Clean Water Optimization Tool Case Studies

Through a grant from the Town Creek Foundation, the Center for Watershed Protection created a user-friendly and simple Clean Water Optimization Tool that Maryland Eastern Shore communities can use to develop more cost-effective strategies for reducing stormwater pollution, determine the practical limits of implementation, and track implementation and estimate progress towards goals. The Clean Water Optimization Tool is available for free at http://owl.cwp.org/ and includes the most up-to-date crediting procedures approved by the Chesapeake Bay Program and also allows the user to evaluate the impact of practices that have not yet been approved. These case studies are a result of testing out the tool with four Eastern Shore communities.

March 2015

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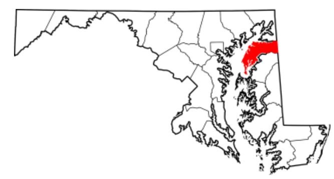
Clean Water Optimization Tool Case Study: Kent County



Background

Kent County, located on the upper Eastern Shore of Maryland, contains 209 miles of shoreline along the Chesapeake Bay, the Sassafras River and the Chester River. The County is home to quaint waterfront towns such as Chestertown, Betterton, Galena, Millington and Rock Hall as well as Washington College. The County is rich in historic and natural resources, and its proximity to water offers many water-related recreational opportunities.

To help achieve the nutrient and sediment reduction targets set by the Chesapeake Bay TMDL, Kent County was assigned the following nutrient load allocations for the stormwater sector: 73,920 lbs/yr of nitrogen (TN) and 3,455 lbs/yr of phosphorus (TP) by 2025. As of 2013, the required reductions to meet the targets are 41,066 lbs/yr of TN and 2,444 lbs/yr of TP. With only 1% of its area comprised of urban impervious surface and 5% urban turf, the County has extremely limited space available to install stormwater retrofit practices to meet these allocations, especially given that only a small portion of this urban land is publicly owned. The County's submitted Phase II Watershed Implementation Plan (WIP) Team strategy reflected this challenge by falling short of the targets. To meet the countywide sector targets, the Maryland Department of the Environment (MDE) supplemented the WIP Team scenarios with a generic set of BMPs. Yet, the level of implementation reflected by the final scenario is not likely to be achievable. The County has not estimated the cost associated with implementation of the final plan.

While some progress has been made on implementation, tracking this progress and quantifying the resulting load reductions using a consistent format is a challenge because numerous entities are involved, including several municipalities and the Sassafrass Riverkeeper. The County has indicated a need for assistance with implementation tracking with development of a cost-optimized BMP scenario that reflects an achievable level of implementation. The Clean Water Optimization Tool was used to:

1. Develop a cost estimate and associated nutrient reductions for an implementation scenario that takes into account practical constraints such as available land, site constraints and willingness of property owners to install practices
2. Evaluate the effect of cost optimization on the total cost of meeting the TMDL

Assessing the Impact of Realistic Implementation Scenarios

County staff indicated that the 2017 WIP Team BMP units submitted to the Maryland Department of the Environment represented the maximum they could feasibly implement for the BMPs available in MAST at that time, so it was used as a starting point for the scenario, which was developed for the timeframe 2013-2025. Since the WIP was developed, changes have been made to how the BMPs are credited in MAST. To account for these changes, as well as the differences between MAST and the Tool, modifications to the WIP scenario were made as shown in Table 1.

Table 1. Kent County 2017 WIP Team Scenario and Clean Water Optimization Tool BMP Scenario

BMP	Unit	Number of Units		Notes
		2017 WIP Team	Clean Water Optimization Tool	
Bioretention/rain gardens	Acres	107	107	100 acres bioretention 7 acres rain gardens
Bioswale	Acres	45	45	
Dry detention ponds and hydrodynamic structures	Acres	124	124	Included under hydrodynamic and filtering practices
Dry extended detention ponds	Acres	217	217	
MS4 permit stormwater retrofit	Acres	146	0	The County indicated this was an error in the WIP, as Kent County is not a regulated MS4 community
Stormwater management generic BMP (1985-2002)	Acres	3,284	0	Accounts for BMPs installed as part of new development and cannot be used to achieve TMDL reductions.
Stormwater management generic BMP (2002-2010)	Acres	2,229		
Urban filtering practices	Acres	53	24	Included under Hydrodynamic and Filtering Practices
Urban forest buffers	Acres	2	2	
Urban infiltration practices	Acres	9	9	
Urban tree planting	Acres	336	336	
Wet ponds and wetlands	Acres	86	86	37 acres wet ponds 49 acres wetlands
Erosion and sediment control on construction	Acres/yr	10	0	The Optimization Tool focuses only on BMPs that are implemented on developed land as retrofits, so these practices were not included
Forest conservation	Acres/yr	571	0	
Street sweeping mechanical monthly	Acres/yr	150	150	
Urban nutrient management	Acres	2,186	0	MDE has chosen to rely on automatic statewide nutrient reduction credits related to its urban nutrient management law, so this practice was not included as an option in the Tool.
Urban stream restoration/shoreline erosion control	Linear feet	6,488	6,488	6,038 stream restoration 450 living shoreline

BMP	Unit	Number of Units		Notes
		2017 WIP Team	Clean Water Optimization Tool	
Permeable pavers	Acres	0	29	Included under Filtering Practices in the WIP

The scenario shown in Table 1 results in a reduction of 6,020 lbs/yr TN and 1,004 lbs/yr of TP, which equates to 14% of the reductions required to meet the 2025 TN goal and 28% of the reductions required to meet the 2025 TP goal. While this is a respectable amount of progress for a small rural County such as Kent, the annual cost for this scenario is $4.7 million per year for a total of $93.4 million over 20 years.

Optimizing Based on Cost-Effectiveness

At the time of this case study, the County had not yet reassembled the WIP Team to discuss maximum practical implementation for "new" BMPs not included in MAST. However, they indicated that pet waste stations have been installed in Chestertown and that rain barrels are widely used throughout the County. Implementation levels were estimated for these two practices as shown in Table 2. The addition of these practices to the previously developed scenario would increase the County's progress towards the 2025 targets by 1% each for TN and TP, at an additional cost per year of $200,000.

Table 2. "New" BMPs Added to the Kent County Clean Water Optimization Tool BMP Scenario

BMP	Units	Number	Notes
Rainwater harvesting	Acres	20	Assumes ~ 500 homes install rain barrels, which the County indicates is a widely accepted practice
Pet waste program	Pet waste stations	10	Chestertown provides pet waste stations as parks but it is unclear how many; 10 was a conservative estimate

Figure 1 shows the BMPs included in the scenario developed for Kent County in order of cost-effectiveness for nitrogen removal. There may be opportunities to achieve some additional reductions by replacing some of the less cost-effective practices with similar BMPs that provide greater reductions per dollar spent. For example, permeable pavers are by far the most expensive practice at a cost of almost $4,000 per pound of nitrogen removed. If this practice was replaced with one that can more cost-effectively treat runoff from those same parking lots—for example, bioswales—we could increase the TN reduction by 1,490 lbs/year.

Practice	Units Treated	TN (lbs/yr reduced)	TP (lbs/yr reduced	TSS (lbs/y	Total Cost ($/yr)	$/lb T	$/lb T	$/lb T
Pet Waste Program	10	63.0	8.2	0	$7,689	$122	$936	
Forest Buffer	2	7.2	0.5	136	$2,395	$332	$5,148	$18
Rain Garden	7	34.0	2.3	896	$12,086	$356	$5,281	$13
Constructed Wetlands	49	142.0	14.4	7,642	$53,261	$375	$3,694	$7
Wet Ponds	37	107.2	10.9	5,770	$40,218	$375	$3,694	$7
Dry Swale/Bioswale	45	227.2	19.0	9,279	$89,301	$393	$4,702	$10
Stream Restoration	6038	1,207.6	410.6	327,562	$504,243	$418	$1,228	$2
Bioretention	100	500.1	39.8	18,667	$230,044	$460	$5,776	$12
Infiltration	9	45.0	3.6	1,680	$22,218	$494	$6,198	$13
Urban Tree Planting	336	2,643.1	334.7	199,055	$1,558,296	$590	$4,655	$8
Living Shoreline	450	48.0	34.5	84,240	$28,373	$591	$822	$0
Extended Detention Ponds	217	359.8	23.3	29,049	$391,957	$1,089	$16,857	$13
Rainwater Harvesting	20	113.6	14.6	9,202	$187,736	$1,653	$12,838	$20
Hydrodynamic and Filtering Practices	148	491.6	85.0	63,543	$960,233	$1,953	$11,294	$15
Street Sweeping	0	42.8	4.7	8,292	$128,790	$3,011	$27,362	$16
Permeable Pavers	29	164.7	21.2	13,343	$650,030	$3,947	$30,657	$49
Total:	**7,497**	**6,196.8**	**1,027.3**	**778,357**	**$4,866,870 per year OR $97,337,391 over 20 years**			
Percent of Required Reductions Met:		**14.5%**	**28.8%**					
Remaining Reductions Needed to Meet Targets		**36,599.1**	**2,536.0**	**0**				

Figure 1. Kent County Cost Optimized BMP scenario 2013-2025

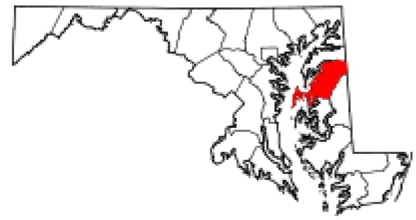
Similar replacements could be done for other BMPs in this scenario, with an emphasis on adding some practices not currently included, such as urban cover crops, outfall netting practices, ditch enhancement, and pond retrofits. Additional GIS and/or field analysis and discussion amongst the WIP Team partners are needed to quantify potential implementation for these practices. Lastly, if there are highly cost-effective practices whose implementation potential is limited by constraints such as property ownership, the County may want to consider whether developing incentives and outreach to encourage more widespread implementation could ultimately be a strategy to reduce costs.

