083593	$0	$0	$0	$2,374,508	$47,610	$199,928	$3,002,478	$52,918	$245,519
South Middleton Township MA	PA0044113	$0	$0	$0	$2,548,725	$51,419	$214,912	$3,418,460	$65,314	$284,599
Springettsbury Township	PA0026808	$0	$0	$0	$0	$29,686	$29,686	$6,654,980	$256,095	$682,993
St. Johns	PA0046388	$0	$0	$0	$0	$185	$185	$724,676	$12,242	$58,727
Stewartstown Borough	PA0036269	$0	$0	$0	$2,304,611	$47,231	$195,066	$2,835,875	$58,511	$240,424
Sunbury City MA	PA0026557	$3,000,000	$63,044	$255,485	$3,197,930	$102,080	$307,218	$5,697,930	$182,367	$547,873
Swatara Township	PA0026735	$2,000,000	$32,982	$161,276	$2,000,000	$50,767	$179,062	$7,659,000	$123,800	$615,103
Towanda MA	PA0034576	$0	$0	$0	$160,000	$9,298	$19,562	$1,271,500	$32,968	$114,531
Tri-Boro MA	PA0023736	$0	$0	$0	$2,374,508	$47,736	$200,054	$3,002,478	$58,834	$251,434
Twin Boroughs SA	PA0023264	$0	$0	$0	$2,444,284	$50,110	$206,903	$3,168,960	$63,114	$266,393

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Tyrone Borough SA	PA0026727	$0	$0	$0	$0	$0	$0	$4,338,920	$99,159	$377,488
University Area JA	PA0026239	$780,000	$6,986	$57,021	$780,000	$6,986	$57,021	$1,300,000	$27,584	$110,975
Upper Allen Township	PA0024902	$0	$0	$0	$2,360,538	$50,070	$201,492	$2,969,167	$72,010	$262,474
Washington Township Municipal	PA0080225	$0	$0	$0	$160,000	$15,254	$25,518	$1,271,500	$47,511	$129,074
Waynesboro Borough	PA0020621	$0	$0	$0	$3,297,563	$120,030	$331,559	$4,776,149	$151,312	$457,689
Wellsboro MA	PA0021687	$0	$0	$0	$3,408,584	$73,375	$292,026	$5,045,434	$106,804	$430,455
Western Clinton County MA	PA0043893	$0	$0	$0	$0	$0	$0	$1,014,794	$12,018	$77,114
White Deer Township	PA0020800	$0	$0	$0	$2,423,823	$52,083	$207,564	$2,974,428	$63,250	$254,051
Williamsport SA-Central	PA0027057	$6,330,000	$137,056	$543,107	$6,634,134	$288,286	$713,846	$16,244,134	$545,016	$1,587,030
Williamsport SA-West	PA0027049	$5,246,000	$112,263	$448,779	$5,459,102	$184,866	$535,052	$15,219,102	$375,425	$1,351,686
Wyoming Valley	PA0026107	$0	$0	$0	$0	$71,004	$71,004	$24,690,000	$601,947	$2,185,739
York City	PA0026263	$0	$0	$0	$0	$0	$0	$11,080,000	$171,126	$881,876
PA Subtotal		**$72,079,813**	**$1,866,433**	**$6,490,146**	**$352,016,372**	**$9,203,774**	**$31,784,614**	**$670,716,278**	**$16,928,086**	**$59,952,609**
Alexandria	VA0025160	$0	$0	$0	$0	$0	$0	$21,709,370	$521,155	$2,104,456
Alleghany Co. Lower Jackson	VA0090671	$0	$0	$0	$3,234,471	$126,119	$362,014	$4,678,316	$149,719	$490,917
Aquia	VA0060968	$8,000,000	$160,000	$743,453	$8,000,000	$160,000	$743,453	$12,000,000	$195,000	$1,070,180
Arlington	VA0025143	$0	$0	$0	$0	$0	$0	$16,305,230	$489,067	$1,678,235
Ashland	VA0024899	$2,415,700	$45,093	$221,274	$2,590,872	$67,818	$256,774	$2,590,872	$76,193	$265,150
Broad Run WRF	VA_BROAD R	$7,500,000	$149,148	$696,135	$13,500,000	$159,069	$1,143,646	$18,224,930	$195,753	$1,524,928