Key Points

- With very limited urban land available to install BMPs, Kent County staff indicate that the BMP estimates provided by the WIP Team for 2017 strategy represent what is achievable in terms of implementation at this time.
- The Clean Water Optimization Tool incorporates recent changes in how BMPs are credited in the Chesapeake Bay Watershed Model, which have generally increased the credit given. Even with these changes, using the Tool to develop a scenario that reflects the level of implementation shown in the County's 2017 WIP Team strategy showed that only 14% of the 2025 TN target and 28% of the 2025 TP target would be met, at an estimated cost of $4.7 million/year.
- The addition of two new practices that are relatively cost-effective (pet waste programs and rainwater harvesting) would increase the County's progress by 1% for both TN and TP at an added cost of $200,000 per year. Similar incremental progress could be made by considering other cost-effective practices, such as pond retrofits, urban cover crops and outfall netting practices. Desktop/field assessment and discussion are needed to estimate the extent to which these practices can be applied within the County.

- While both scenarios show a respectable amount of progress for a small rural County such as Kent, the annual cost for the “optimized” scenario is $4.9 million per year for a total of $97.3 million over 20 years, which is likely more than an order of magnitude greater than the County’s available budget.

Clean Water Optimization Tool Case Study: Queen Anne's County



Background

Queen Anne's County, Maryland is located on the upper Eastern Shore of Maryland, bordered by Kent County to the north, Talbot County to the south, Caroline County to the southeast, the State of Delaware to the east, and the Chesapeake Bay to the west. Eight incorporated towns lie within the county: Barclay, Centreville, Church Hill, Millington, Queen Anne, Queenstown, Sudlersville, and Templeville. The County is approximately 5% urban, with the rest being primarily agricultural, with some forest.

To help achieve the Chesapeake Bay TMDL targets, Queen Anne's County was assigned nutrient load allocations for the stormwater sector of 132,484 lbs/yr of nitrogen (TN), 6,786 lbs/yr of phosphorus (TP) by 2025. The associated load reduction goals (as of 2013) to reach these targets are 62,984 lbs/yr of TN and 3,412 lbs/yr of TP. The County's Watershed Implementation Plan (WIP) Team submitted a plan to the Maryland Department of the Environment (MDE) that outlined how the County would work towards achieving these targets. In developing the final Phase II WIP for Maryland, MDE supplemented the WIP Team scenarios with a generic set of BMPs so that the countywide targets would be met. This resulted in a level of implementation for certain best management practices (BMPs) that is likely unachievable given the limited amount of urban land available. The County has not estimated the costs associated with implementation of the final stormwater scenario but indicated in their submitted WIP plan that these costs are very likely to be out of reach.

Purpose and Process

The Clean Water Optimization Tool was used to:

- Evaluate the costs and feasibility of implementation associated with the submitted WIP scenario
- Help the County identify the practical limits of implementation for the most cost-effective/applicable BMPs
- Help the County determine the nutrient and sediment reductions they can achieve and the associated cost

Using available GIS data and information gleaned from conversations with planners from Queen Anne's County, the Center followed the guidance provided in the Clean Water Optimization Tool User Manual to estimate the maximum practical units that can be treated. The Tool was then used to run two scenarios: (1) the 2025 final WIP strategy for Queen Anne's County; and (2) a cost-optimized scenario based on the aforementioned estimated maximum practical units treated.

2025 Final WIP Strategy

The BMP units for the MDE-backfilled 2025 final strategy are shown in Table 1, along with the changes that were made when using the Clean Water Optimization Tool to run the scenario, and brief explanations for those changes. Two major differences between the Tool and MAST that necessitate these changes are that 1) the Tool includes a broader range of BMPs that have been recently approved or are under consideration by the Chesapeake Bay Program and 2) the Tool focuses solely on retrofits to address pollutant loads from existing developed land and does not account for increased loads associated with future land use changes.

Table 1. Queen Anne's County 2025 Final WIP Strategy, and Clean Water Optimization Tool BMP Scenario

BMP	Units	2025 Final Strategy	Clean Water Optimization Tool	Notes
Bioretention/rain gardens	Acres	2,376	2,376	
Dry detention ponds and hydrodynamic structures	Acres	180	180	Included under Hydrodynamic and Filtering Practices
Dry extended detention ponds	Acres	107	107	
Impervious Urban Surface Reduction	Acres	787	787	
MS4 permit stormwater retrofit	Acres	146	0	Queen Anne's County is not a regulated MS4 community – this was an error
Stormwater management generic BMP (1985-2002)	Acres	3,284	0	Accounts for BMPs installed as part of new development and cannot be used to achieve TMDL reductions.
Stormwater management generic BMP (2002-2010)	Acres	2,229		
Urban filtering practices	Acres	6,892	6,892	Included under Hydrodynamic and Filtering Practices
Urban forest buffers	Acres	962	962	
Urban infiltration practices	Acres	266	266	
Vegetated open channels	Acres	12,119	12,119	
Wet ponds and wetlands	Acres	3,378	3,378	1,378 acres wet ponds 2,000 acres wetlands – assumed split favored wetlands due to low average elevation of County, and shallow water table
Erosion and sediment control on construction	Acres/yr	551	0	The Optimization Tool focuses only on BMPs that are implemented on

BMP	Units	2025 Final Strategy	Clean Water Optimization Tool	Notes
Erosion and sediment control on extractive	Acres/yr	88		developed land as retrofits, so these practices were not included
Forest conservation	Acres/yr	571		
Street sweeping mechanical monthly	Acres/yr	96	96	
Urban nutrient management	Acres	12,901	0	MDE has chosen to rely on automatic statewide nutrient reduction credits related to its urban nutrient management law, so this practice was not included as an option in the Tool.
Urban stream restoration/shoreline erosion control	Linear feet	55,000	55,000	45,000 stream restoration – assumed split favored stream restoration due to greater access, and greater nitrogen removal cost-effectiveness
				10,000 living shoreline

Despite several BMPs being removed from the Tool scenario (e.g., urban nutrient management, forest conservation), the 2025 targets were exceeded due to recent changes in BMP crediting protocols developed by Chesapeake Bay Program expert panels. The following load reductions and costs were estimated for the WIP scenario using the Tool:

- Total nitrogen (TN) reduction: 65,203.0 lbs/yr (103.5% of target)
- Total phosphorus (TP) reduction: 10,556.3 lbs/yr (309.4% of target)
- Total suspended solids (TSS) reduction: 8,720,536 lbs/yr
- Cost: $42,784,873 per year, or $855,697,467 over 20 years
- Average cost per pound of TN reduction: $656
- Average cost per pound of TP reduction: $4,053

Although this scenario actually exceeds the TMDL targets, the level of implementation (in particular the BMP units added by MDE) are unrealistic. For example, the 787 acres of impervious urban surface reduction added by MDE equates to roughly 13% of the impervious cover in the entire county, much of which is accounted for by residences. The 6,831 acres of urban filtering practices added by MDE is also quite unrealistic given that this number exceeds the total impervious cover available in the County. The WIP scenario shows 962 acres of urban forest buffers; yet GIS analysis indicates that there are only 657 acres of urban pervious land within 100 feet of streams. The cost associated with this scenario is another limiting factor, as Queen Anne's County Department of Public Works had a capital and operating budget of only $25,000 per year for stormwater retrofits as of 2009. The County now has additional funding for WIP projects, but at $150,000 per year this is still very short of what is needed to achieve the nutrient reduction goals. The 2025 final WIP strategy scenario, as it stands, is two orders of magnitude more expensive on a yearly basis than the County can currently afford. The Eastern Shore communities are all similarly under-funded given the large load reductions required, limited funds available for stormwater mitigation, and lack of available land on which to implement retrofit practices.

Clean Water Optimization Tool Cost-Optimized and Realistic Strategy

In order to develop a more realistic implementation scenario for the County, GIS data was analyzed to determine the physical limits of available space to install practices. Table 2 shows the pertinent metrics that were derived.

Table 2. Quantities of land uses and hydrological features in Queen Anne's County

Parameter	Quantity	Units	Notes
Urban pervious area	10,597	acres	
Urban impervious area	5,875	acres	
Percent of pervious land publicly owned	26	percent	2,755 acres
Percent of pervious land privately owned	69	percent	7,312 acres
Percent of impervious land publicly owned	10	percent	588 acres
Percent of impervious land privately owned	82	percent	4,817 acres
Streams	502	miles	
Shoreline	495	miles	
Tax ditches	*125*	miles	Extremely conservative estimate
Urban pervious land within 100 feet of streams	657	acres	

The values in Table 2 and other assumptions were used to estimate the maximum practical units treated for BMPs shown in Table 3. These units were entered into the Tool and optimized based on the most cost-effective practices for nitrogen reduction (cost per pound is shown in Table 3). Gray highlighted cells are practices not currently credited by the Chesapeake Bay Program.

Table 3. Entries into the Tool for maximum practical units treated, based on best available data

BMP	Units	Maximum Practical Units Treated	$/lb TN	Assumptions/Notes/Derivation
Downspout Disconnection	Acres	34.4	5	750 homes @ 1,000 sf/home (<5% of households), and an equivalent amount of commercial or institutional disconnection
Cross-sector trading	lbs/yr TN	6,298	50	Assumed nitrogen credits could be purchased from the agricultural community for $50/lb/yr and that use of trading would be limited to 10% of reduction goals.
Pet Waste Program	Number of pet waste stations	50	121	With 24 parks, multiple trails and public spaces, many allowing dogs, 50 seemed a conservative estimate
Vegetated Filter Strips	Acres	59	262	10% of publicly owned impervious cover
Conversion of Dry Pond to Wet Pond	Acres	50	304	The County indicated very few dry ponds – perhaps 5 – are in use. Assumed 10 acres average served by each.
Forest Buffer	Acres	164	341	25% of the open pervious land within 100' of a stream

BMP	Units	Maximum Practical Units Treated	$/lb TN	Assumptions/Notes/Derivation
Ditch Enhancement	Acres	29	432	Assuming 0.1 miles per year, 12' width, and a 20:1 treatment area - this could be a highly variable number. Assumed the County-owned farms that could be classified as urban land, or were adjacent to urban land, did not have more than one mile of ditches that were both feasible for retrofit, and practical given other site constraints.
Wet Ponds	Acres	20	434	Pond installation is limited on the Eastern Shore due to low elevations and high water table; conservative estimate based on conversation with County
Constructed Wetlands	Acres	10	434	The County has expressed interest in continuing stream, shoreline, and wetland improvements, but these are very time-consuming and expensive practices; conservative estimate based on conversation with County
Vegetated Open Channels	Acres	59	463	10% of publicly owned impervious cover
Bioretention	Acres	167	527	5% of publicly owned land
Rain Garden	Acres	20	561	200 homes @ 0.1 acres each rain garden - This can be incentivized in a manner similar to Montgomery County's RainScapes program, though this would change the life cycle costs
Living Shoreline	Linear feet	26,136	586	Assumption: 1% of shoreline is available for living shoreline restoration efforts - 4.95 miles (26,136 linear feet)
Urban Tree Planting	Acres	20	638	The County continues to plant trees, but even if including private incentives for tree planting, it is unlikely to exceed 20 acres, based on conversation with County
Urban Cover Crop	Acres	137.8	783	The County has expressed interest in increasing switchgrass planting; assumed 5% of publicly owned pervious cover
Stream Restoration (using interim rate option)	Linear feet	52,746	1104	Assumption: 5% of the streams adjacent to public lands and 1% of those adjacent to private lands are able to be restored, and good candidates for restoration efforts - ~10 miles (52,746 linear feet)
Rainwater Harvesting	Acres	17.2	1715	750 homes @ 1,000 sf/home – we assumed less than 5% of 17,292 households (2010 census) would take advantage of rainwater harvesting
Street Sweeping	Acres	150	3125	Centreville currently operates a street-sweeping program, and the County has expressed intent to increase this. We were unable to find this area, but assumed a 50' wide average right-of-way, and 25 linear miles of roads swept.
Impervious Cover Removal	Acres	1	4084	Very conservative estimate based on conversation with County staff
Permeable Pavers	Acres	2	4096	The County indicated this BMP was a low priority due to its high cost.

The estimated pollutant reductions and cost associated with this scenario are:

- TN reduction: 16,577.9 lbs/yr (26.3% of target)
- TP reduction: 7,272.7 lbs/yr (213.2% of target)
- TSS reduction: 7,329,540 lbs/yr
- Cost: $8.2 million per year, or $163.4 million over 20 years
- Average cost per pound of TN reduction: $493
- Average cost per pound of TP reduction: $1,123

While the Tool allows for development of scenarios that are optimized based on cost-effectiveness, implementation constraints are significant hurdles to achieve the load reduction goals. For example, downspout disconnection is by far the most cost-effective BMP, but its use in Queen Anne's County has a discrete limit. If we assumed that 10% of the County's impervious acres are comprised of rooftops, and that half of those rooftops already drain to yards and other pervious surfaces, this leaves only 293 acres available for treatment. Of these rooftops, perhaps 5-20% of the homeowners could be encouraged or incentivized to disconnect.

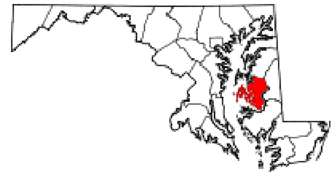
Although the level of implementation associated with this scenario is based on practical limits, the cost associated with implementation is out of reach for a County with an annual budget of $25,000 per year for stormwater retrofits. The scenario also only achieves 26% of the TN target. Innovative restoration and financing strategies are going to be needed to help the Eastern Shore communities meet these ambitious restoration goals.

Key Points

- The County's final WIP strategy meets the pollution reductions targets at a cost of $42.8 million per year, but the level of implementation specified is not realistic given the available urban land to install practices. The estimated cost is much greater than the County's annual budget for stormwater retrofits of $150,000.
- The reason the WIP strategy was still able to meet the TMDL targets using the Tool, even with removal of key practices such as urban nutrient management, is that the Tool incorporates recent changes in how BMPs are credited in the Chesapeake Bay Watershed Model, which have generally increased the credit given.
- Using the most cost-effective BMPs and more realistic estimates of how many BMPs can be installed, the County can achieve 26.3% of their TN reduction target and exceed their TP reduction target at a cost of $8.2 million per year, if accounting for 10% of their overall nitrogen reduction goals through cross-sector trading. The cost of pollutant removal for this scenario was reduced by $163/lb for TN and $2,930/lb for TP compared to the WIP 2025 scenario.
- The assumptions about BMP implementation made here were conservative; continued, directed efforts to assess the County's watersheds for retrofit feasibility are important, and will help more precisely identify the availability of land for various stormwater retrofits.
- For highly cost-effective practices that are heavily dependent on homeowner or business cooperation for implementation (such as downspout disconnection), the County may wish to assess the potential benefits against the costs of financially incentivizing private action, and administering the program(s).

- The inclusion of trading in the County's cost-optimized scenario increased the bottom line from meeting just 15% of the TN target to 26% of the target, yet they are still a long way off from their restoration goals. Although the assumptions made regarding trading were conservative, this exercise shows that if trading comes to fruition, it is not likely to be a "magic bullet" for the Eastern Shore counties.
- Given the current budgets available to Queen Anne's County and the estimated costs of restoration, innovative restoration and financing strategies are going to be needed to help meet these ambitious restoration goals.

Clean Water Optimization Tool Case Study: Talbot County



Background

Talbot County, located on the lower Eastern Shore of Maryland, contains several small municipalities including the Towns of Easton, Trappe, St. Michaels, and Oxford with approximately 270 square miles of land area. The County is highly rural in nature with agriculture one of the predominant industries. Land development has a direct impact on water quality given the proximity to the Chesapeake Bay with over 600 miles of shoreline. The dispersed nature of the urban centers requires the partnership and coordination of multiple stakeholders to ensure broad-based implementation of BMPs to meet the required Chesapeake Bay Total Maximum Daily Load (TMDL) load reductions.

Talbot County has roughly 4,500 acres of urban impervious area and 20,000 acres of urban pervious area within the Chesapeake Bay watershed. The four incorporated towns in the county are home to approximately 50% of the total population. These towns account for approximately 22% of the nitrogen loading from the urban sector in Talbot County. Although Talbot County is not a NPDES MS4 Phase II community, it proactively works with the towns and incorporated villages to implement stormwater management practices to capture and treat stormwater runoff.

To help achieve the nutrient and sediment reduction targets set by the Chesapeake Bay TMDL, Talbot County was assigned the following nutrient load allocations for the stormwater sector: 126,792 lbs/yr of nitrogen (TN) and 6,119 lbs/yr of phosphorus (TP) by 2025. As of 2013, the resulting reductions the County must achieve on developed land to meet the targets are 68,667 lbs/yr of TN and 4,234 lbs/yr of TP. With only 3% of its area comprised of urban impervious surface and 12% urban turf, the County has limited space available to install stormwater retrofit practices, especially when considering the portion of urban land that is publicly owned. While the County's Phase II WIP showed achievement of these targets, it requires a level of implementation that may not be feasible; yet little information is available regarding project feasibility on the County's urban lands. In addition, the WIP relies heavily on one practice, Urban Nutrient Management (UNM), which has been essentially taken off the table as an option.

Since the WIP was completed, the County has made progress on implementation of stormwater retrofits. The County has also secured funding for several more projects to be completed in the near future. There is no designated budget for stormwater and the annual budget for the entire Public Works Department is around $380,000, which leaves little room for stormwater implementation beyond funds received through grants.