Buena Vista	VA0020991	$0	$0	$0	$3,757,275	$90,102	$364,127	$5,490,628	$129,571	$530,012
Cape Charles	VA0021288	$0	$0	$0	$2,288,710	$48,501	$215,420	$2,674,915	$55,864	$250,950
Caroline County Regional	VA0073504	$0	$0	$0	$2,487,286	$55,063	$236,464	$3,115,256	$62,753	$289,954
Clifton Forge	VA0022772	$0	$0	$0	$3,583,756	$85,609	$346,979	$5,220,606	$120,531	$501,278
Colonial Beach	VA0026409	$90,000	$740	$7,304	$265,172	$16,310	$35,650	$3,625,172	$60,648	$325,038
Covington	VA0025542	$0	$0	$0	$4,273,345	$130,890	$442,552	$6,296,205	$175,535	$634,727
Crewe Stp	VA0020303	$0	$0	$0	$2,374,508	$47,295	$220,472	$3,002,478	$53,949	$272,925
Culpepper	VA0061590	$4,200,000	$82,381	$388,694	$4,200,000	$93,433	$399,746	$6,801,875	$145,678	$641,750
Dahlgren (Dahlgren Sanitary District)	VA0026514	$0	$0	$0	$30,000	$0	$2,188	$550,000	$13,469	$53,582

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Dale City #1	VA0024724	$0	$0	$0	$0	$0	$0	$1,060,000	$24,433	$101,741
Dale City #8	VA0024678	$0	$0	$0	$0	$0	$0	$1,060,000	$22,724	$100,032
Doswell	VA0029521	$3,045,000	$57,875	$279,952	$3,205,000	$143,615	$377,361	$3,205,000	$149,018	$382,764
Falling Creek	VA0024996	$395,818	$2,206	$31,074	$395,818	$19,918	$48,786	$5,993,818	$457,439	$894,578
Farmville	VA0083135	$0	$0	$0	$181,241	$19,315	$32,533	$1,972,495	$45,297	$189,154
Fishersville	VA0025291	$0	$0	$0	$1,443,064	$50,295	$155,540	$3,979,086	$88,878	$379,079
FMC	VA0068110	$0	$0	$0	$0	$13,603	$13,603	$2,949,284	$87,018	$302,115
Fredericksburg	VA0025127	$0	$0	$0	$0	$5,819	$5,819	$2,215,865	$59,822	$221,429
Front Royal	VA0062812	$0	$0	$0	$50,000	$2,469	$6,116	$4,840,000	$117,049	$470,038
FWSA Opequon	VA0065552	$0	$0	$0	$0	$6,903	$6,903	$6,390,000	$276,733	$742,766
Gordonsville	VA0021105	$0	$0	$0	$2,809,462	$58,281	$263,180	$3,862,938	$78,043	$359,774
H.L. Mooney	VA0025101	$0	$0	$0	$0	$0	$0	$8,011,100	$267,500	$851,763
Harrisonburg-Rockingham (North River Regional)	VA0060640	$0	$0	$0	$0	$0	$0	$7,040,990	$232,712	$746,223
Haymount STP	VA0089125	$2,687,559	$53,319	$249,327	$2,687,559	$57,246	$253,254	$3,750,706	$90,365	$363,910
Henrico County	VA0063690	$0	$0	$0	$300,000	$500,000	$521,879	$25,300,000	$4,770,175	$6,615,346
Hopewell	VA0066630	$0	$0	$0	$58,300,000	$2,748,200	$7,000,116	$71,500,000	$4,351,500	$9,566,114
HRSD-Army Base	VA0081230	$0	$0	$0	$81,000,000	$209,819	$6,117,284	$88,813,010	$556,083	$7,033,363
HRSD-Boat Harbor	VA0081256	$0	$0	$0	$112,000,000	$229,125	$8,397,471	$122,515,080	$679,691	$9,614,920
HRSD-Chesapeake/Elizabeth	VA0081264	$0	$0	$0	$35,000,000	$338,604	$2,891,212	$45,129,070	$853,532	$4,144,871
HRSD-James River	VA0081272	$0	$0	$0	$27,300,000	$184,767	$2,175,802	$35,885,030	$579,518	$3,196,673
HRSD-Nansemond	VA0081299	$0	$0	$0	$13,100,000	$43,772	$999,177	$25,545,130	$440,573	$2,303,622