The Clean Water Optimization Tool was used to:

1. Help the County identify "replacement" practices for Urban Nutrient Management

2. Estimate the potential cost savings associated with the use of BMPs that do not yet have a specified credit from the Chesapeake Bay Program
3. Evaluate how standardizing alternative practices to reduce implementation costs can affect overall cost savings

Bridging the Urban Nutrient Management Gap

According to the *Urban Nutrient Management Expert Panel Recommendation*s Appendix F (Schueler and Lane, 2013), Maryland has elected NOT to use written UNM plans or pledges as a major element of its state-wide WIP implementation efforts. Instead, Maryland has chosen to rely on automatic statewide nutrient reduction credits that are related to its state UNM law and subsequent regulations. These focus on both the "do it yourself" consumer and regulations on application rates and certification of commercial applicators. There is still the option that Maryland localities can report UNM plans for unfertilized lawns; however, the resources needed to identify unfertilized lawns, and track and verify the use of UNM plans for these lawns is likely beyond the capacity of most jurisdictions, especially smaller ones with limited staff such as Talbot County. This essentially puts this practice out of reach for many communities or, at best, greatly reduces the available credit. As Talbot County relied heavily on UNM for meeting their TMDL nutrient reduction goals, alternative practices need to be considered.

The Clean Water Optimization Tool was used to answer the following questions:

1. How much of a pollutant reduction gap is created by eliminating UNM from the County's WIP for the 2025 milestones?
2. What are potential BMP alternatives to UNM to meet milestone goals?
3. What are the costs of the resulting scenarios?

The first step was to run the 2025 WIP scenario through the Tool without UNM to determine the gap. 2013 was selected as the starting point for the scenario, so the BMP units for the scenario were derived by subtracting the 2010 Progress units from the 2025 Final Strategy units shown in the Maryland Phase II WIP Strategies document for Talbot County[i] and were entered in the "Scenario Setup" input tab of the Tool. The scenario results show a deficit of 23,110 lbs/year for TN and no deficit for TP (Table 1).

Table 1. Estimated TN and TP Reductions achieved by the 2025 WIP Strategy for Talbot County, excluding UNM, compared against the targets

Pollutant	2013-2025 Scenario		
	Target	Reductions Achieved	Deficit
TN	68,667 lbs/yr	45,557 lbs/yr	23,110 lbs/yr
TP	4,234 lbs/yr	5,913 lbs/yr	none

Practices included in the 2025 WIP and their level of implementation are shown in Table 2. The total cost for this scenario was estimated at $44 million per year, but it only meets 66% of the TN goal. It is clear the County will need to find "replacement' BMPs for UNM in order to meet their TN reduction goals.

Table 2. Results from Talbot County's 2025 WIP scenario excluding Urban Nutrient Management

Practice	Units Treated	TN (lbs/yr reduced)	TP (lbs/yr reduced)	TSS (lbs/yr reduced)	Total Cost ($/yr)	$/lb TN	$/lb TP	$/lb TSS
Forest Buffer	289	1,002.9	69.9	17,972	$343,261	$342	$4,914	$19
Vegetated Open Channels	7000	20,762.9	2,376.3	1,384,053	$8,348,797	$402	$3,513	$6
Bioretention	2000	10,097.5	818.9	382,984	$4,563,394	$452	$5,572	$12
Hydrodynamic and Filtering Practice	4297	13,468.2	2,450.3	1,913,022	$27,652,078	$2,053	$11,285	$14
Impervious Cover Removal	305	225.8	197.2	166,129	$3,270,566	$14,485	$16,589	$20
Total:	**13,891**	**45,557.3**	**5,912.5**	**3,864,161**	**$44,178,096 per year OR $883,561,917 over 20 years**			

To identify potential alternatives to UNM, the Tool was used to find the top five most cost-effective BMPs for reducing TN and TP in Talbot County. These BMPs are shown in Table 3. Starting with the BMPs in Table 3, some assumptions were made about how many units of each BMP could practically be implemented in the County to help fill in the gap left by UNM.

Table 3. Most cost-effective BMPs for Talbot County

Most Cost-Effective BMPs for Talbot County	
For TN Reductions	**For TP Reductions**
Downspout disconnection	Downspout disconnection
Pet waste program*	Stream restoration
Stream restoration	Living shoreline
Vegetated filter strips	Pet waste program*
Pond retrofits	Pond retrofits

* Not Chesapeake Bay Program Approved

In addition to assessing the BMPs in Table 3 as potential UNM replacements, BMPs already included in the WIP strategy were evaluated in terms of their cost-effectiveness to see if the number of units of less cost-effective BMPs could be replaced with those of similar BMPs that are more cost-effective. The following assumptions were used to develop a new 2025 scenario, focusing only on the BMPs that are approved by the CBP, and reduction results are summarized in Table 4:

- *Downspout Disconnection:* If an aggressive downspout disconnection program was started that was able to influence 15% of the households in the county (roughly 2,400 housing units or about 72 acres assuming houses comprise 10% of the impervious area). There would also be a program startup cost, which is not reflected in tabulated Tool costs.
- *Stream restoration:* Since little information in known about the overall condition of streams in Talbot County in terms of annual sediment loss, a conservative estimate of 10 stream miles (52,800 linear feet) being restored was used in this scenario. This is less than 1.5% of the stream miles in the county. Again, since little information about stream condition is known, interim stream restoration rates were used for this effort.
- *Vegetated filter strips:* An assumed treatment of 20% of the County impervious surfaces was used for this practice.
- *Pond retrofits*: There are a total of 100 stormwater ponds in the unincorporated county and Easton combined. Guidance for pond retrofits is provided in the Maryland Department of the Environment's document for Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated[ii], which applies to Talbot County even though the County is not an MS4. We

assumed only dry ponds would be considered (since their upgrade potential is high), and thatr 30 facilities would be upgraded, with an average drainage area of 15 residential or commercial acres to each facility.

- *Dry swales*: It was assumed that a portion of the 7,000 acres treated with vegetated open channels in the WIP could be replaced with a similar practice. Dry swales are similarin design but are more cost-effective so the scenario included 1,200 acres treated with dry swales as a replacement.
- *Living shoreline*: With over 600 miles of shoreline, reducing coastal erosion is a logical approach for Talbot County. The Chesapeake Bay Program suggests a cap on nutrient reductions associated with living shorelines of 33% of the waste load reduction goals. Implementing living shorelines up to the cap equates to about 20 miles of shoreline management activities (assuming a 15 foot wide project, a starting bank height of 2 feet, and a lateral recession rate of 2 feet per year). Note that credits for this practice will be change in the relatively near future, as this practice is "updated" by the Chesapeake Bay Program.

These assumptions were used to build a new scenario for 2025 that fills the gap left by UNM and optimizes BMPs based on cost-effectiveness for TN. Table 4 presents the results of the 2025 scenario, which essentially meets the TN reduction goal and substantially exceeds the required TP reductions. The annual price tag for this scenario is roughly $53 million, which is nearly 140 times the annual budget for Talbot County Public Works.

Table 4. Talbot County 2025 BMP scenario with urban nutrient management replaced

Practice	Units Treated	TN (lbs/yr reduced)	TP (lbs/yr reduced)	TSS (lbs/yr reduced)	Total Cost ($/yr)	$/lb TN	$/lb TP	$/lb TSS
Downspout Disconnection	72	385.8	52.3	34,352	$2,115	$5	$40	$0
Vegetated Filter Strips	900	4,543.9	368.5	172,343	$1,020,299	$225	$2,769	$6
Conversion of Dry Pond to Wet Pon	450	1,323.1	136.8	71,842	$340,674	$257	$2,491	$5
Forest Buffer	289	1,002.9	69.9	17,972	$343,261	$342	$4,914	$19
Dry Swale/Bioswale	1000	5,070.9	432.1	211,893	$1,968,293	$388	$4,556	$9
Vegetated Open Channels	6000	17,796.8	2,036.8	1,186,331	$7,156,112	$402	$3,513	$6
Stream Restoration	52800	10,560.0	3,590.4	2,864,400	$4,373,487	$414	$1,218	$2
Bioretention	2000	10,097.5	818.9	382,984	$4,563,394	$452	$5,572	$12
Living Shoreline	36960	3,943.8	4,233.7	6,918,912	$2,311,414	$586	$546	$0
Hydrodynamic and Filtering Practice	4297	13,468.2	2,450.3	1,913,022	$27,652,078	$2,053	$11,285	$14
Impervious Cover Removal	305	225.8	197.2	166,129	$3,270,566	$14,485	$16,589	$20
Total:	**105,073**	**68,418.6**	**14,386.7**	**13,940,181**	**$53,001,693 per year OR $1,060,033,854 over 20 years**			
Percent of Required Reductions Met:		**99.6%**	**339.8%**					

Reducing Costs with Alternative Practices

Next, the suite of BMPs included in the previous scenario were evaluated to determine if there were additional opportunities to reduce the total cost by substituting the more expensive practices with more cost-effective alternative techniques that were not previously included in the WIP. This analysis considered both "approved" BMPs and ones not currently credited by the Chesapeake Bay Program. For example, as shown in Figure 1, hydrodynamic and filtering practices constitute 52% of the cost but only provide 20% of the overall nitrogen reduction and are a good candidate for replacement. Simply eliminating the use of hydrodynamic and filtering practices would free-up $27.6 million for use in installing other practices. Another practice to reconsider is impervious cover removal, which makes up 11% of the cost but less than 1% of the TN reductions.

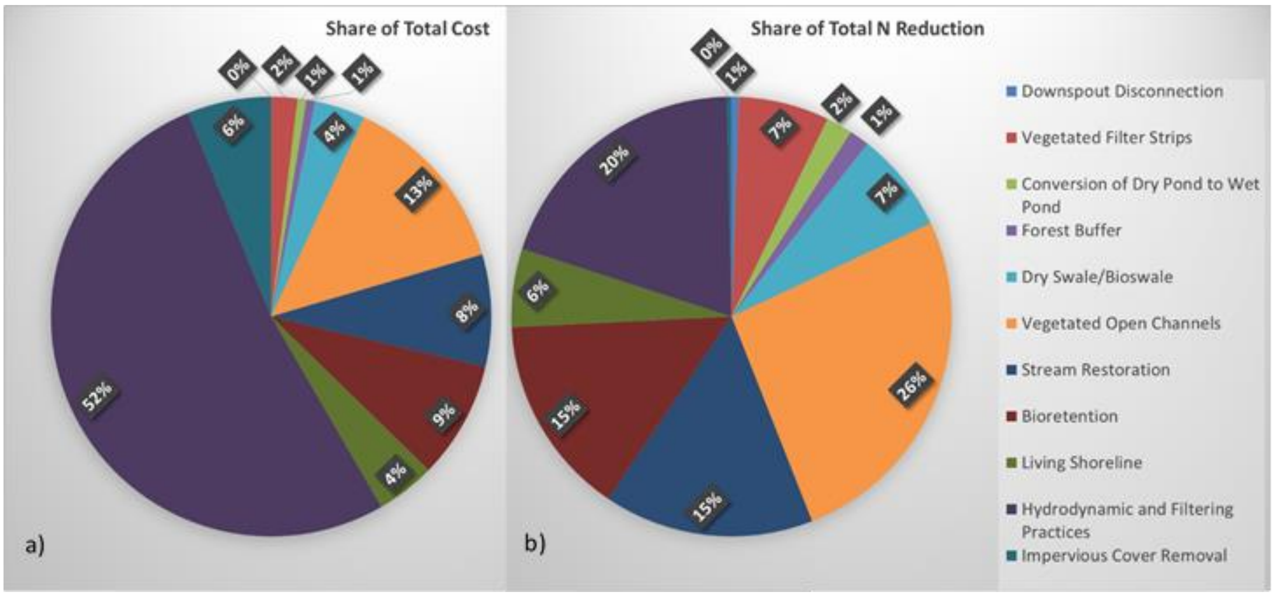


Figure 1. a) Relative cost breakdown and b) nitrogen reduction for BMPs in the Talbot County 2025 BMP scenario with urban nutrient management replaced

By eliminating these practices from the scenario, we can substitute more cost-effective practices like pet waste programs and rain gardens. In addition, the acres treated by vegetated open channels were replaced with dry swales/bioswales because they are similar in nature but more cost-effective per pound of nitrogen removed. Making these changes resulted in exceedance of the nutrient targets, allowing for a reduction in shoreline management of two miles (10,560 linear feet). The final scenario, shown in Table 5, would reduce costs over the previous scenario by $26.2 million annually. The total costs for this scenario is $26.8 million annually, or $537.5 million over 20 years.

Table 5. Optimized Talbot County 2025 BMP strategy

Practice	Units Treated	TN (lbs/yr reduced)	TP (lbs/yr reduced)	TSS (lbs/yr reduced)	Total Cost ($/yr)	$/lb TN	$/lb TP	$/lb TSS
Downspout Disconnection	72	385.8	52.3	34,352	$2,115	$5	$40	$0
Pet Waste Program	40	251.9	32.9	0	$30,505	$121	$929	
Vegetated Filter Strips	900	4,543.9	368.5	172,343	$1,020,299	$225	$2,769	$6
Conversion of Dry Pond to Wet Pon	450	1,323.1	136.8	71,842	$340,674	$257	$2,491	$5
Forest Buffer	289	1,002.9	69.9	17,972	$343,261	$342	$4,914	$19
Rain Garden	450	2,242.1	153.8	58,630	$770,657	$344	$5,012	$13
Dry Swale/Bioswale	7000	35,496.0	3,024.4	1,483,253	$13,778,048	$388	$4,556	$9
Stream Restoration	52800	10,560.0	3,590.4	2,864,400	$4,373,487	$414	$1,218	$2
Bioretention	2000	10,097.5	818.9	382,984	$4,563,394	$452	$5,572	$12
Living Shoreline	26400	2,817.0	4,233.7	4,942,080	$1,651,010	$586	$390	$0
Total:	**90,401**	**68,720.1**	**12,481.5**	**10,027,856**	**$26,873,451 per year OR $537,469,020 over 20 years**			
Percent of Required Reductions Met:		**100.1%**	**294.8%**					

*Pet waste programs are not a Chesapeake Bay Program approved practice

Reducing Costs through Standardization

The total costs to achieve the required urban reductions in Talbot County are so high because they rely heavily on stormwater retrofits, which tend to be expensive due to modifications of existing infrastructure. Costs are also highly site-dependent, and may reflect a lack of experience by local engineers and contractors in designing and constructing these practices. In theory, these costs will go down over time as the designs and process become more standard. The Clean Water Optimization Tool was used to evaluate the effect of standardizing the design for a BMP that is highly applicable in Talbot County: Ditch Enhancement.

Ditch Enhancement can broadly encompass a variety of practices installed within drainage ditches, but in the Tool they are assumed to function similar to a dry swale. Talbot County's WIP relied heavily on placing practices within the extensive ditch network (e.g., 7,000 acres of vegetated open channels), which provides an opportunity to test out and refine the various ditch retrofit designs that have been suggested and show great promise for cost-effective nutrient reduction. Currently, the Tool assigns a per-acre cost of roughly $3,800 to Ditch Enhancement, based on the assumption they have a similar design to dry swales. The Tool allows user to override the default costs (Table 6), so if the County were to aggressively pursue standardization of a ditch retrofitting effort, and reduce the per acre cost of installation to $1,520 (60% reduction in cost), the annual cost of the previous scenario could be reduced by $12.4 million if Ditch Enhancement replaced all the dry swales. This would bring the total annual cost down to $18.4 million.

Table 6. Sample table from the Clean Water Optimization Tool showing the potential to override default annual practice costs

2. BMP Cost Data:			
For each BMP, an average annual cost per unit treated is provided below, based on the County selected in the Scenario Setup sheet.			
Review the County-Specific costs, and if desired, enter annual per-unit cost data that better reflects local conditions in the User Defined column.			
BMP	**Units**	**Default Annual Cost per Unit**	**User-Defined Annual Cost per Unit**
Permeable Pavement	Acres	$22,232.23	
Permeable Pavers	Acres	$22,232.23	
Rainwater Harvesting	Acres	$9,310.32	
Stormwater Planter	Acres	$10,747.42	
Green Roof	Acres	$123,821.83	
Downspout Disconnection	Acres	$29.38	
Bioretention	Acres	$4,937.61	
Rain Garden	Acres	$4,937.61	
Green Streets	Acres	$14,060.59	
Vegetated Filter Strips	Acres	$2,453.26	
Hydrodynamic and Filtering Practices	Acres	$6,435.21	
Infiltration	Acres	$5,298.62	
Stormwater Tree Pits/Structural Soils	Acres	$28,938.35	
Sand Filter	Acres	$5,451.54	
Dry Swale/Bioswale	Acres	$3,932.45	
Wet Swale	Acres	$2,382.86	
Vegetated Open Channels	Acres	$2,382.86	
Regenerative Stormwater Conveyance	Acres	$20,944.44	
Wet Ponds	Acres	$2,544.60	
Constructed Wetlands	Acres	$2,544.60	
Extended Detention Ponds	Acres	$4,228.48	
Ditch Enhancement	Acres	$3,801.51	$1,520.60
Conversion of Dry Pond to Wet Pond	Acres	$1,786.84	
Forest Buffer	Acres	$1,187.75	
Urban Tree Planting	Acres	$4,600.00	
Impervious Cover Removal	Acres	$10,723.17	
Urban Cover Crop	Acres	$3,543.67	
Soil Augmentation	Acres	$5,558.42	
Pet Waste Program	Number of pet waste stations	$762.63	
Street Sweeping	Acres or Pounds	$851.61	
Outfall Netting System	Acres	$451.46	
Correction of Cross-Connections	Number of Repairs	$409.33	
Sewer Repair	Number of Repairs	$7,016.61	
User Defined	Acres	$0.00	
Living Shoreline	Linear Feet	$62.54	
Stream Restoration	Linear Feet	$82.83	

Key Points

- Since Talbot County's WIP relied heavily on urban nutrient management, which is no longer an option for most local jurisdictions, additional practices must be considered to meet the TMDL goals. Without urban nutrient management, the suite of BMPs in the WIP only achieve 66% of the TN goals (and exceed the TP goals)
- Replacing urban nutrient management with the top most cost-effective BMPs that are approved by the Chesapeake Bay Program (downspout disconnection, stream restoration, vegetated filter strips, pond retrofits and living shorelines), and substituting the more cost-effective dry swales

for some of the similar-in-design vegetated open channels resulted in a scenario that fills the TN gap at an annual cost of $53 million.