HRSD-VIP	VA0081281	$0	$0	$0	$10,000,000	$0	$729,317	$26,305,230	$687,846	$2,606,330
HRSD-Williamsburg	VA0081302	$0	$0	$0	$15,800,000	$0	$1,152,320	$25,350,055	$312,147	$2,160,968
HRSD-York	VA0081311	$17,700,000	$132,100	$1,422,990	$17,700,000	$166,896	$1,457,787	$24,354,980	$422,229	$2,198,479
Kilmarnock	VA0020788	$0	$0	$0	$2,248,904	$65,962	$229,978	$2,586,756	$79,166	$267,822
Lake Monticello STP	VA0024945	$0	$0	$0	$2,566,507	$57,176	$244,355	$3,291,183	$78,511	$318,542
Leesburg	MD0066184	$0	$0	$0	$0	$10,322	$10,322	$2,736,978	$77,501	$277,114
Lexington-Rockbridge Reg. STP	VA0088161	$0	$0	$0	$205,516	$14,863	$29,851	$2,614,386	$35,274	$225,946
Little Falls Run	VA0076392	$0	$0	$0	$0	$0	$0	$4,000,000	$37,207	$328,934

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Luray	VA0062642	$0	$0	$0	$0	$0	$0	$3,360,000	$86,100	$331,150
Lynchburg	VA0024970	$0	$0	$0	$54,478,612	$928,781	$4,901,997	$55,323,612	$2,022,802	$6,057,645
Massanutten Public Service STP	VA0024732	$0	$0	$0	$2,685,114	$57,618	$253,448	$3,554,849	$71,330	$330,591
Massaponax	VA0025658	$0	$0	$0	$0	$0	$0	$3,952,910	$92,755	$381,047
Mathews Courthouse	VA0028819	$0	$0	$0	$2,094,204	$42,093	$194,827	$2,335,350	$48,162	$218,483
Middle River	VA0064793	$0	$0	$0	$247,998	$54,207	$72,294	$3,737,696	$176,155	$448,751
Montross - Westmoreland	VA0072729	$0	$0	$0	$2,094,204	$41,914	$194,648	$2,335,350	$44,268	$214,589
Moores Creek-Rivanna Authority	VA0025518	$0	$0	$0	$11,614,484	$428,783	$1,275,847	$18,269,464	$666,666	$1,999,089
New Market STP	VA0022853	$0	$0	$0	$2,487,286	$55,524	$236,926	$3,115,256	$77,469	$304,670
Noman M. Cole Jr. Pollution Control Plant	VA0025364	$0	$0	$0	$0	$0	$0	$15,338,696	$415,696	$1,534,373
Onancock	VA0021253	$0	$0	$0	$2,288,710	$53,538	$220,458	$2,674,915	$64,858	$259,944
Orange	VA0021385	$3,066,885	$59,901	$283,574	$3,234,471	$71,827	$307,723	$4,678,316	$93,586	$434,783
Parham Landing WWTP	VA0088331	$0	$0	$0	$2,423,364	$48,416	$225,156	$3,119,028	$52,112	$279,588
Parkins Mill	VA0075191	$0	$0	$0	$272,172	$22,047	$41,897	$3,632,172	$96,504	$361,404
Proctors Creek	VA0060194	$0	$0	$0	$0	$0	$0	$1,500,000	$526,000	$635,397
Purcellville	VA0022802	$0	$0	$0	$160,000	$8,452	$20,121	$1,271,500	$16,531	$109,263
Reedville	VA0060712	$0	$0	$0	$2,248,904	$46,528	$210,544	$2,586,756	$48,551	$237,207
Remington Regional	VA0076805	$0	$0	$0	$0	$0	$0	$1,636,850	$16,220	$135,599
Richmond	VA0063177	$32,050,000	$618,255	$2,955,715	$32,050,000	$816,628	$3,154,088	$59,935,530	$1,617,308	$5,988,507
Round Hill WWTP	VA0026212	$0	$0	$0	$2,487,286	$51,922	$233,324	$3,115,256	$57,823	$285,024
SIL MRRS	VA0090263	$0	$0	$0	$0	$0	$0	$0	$0	$0
South Central	VA0025437	$7,800,000	$338,000	$906,867	$7,800,000	$391,448	$960,315	$12,100,000	$708,448	$1,590,921
South Wales STP	VA0080527	$2,622,367	$52,058	$243,311	$2,622,367	$55,596	$246,849	$3,594,610	$85,891	$348,052