- Considering BMPs that are not yet credit by the Chesapeake Bay Program (pet waste programs), and replacing some of the less cost-effective practices (hydrodynamic and filtering practices, impervious cover removal, vegetated open channels) with more cost-effective ones (rain gardens, dry swales) resulted in a scenario that still meets both the TN and TP goals and reduces the annual cost by $26.2 million.
- Standardizing the design for newer but highly applicable practices such as ditch enhancement in order to reduce implementation costs by 60% could result in cost savings of $12.4 million per year if these practices are applied in place of the vegetated open channels specified in the 2025 WIP.
- Even the least expensive plan developed with the Tool, at a cost of $18.4 million per year, has a cost that is 48 times greater than the County's currently available budget of $380,000 for the Department of Public Works.

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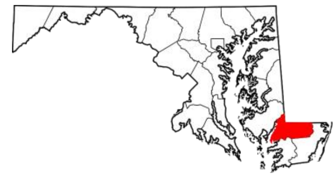
[i] http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Documents/WIP_P2_County_Strategy_Summaries/October2012/WIPII_BMP_Summary_TALBOT_Oct2012.pdf

[ii] http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20MS4%20Guidance%20August%2018%202014.pdf

Clean Water Optimization Tool Case Study: Wicomico County



Background

Wicomico County, located on the lower Eastern Shore of Maryland, contains the Shore's only NPDES regulated community (the City of Salisbury) as well as the City of Fruitland and the Towns of Delmar, Hebron, Mardela Springs, Pittsville, Sharptown and Willards. With the exception of Salisbury, the rest of the County is more rural in nature with agriculture one of the predominant industries.

To help achieve the nutrient and sediment reduction targets set by the Chesapeake Bay TMDL, Wicomico County was assigned the following nutrient load allocations for the stormwater sector: 206,105 lbs/yr of nitrogen (TN) and 11,122 lbs/yr of phosphorus (TP) by 2025 (the City of Salisbury has its own separate allocation). The resulting reductions the County must achieve on developed land to meet the targets are 52,340 lbs/yr of TN and 4,677 lbs/yr of TP. With only 3% of its area comprised of urban impervious surface and 10% urban turf, the County has limited space available to install stormwater retrofit practices to meet these allocations, especially given that only a small portion of this urban land is publicly owned. While the County's Phase II Watershed Implementation Plan (WIP) showed achievement of these targets, it had an estimated price tag of more than $694 million and required a level of implementation that may not be feasible given that stormwater retrofitting can be highly constrained by site conditions such as poorly drained soils and nearby utilities.

Since the WIP was completed, the County has made steady progress on implementation of stormwater retrofits, achieving an estimated reduction of 300 lbs/yr TN, 30 lbs/yr TP and 12,000 lbs/yr of TSS for 18 projects. The annual budget for stormwater management is only $200,000, yet County staff are committed to using these limited funds to protect and improve water quality both locally and in the Bay.

The Clean Water Optimization Tool was used to:

1. Help the County target their limited budgetary resources towards the most cost-effective BMPs
2. Estimate the cost associated with a BMP scenario that meets the Bay TMDL targets, prioritizes the most cost-effective practices and considers physical and practical constraints on implementation
3. Focus implementation efforts on locally impaired waters to improve both local water quality and the Bay

Targeting Existing Budget to Cost-Effective BMPs

The County's annual stormwater budget of $200,000 was entered into the Tool to identify the level of effort that could potentially be funded using the most cost-effective BMPs. The Tool automatically populates with the number of units that can be treated with the given budget for the top four most cost-effective BMPs for nitrogen removal (since nitrogen is considered to be the more difficult nutrient to control). These units were entered into the Tool in four separate scenario runs to determine the associated pollutant reductions. Table 1 presents the results.

Table 1. Nutrient Reductions Achieved with an Annual Budget of $200,000 for Top Cost-Effective BMPs

BMP	# of Units	TN Reduction (lbs/yr) and % of 2025 TMDL Target Met*	TP Reduction (lbs/yr) and % of 2025 TMDL Target Met*	Annual Cost
Downspout disconnection	6,835 acres	43,594 (63%)	4,810 (103%)	$199,991
Pet waste program	263 pet waste stations	1,656 (2.4%)	216 (4.7%)	$199,748
Vegetated filter strips	177 acres	795 (1.1%)	62 (1.4%)	$199,835
Pond retrofits	115 acres	422 (0.6%)	62 (1.3%)	$198,352

* Percent of 2025 target met accounts for progress through 2010 and reductions from 18 recently designed/implemented projects

While the number of units identified in Table 1 may not be practical for the County to implement, these results can help the County narrow their focus to the more cost-effective BMPs and further investigate what is feasible through desktop and field assessments. In some cases, there may a limited supply of available sites to install these practices, while for other BMPs, practical constraints create impediments to their widespread use. For example, while downspout disconnection is clearly a highly cost-effective practice, the area of rooftop available for this practice is significantly lower than the 6,835 acres shown in Table 1 (which exceeds the total impervious cover in the County). On top of that, the County indicates that many rooftops already drain to lawns, so opportunities for disconnection may be limited. The *User Manual for the Clean Water Optimization Tool* provides some guidance on how to quantify implementation potential for the suite of BMPs included in the Tool.

On the other hand, there are numerous ponds with retrofit potential in the County, but there is concern that because they are owned by HOAs, upgrading them could require the County to take over their maintenance. Further investigation into these BMPs and potential opportunities and constraints is warranted to help develop a more realistic picture of what level of implementation is achievable with the County's annual budget and also determine if implementation of these more cost-effective practices can be accelerated through the creation of incentive programs, such as for downspout disconnection.

Reduced-Cost Scenario to Meet Bay TMDL Goals

Wicomico County's Phase II WIP strategy for achieving the urban load reductions showed achievement of the targets at a cost of $57.9 million per year, for a total of $694.6 million over 12 years. When this scenario was developed, it was limited to the BMPs available in MAST at that time, and was based on very preliminary (desktop) assumptions about the actual feasibility of implementing those BMPs. Since the WIP development, Chesapeake Bay Program Expert Panels have not only added BMPs to the toolbox but have also revised how some BMPs are credited. All of these changes are incorporated into the Tool and "up and coming" BMPs are also included so they can be considered during strategy development.

Three scenarios were compared for Wicomico County: 1) the original Phase II WIP, 2) a scenario developed using the Tool that includes the same BMPs and units as the Phase II WIP, and 3) a new cost-effective scenario developed with the Tool that considers all BMPs. Scenario 2 mirrored the BMPs included in the Phase II WIP to evaluate how recent changes in BMPs and credits have affected the total reductions and cost. Scenario 3 was developed based on the most cost-effective BMPs for reducing nitrogen in the County, and was also more conservative in its assumptions about the feasibility of retrofitting existing impervious cover, give the numerous challenges of the retrofit process and limited available public lands to install BMPs. Table 2 presents the total pollutant reductions and cost achieved by each of the three scenarios.

Table 2. Comparison of Urban BMP Scenarios for Wicomico County

Scenario	Percent of TN Reductions Achieved	Percent of TP Reductions Achieved	Annual Cost	Total Cost Over 12 Years
1. Phase II WIP	105%	100%	$57.9 million	$694.6 million
2. BMP units from Phase II WIP run through Clean Water Optimization Tool	152%	272%	$50.9 million	$610.9 million
3. Optimized Scenario using Clean Water Optimization Tool	101%	213%	$27.3 million	$327.3 million

The results clearly show the value of the Expert Panel review of BMPs and their effectiveness based on the resulting increase in pollutant load reductions for scenario 2 as compared to scenario 1 for implementation of the same number of BMP units. The cost for scenario 2 is slightly lower than for scenario 1, but it greatly exceeds the nutrient reduction targets, so the actual cost would be much lower. The optimized scenario (scenario 3) meets the TMDL targets and reduces the total annual cost by 30.6 million. It also is more likely to be achievable from a practical standpoint, as this scenario assumes treatment of only 30% of the County's urban impervious cover, compared to almost 60% in the Phase II WIP scenarios. Table 3 shows the BMPs included in the optimized scenario and the assumptions made regarding the units treated. This scenario was generally developed by starting with the units in the WIP, adding some of the newer more cost-effective practices, and scaling back on the units for the less cost-effective practices. Figures 1-3 show the portions of the total nutrient reductions and costs that are attributed to each BMP.

Table 3. Optimized Urban BMP Scenario for Wicomico County

BMP	Units Treated	Assumptions
Downspout disconnection	10 acres	Conservative estimate included because this BMP is the top most cost-effective practice; Assuming an average 1,000 sq. ft. rooftop, this would require disconnection of 435 directly connected downspouts
Vegetated filter strips	420 acres	Newly approved practice that is very cost effective; Assumed that 420 acres of bioretention identified in the WIP could be shifted to this practice
Conversion of dry pond to wet pond	460 acres	WIP identifies 460 acres of land treated by dry ponds; although it is not likely to be feasible to retrofit all existing dry pond, there are an additional 6,120 acres treated by wet ponds with some retrofit potential. Cost of maintenance is included in scenario.
Forest buffer	85 acres	Units identified in WIP
Ditch enhancement	315 acres	Ditch enhancement is not yet available in MAST but is more cost-effective than bioretention and bioswales; Assumed that 315 of bioswales identified in WIP would be located in ditches
Stream restoration	26,400 linear feet	Units identified in WIP
Constructed wetlands	2,500 acres	Reduced from 3,003 acres of wet ponds and wetlands identified in WIP; Assumed all would be wetlands because more cost-effective than wet ponds
Vegetated open channels	1,200 acres	Reduced from 1,260 acres identified in WIP
Urban tree planting	1,700 acres	Reduced from 2,500 acres identified in WIP; Ranked low on cost-effectiveness but provides additional community and ties in with County's UTC program; Costs can be reduced if purchase of land is not required.
Living shoreline	150,000 linear feet	Reduced from 158,400 linear feet identified in WIP
Street sweeping	400 acres	One of the least cost effective practices for nutrients, but the County already sweeps 595 acres of streets each year; In this scenario they could reduce this acreage to 400

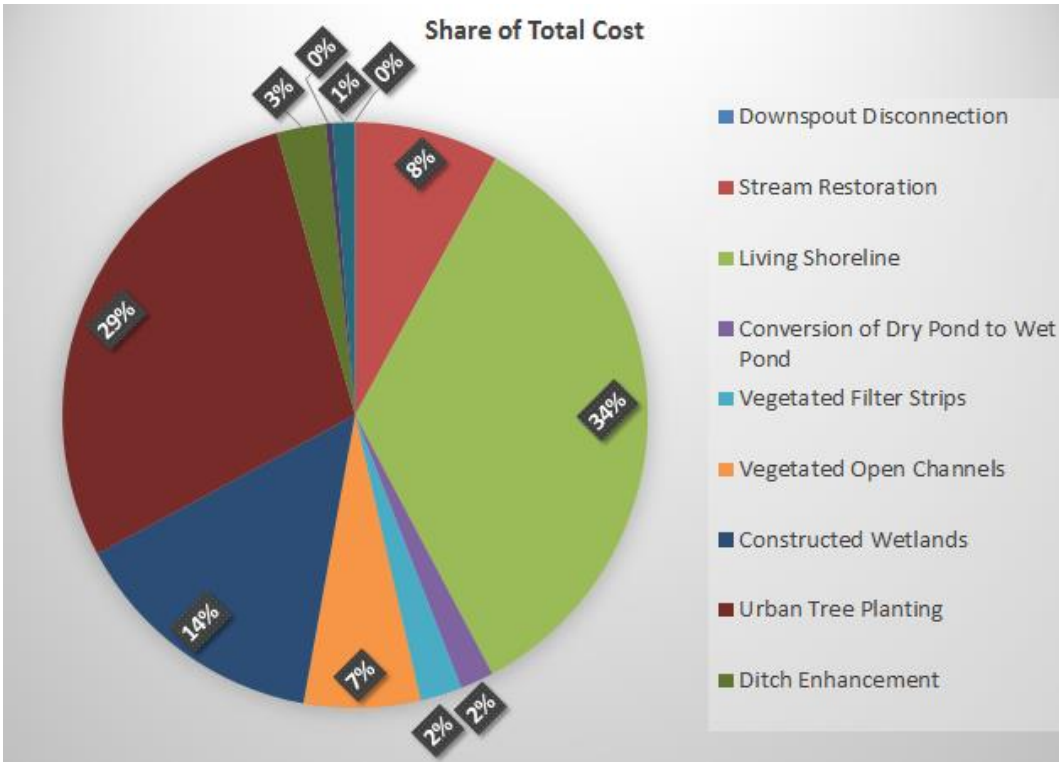


Figure 1. Optimized Scenario BMPs As a Share of Total Cost

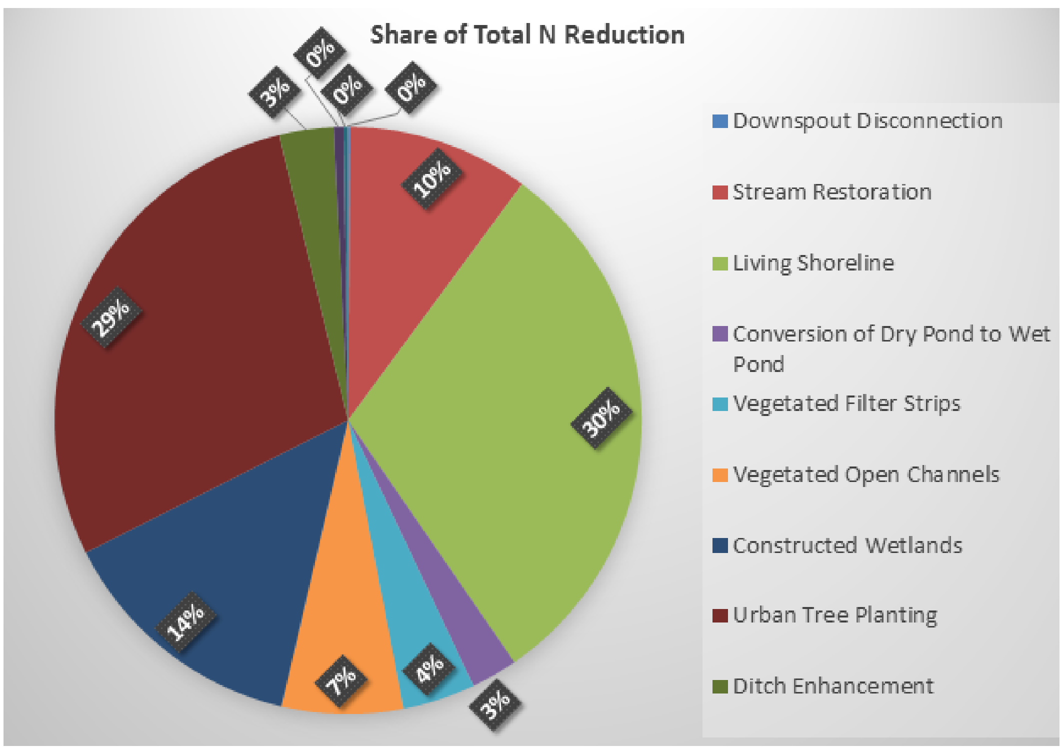


Figure 2. Optimized Scenario BMPs As a Share of Total Nitrogen Reduction

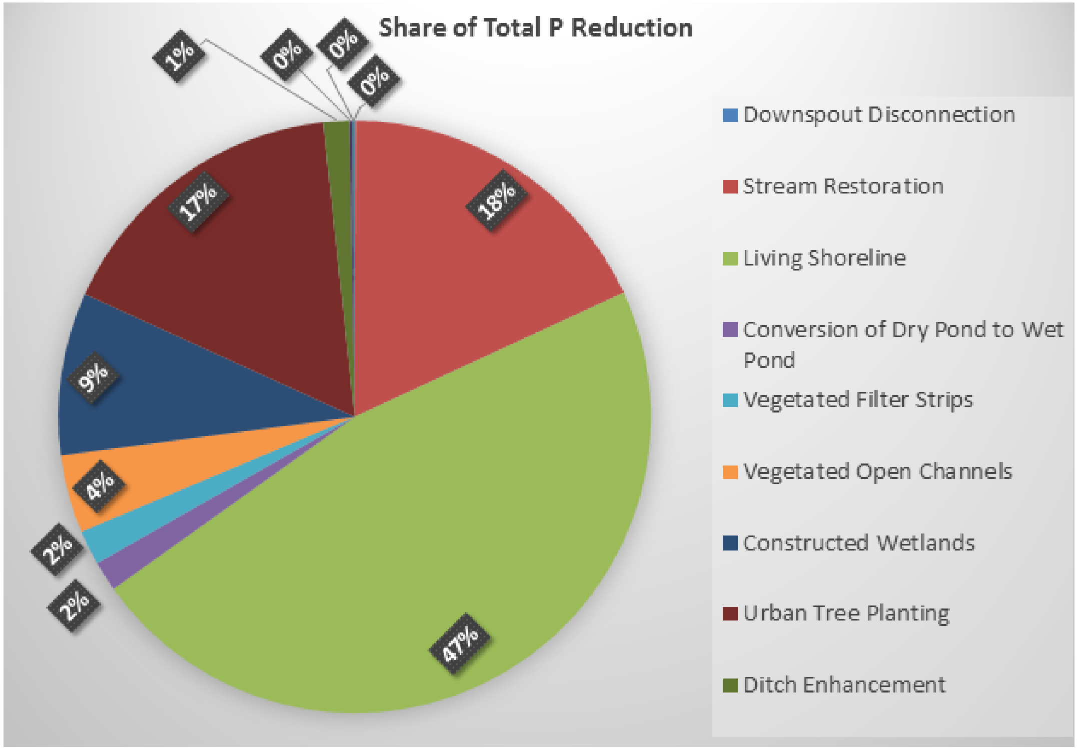


Figure 3. Optimized Scenario BMPs As a Share of Total Phosphorus Reduction

Focusing on Local Water Quality

The Tony Tank subwatershed of the Wicomico River Watershed (Figure 4) was selected as the focus area for the second part of the case study. Tony Tank Lake is impaired for phosphorus and sediment and a TMDL was approved by EPA in 1999. In 2013, the Center for Watershed Protection completed a watershed assessment and management plan for the Wicomico River that identified restoration opportunities in the Tony Tank subwatershed.