Stony Creek STP	VA0028380	$0	$0	$0	$2,566,507	$54,061	$241,241	$3,291,183	$64,029	$304,060
Strasburg	VA0020311	$0	$0	$0	$278,111	$13,538	$33,821	$2,928,111	$72,663	$286,215
Stuarts Draft	VA0066877	$0	$0	$0	$0	$11,513	$11,513	$520,000	$34,588	$72,513
Tangier Island	VA0067423	$0	$0	$0	$2,169,205	$45,611	$203,814	$2,410,351	$49,119	$224,910
Tappahannock	VA0071471	$0	$0	$0	$0	$0	$0	$918,088	$13,372	$80,330
Totopotomoy	VA0089915	$0	$0	$0	$0	$20,668	$20,668	$2,794,880	$133,621	$337,456

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Upper Occoquan SA	VA0024988	$0	$0	$0	$22,601,459	$1,272,000	$2,920,362	$22,601,459	$1,272,000	$2,920,362
Urbanna	VA0026263	$0	$0	$0	$2,169,205	$50,577	$208,781	$2,410,351	$59,150	$234,940
Warrenton	VA0021172	$0	$0	$0	$3,747,289	$74,015	$347,311	$5,577,144	$105,163	$511,913
Warsaw	VA0026891	$0	$0	$0	$2,328,485	$62,036	$231,857	$2,763,043	$71,873	$273,386
Waynesboro	VA0025151	$0	$0	$0	$3,705,516	$127,144	$397,394	$3,705,516	$142,355	$412,604
West Point	VA0075434	$0	$0	$0	$2,566,507	$58,492	$245,672	$3,291,183	$81,605	$321,636
Weyers Cave STP	VA0022349	$0	$0	$0	$2,487,286	$54,453	$235,855	$3,115,256	$70,135	$297,336
Widewater WWTP	VA0090387	$2,374,508	$47,445	$220,621	$2,487,286	$50,527	$231,929	$3,834,629	$66,693	$346,359
Wilderness Shores	VA0083411	$0	$0	$0	$3,007,691	$69,199	$288,555	$3,635,661	$90,618	$355,773
Woodstock	VA0026468	$0	$0	$0	$841,111	$21,141	$82,485	$3,491,111	$60,069	$314,682
VA Subtotal		**$93,947,837**	**$1,798,521**	**$8,650,293**	**$619,123,296**	**$11,187,478**	**$56,341,171**	**$953,000,102**	**$27,875,160**	**$97,379,045**
Berkeley County PSSD	WV0020061	$0	$0	$0	$2,803,451	$65,993	$216,696	$3,818,245	$87,127	$292,381
Berkeley County PSSD	WV0082759	$0	$0	$0	$3,826,474	$91,831	$297,527	$5,598,427	$116,742	$417,692
Charlestown	WV0022349	$0	$0	$0	$3,023,464	$72,361	$234,891	$4,351,506	$98,245	$332,165
Keyser	WV0024392	$0	$0	$0	$3,679,787	$75,198	$273,009	$5,471,041	$107,430	$401,532
Martinsburg	WV0023167	$0	$0	$0	$190,344	$42,604	$52,836	$2,213,204	$101,563	$220,536
Moorefield	WV0020150	$0	$0	$0	$2,566,506	$51,795	$189,761	$3,291,182	$52,335	$229,257
Petersburg	WV0021792	$0	$0	$0	$2,724,589	$66,531	$212,994	$3,642,677	$92,850	$288,666
Romney	WV0020699	$0	$0	$0	$2,487,286	$56,451	$190,158	$3,115,256	$74,353	$241,817
WV Subtotal		**$0**	**$0**	**$0**	**$21,301,901**	**$522,764**	**$1,667,872**	**$31,501,539**	**$730,645**	**$2,424,046**
Municipal Total		**$655,200,669**	**$11,012,892**	**$53,118,926**	**$1,615,116,578**	**$40,352,603**	**$148,348,647**	**$3,086,865,979**	**$81,311,617**	**$285,526,138**
Industrial Facilities										
Dupont-Seaford	DE0000035	$0	$0	$0	$0	$0	$0	$0	$0	$0
DE Subtotal		**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Allen Family Foods	MD0067857	$0	$0	$0	$0	$0	$0	$0	$0	$0