The Clean Water Optimization Tool was used to develop two scenarios that answer the following questions:

1. If the restoration projects identified in the Tony Tank subwatershed are fully implemented, will the local TMDL be met?
2. For the restoration projects identified in the County portion of the Tony Tank subwatershed, how much progress towards the Bay TMDL reduction goals can be made?

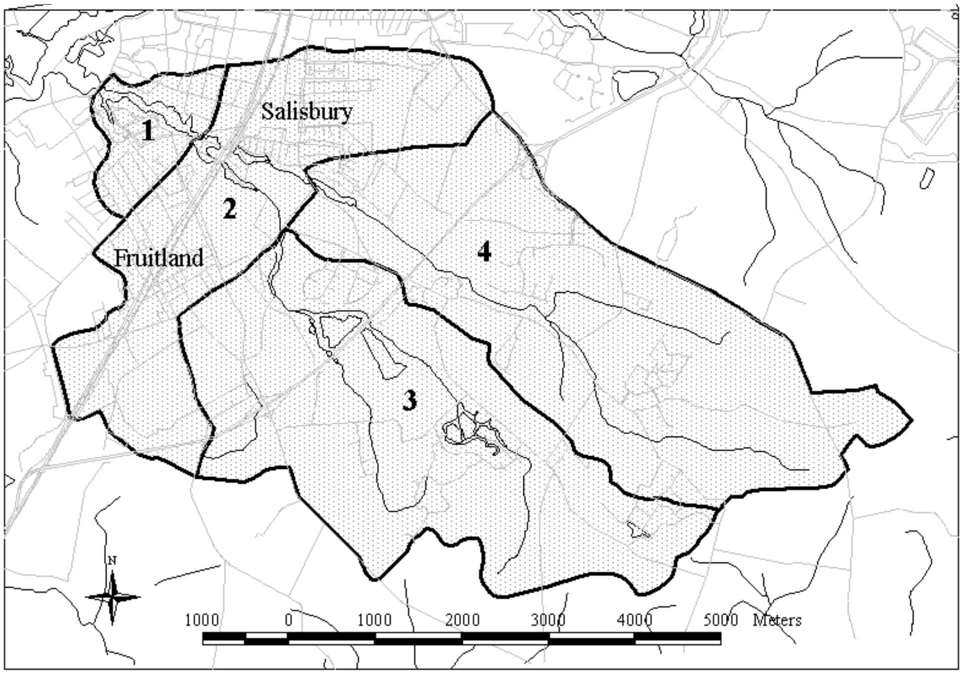


Figure 4. Tony Tank Lake Subwatershed (Source: Maryland Department of the Environment)

First, to determine the required reductions for the local TMDL, we used the following information from the approved TMDL:

- TMDL for TP (includes load allocation and margin of safety): 735.7 lbs/yr
- TMDL for TSS (includes load allocation and margin of safety): 188.3 tons/yr

The TMDL document states that to meet the TMDL will require a 63.5% reduction in TP loads and a 31.8% reduction in sediment loads. This information (and a conversion from tons to pounds of sediment) was used to calculate the loads and required reductions (for all source sectors combined) shown in Table 4.

Table 4. Phosphorus and Sediment Loads and Required Reductions to Meet the Tony Tank Lake TMDL

Calculation	TP	TSS
Pollutant Loads (lbs/yr)	2,104.63	828,301.89
Required Reductions (lbs/yr)	1,279.92	263,400

These values were entered in the Scenario Setup worksheet of the Tool in the "Reduction Goal for Scale Other Than County" column and serve as the target for the scenario that was subsequently developed.

Next, the Wicomico River Watershed Management Plan was consulted to isolate the restoration projects identified in the Tony Tank subwatershed by the Center during the field assessment. Table 5 shows the BMPs, units treated and impervious percentage in the drainage area that were entered into the “Maximum Practical Units Treated” columns of the Tool. This included all projects identified as viable for implementation in both the Wicomico County and City of Salisbury portions of the watershed, upstream of Tony Tank Lake.

Table 5. Restoration Projects Identified in Tony Tank Lake Subwatershed

BMP	Units Treated	Impervious % in Drainage Area
Urban Tree Planting	52.75 acres	N/A
Forest Buffers	0.90 acres	N/A
Bioretention	4.68 acres	56
Infiltration	0.24 acres	95
Outfall Netting System	12.95 acres	95
Dry Swales	0.75 acres	90
Regenerative Stormwater Conveyance	2.58 acres	49

The total annual load reductions resulting from implementation of the BMPs in this scenario represent only 1% of the required reductions for the TP TMDL and 4.3% of the required reductions for the sediment TMDL. The annual cost (based on life-cycle costs over 20 years) to implement this scenario is $300,136 for a total of $6 million over 20 years. Note that Table 5 contains a very limited number of projects, since the assessment of Tony Tank subwatershed was not specifically focused on meeting either the Bay or local TMDL and the budget for field assessment was limited. Additional projects could likely be identified to increase the pollutant reductions. In addition, this scenario does not include any reductions from other sectors such as agriculture, which will need to contribute to the water quality improvements as well.

Next, a new scenario was created for Wicomico County where only the BMPs recommended for the County portion of the subwatershed were included. If these BMPs were fully implemented (see Table 6 for units), they would result in achievement of 0.5% of the required TN reductions, and 0.6% of the required TP reductions for the Bay TMDL, at an annual cost of $172,464 ($3.4 million over 20 years). Note that this scenario does not include County-wide practices such as street sweeping, which was included in the Phase II WIP. Although the Tony Tank Lake subwatershed is only a small portion (3%) of the County’s total area, it is located within the “urban” section of the County, where most of the stormwater retrofit opportunities are likely to be found.

Table 6. Restoration Projects Identified in Tony Tank Lake Subwatershed- County Portion Only

BMP	Units Treated	Impervious % in Drainage Area
Urban Tree Planting	27.16 acres	N/A
Forest Buffers	0.8 acres	N/A
Bioretention	3.17 acres	75
Outfall Netting System	12.95 acres	95
Dry Swales	0.75 acres	90
Regenerative Stormwater Conveyance	2.24 acres	43

Key Points

- Urban BMP strategies to meet WIP goals are limited to the practices available in MAST, do not prioritize the most cost-effective BMPs and often do not account for practical constraints on implementation. The Clean Water Optimization Tool was used to develop BMP scenarios for Wicomico County that addresses these issues.
- The most cost-effective stormwater BMPs for nitrogen removal in Wicomico County are downspout disconnection, pet waste programs, vegetated filter strips and pond retrofits.
- Even with the most cost-effective BMPs, the County's Bay TMDL targets cannot be achieved with an annual budget of $200,000.
- If the entire $200,000 was spent on the top most cost-effective practice, only 63% of the TN goal would be met, and the TP goal would be exceeded. However, this level of implementation is not practical based on the available acres of rooftop for disconnection in the County.
- The County can further investigate opportunities and physical/practical constraints to implementing the most cost-effective BMPs to determine what is actually achievable with the given budget using the guidance provided with the Tool on desktop and field assessment methods.
- For those BMPs with high cost-effectiveness and plenty of available opportunities, the County may want to weigh the costs associated with gaining access to these sites (e.g., establishing an incentive program to help homeowners disconnect their downspouts; taking over pond maintenance from HOAs; subsidizing the cost of residential tree planting) against their potential future benefits.
- Recent changes in how urban BMPs are credited in the Chesapeake Bay Watershed Model have increased the credit available for practices such as stormwater retrofits and stream restoration, which could substantially change the cost associated with the Phase II WIP strategies.
- An N-optimized scenario developed for Wicomico County that meets the Bay TMDL targets has an associated cost of $27.3 million per year, or $327.3 million over 12 years.
- While the estimated cost is currently out of reach for the County with its available budget, it does represent a reduction of $30.6 million per year (or $367.3 million over 12 years) compared to the original Phase II WIP estimate.
- The optimized scenario also reduced by half the percent of the County's urban impervious cover treated, which is still very high but is more in line with findings from stormwater retrofit inventories that 7-25% of impervious cover assessed is feasible to install retrofits.
- Restoration projects identified through watershed assessments can help to meet local TMDL goals and their nutrient and sediment reductions can also be counted towards the Bay TMDL.
- Projects identified for the Tony Tank subwatershed would achieve just 1% of the TP reductions and 4.3% of the TSS reductions for the Tony Tank Lake TMDL. Additional information is needed to quantify the reductions from other sectors and determine if additional restoration projects can be identified.
- Projects implemented in the County portion of the Tony Tank subwatershed would achieve just 0.5% of the TN reductions and 0.6% of the TP reductions required for the Bay TMDL.

- The County and local partners (e.g., Wicomico Environmental Trust) should continue to complete field assessments to identify restoration opportunities in the County, focusing their efforts on the five subwatersheds with nutrient and/or sediment impairments, as well as the three segments with bacteria impairments. This approach will ensure that restoration is targeted to local problems but the benefits can also be quantified in terms of meeting Chesapeake Bay restoration goals.
- Future assessments should consider “new” BMPs included in the Tool, such as urban cover crops (e.g., planting switchgrass or other ground cover on urban turf), or pet waste stations to improve the understanding of the extent to which these BMPs can be used to meet water quality goals.