Bethlehem Steel Corporation-Sparrows Point	MD0001201	$0	$0	$0	$0	$0	$0	$0	$0	$0
Chemetals	MD0001775	$0	$0	$0	$0	$0	$0	$0	$0	$0
Congoleum	MD0001384	$0	$0	$0	$0	$0	$0	$398,764	$11,061	$45,153
Garden State Tanning	MD0053431	$0	$0	$0	$5,000,000	$400,000	$827,468	$10,000,000	$800,000	$1,654,936

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
MD & VA Milk Producers	MD0000469	$0	$0	$0	$7,350,911	$181,548	$810,004	$7,840,242	$196,844	$867,134
Mettiki Coal D	MD0064149	$0	$0	$0	$0	$0	$0	$0	$0	$0
Upper Potomac River Commission	MD0021687	$0	$0	$0	$0	$0	$0	$0	$109,197	$109,197
W R Grace	MD0000311	$0	$0	$0	$0	$0	$0	$0	$0	$0
Westvaco Corporation-Luke	MD0001422	$0	$0	$0	$0	$0	$0	$0	$0	$0
MD Subtotal		**$0**	**$0**	**$0**	**$12,350,911**	**$581,548**	**$1,637,472**	**$18,239,006**	**$1,117,102**	**$2,676,421**
Appleton Paper Springmill	PA0008265	$0	$0	$0	$0	$0	$0	$0	$23,341	$23,341
Chloe Textiles Inc.	PA0009172	$0	$0	$0	$0	$0	$0	$406,239	$12,159	$46,890
Consolidated Rail Corporation-Enola	PA0009229	$0	$0	$0	$0	$0	$0	$0	$0	$0
Empire Kosher Poultry-Mifflintown	PA0007552	$0	$0	$0	$0	$0	$0	$1,315,629	$33,331	$145,808
Gold Mills Dyehouse	PA0008231	$0	$0	$0	$0	$0	$0	$805,777	$21,430	$90,319
Heinz Pet Foods	PA0009270	$0	$0	$0	$4,166,532	$126,991	$483,203	$4,812,532	$147,153	$558,594
Merck & Company	PA0008419	$0	$0	$0	$337,450	$58,179	$87,029	$337,450	$126,782	$155,631
National Gypsum Company-Milton Plant	PA0008591	$0	$0	$0	$0	$718	$718	$0	$2,393	$2,393
Osram Sylvania Products, Inc.	PA0009024	$0	$0	$0	$0	$0	$0	$0	$5,863	$5,863
Pennsylvania Fish & Boat Commission-Bellefonte	PA0040835	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pennsylvania Fish & Boat Commission-Benner Springs	PA0010553	$0	$0	$0	$0	$0	$0	$3,180,697	$102,575	$374,505
Pennsylvania Fish & Boat Commission-Pleasant Gap	PA0010561	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pennsylvania Fish & Boat Commission-Typlersville	PA0112127	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pennsylvania Fish & Boat Commission-Upper Spring	PA0044032	$0	$0	$0	$0	$0	$0	$0	$0	$0
P-H Glatfelter Company	PA0008869	$0	$0	$0	$4,905,080	$86,637	$505,990	$10,576,472	$256,021	$1,160,242
Pope & Talbot Wis Inc.	PA0007919	$0	$0	$0	$0	$0	$0	$1,502,717	$51,235	$179,708
Proctor & Gamble Paper Products	PA0008885	$0	$0	$0	$4,674,320	$142,312	$541,937	$7,424,503	$257,765	$892,513
Tyson Foods	PA0035092	$0	$0	$0	$4,039,977	$79,131	$424,523	$4,716,300	$97,263	$500,476

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
PA Subtotal		**$0**	**$0**	**$0**	**$18,123,358**	**$493,968**	**$2,043,399**	**$35,078,315**	**$1,137,311**	**$4,136,284**
Allied Signal-Hopewell	VA0005291	$0	$0	$0	$0	$0	$0	$0	$0	$0
Amoco-Yorktown	VA0003018	$0	$0	$0	$0	$0	$0	$0	$0	$0
Brown & Williamson	VA0002780	$0	$0	$0	$0	$5,173	$5,173	$942,156	$34,534	$115,083
BWXT	VA0003697	$0	$0	$0	$0	$0	$0	$0	$2,588	$2,588
Dupont-Spruance	VA0004669	$0	$0	$0	$0	$0	$0	$0	$0	$0
Dupont-Waynesboro	VA0002160	$0	$0	$0	$0	$0	$0	$0	$0	$0
Georgia Pacific Corporation	VA0003026	$0	$0	$0	$254,176	$386,421	$408,151	$254,176	$425,365	$447,095
Hoechst Celanese	VA0003387	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lees Commercial Carpet	VA0004677	$0	$0	$0	$2,000,000	$0	$170,987	$2,000,000	$0	$170,987
Merck & Company Inc.-Stonewall Plant-Elkton	VA0002178	$0	$0	$0	$0	$0	$0	$800,000	$54,503	$122,898
Phillip Morris-Park 500	VA0026557	$0	$0	$0	$3,500,000	$1,300,000	$1,599,228	$11,500,000	$3,200,000	$4,183,177
Pilgrims Pride-Hinton	VA0002313	$0	$0	$0	$5,442,689	$247,682	$712,998	$6,109,177	$268,481	$790,776
Rocco Farm Foods-Edinburg	VA0077402	$0	$0	$0	$3,848,000	$0	$328,979	$3,848,000	$0	$328,979
Rocco Quality Foods	VA0001791	$0	$0	$0	$0	$0	$0	$0	$0	$0
St. Laurent Paper	VA0003115	$0	$0	$0	$0	$35,786	$35,786	$0	$135,464	$135,464
Tyson Foods, Inc.	VA0004031	$0	$0	$0	$0	$0	$0	$150,000	$1,200	$14,024
Tyson Foods, Inc.-Temperanceville	VA0004049	$0	$0	$0	$6,500	$150,000	$150,556	$631,500	$195,625	$249,614
Wampler Foods-Timberville	VA0002011	$0	$0	$0	$0	$0	$0	$0	$0	$0
Westvaco Corporation-Covington Hall	VA0003646	$0	$0	$0	$0	$0	$0	$12,340,085	$307,945	$1,362,943
VA Subtotal		**$0**	**$0**	**$0**	**$15,051,365**	**$2,125,063**	**$3,411,858**	**$38,575,094**	**$4,625,704**	**$7,923,629**
Hester Industries, Inc.	WV0047236	$0	$0	$0	$0	$0	$0	$0	$0	$0
Republic Paperboard	WV0005517	$0	$0	$0	$0	$0	$0	$0	$0	$0
Specratech International, Inc.	WV0005533	$0	$0	$0	$5,286,279	$107,156	$559,099	$5,736,257	$121,229	$611,642
Virginia Electric & Power Co.	WV0005525	$0	$0	$0	$0	$0	$0	$0	$0	$0
Wampler-Longacre, Inc.	WV0005495	$0	$0	$0	$0	$0	$0	$0	$0	$0
WV Subtotal		**$0**	**$0**	**$0**	**$5,286,279**	**$107,156**	**$559,099**	**$5,736,257**	**$121,229**	**$611,642**
Industrial Total		**$0**	**$0**	**$0**	**$50,811,912**	**$3,307,735**	**$7,651,829**	**$97,628,672**	**$7,001,346**	**$15,347,975**

Exhibit 40: Cumulative Point Source Facility Costs by Tier

Facility	NPDES	Tier 1 Costs			Tier 2 Costs			Tier 3 Costs		
		Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]	Capital	O&M	Annual Costs[1]
Grand Total		**$655,200,669**	**$11,012,892**	**$53,118,926**	**$1,665,928,490**	**$43,660,338**	**$156,000,476**	**$3,184,494,651**	**$88,312,963**	**$300,874,113**

1. Costs for municipal facilities are annualized at 2.4% for DC, 1.0% for DE, 2.2% for MD, 2.5% for NY, 3.9% for VA, and 0.7% for WV over 20 years. Industrial costs are annualized at 5.76% over 20 years.
2. Costs for Blue Plains are for the total facility and will be shared by the states of Maryland and Virginia, and the District of Columbia.

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