APPENDIX A

EIP Report: Stormwater Backup in the Chesapeake Region

Stormwater Backup in the Chesapeake Region

Hit by Increasing Rainfall, Pennsylvania and Maryland Retreat in their Plans to Control Stormwater Pollution

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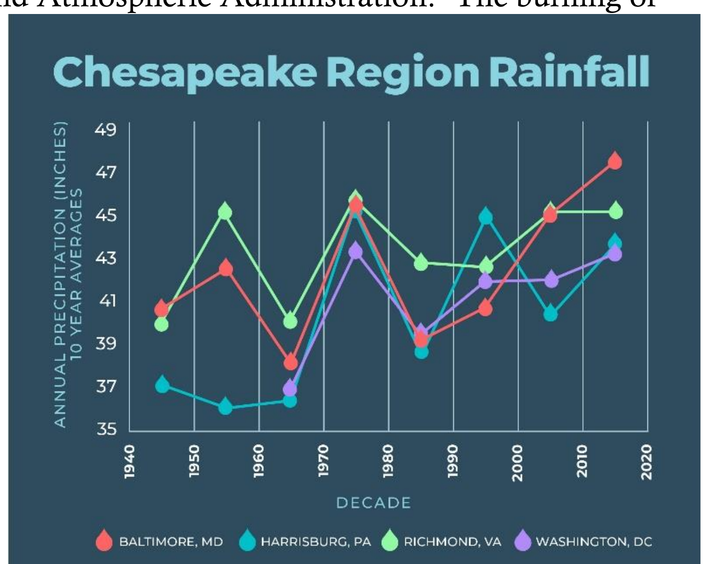
Stormwater Backup:

Despite Increasing Rainfall, PA and MD Retreat in their Plans to Control Stormwater Pollution

Executive Summary

In 2018, record-setting amounts of rain drenched the Chesapeake Bay region, including 72 inches in Baltimore – which was 75 percent more than the annual average stretching back to the 1940s.[1] Another 67 inches deluged Washington, D.C., 64 inches pummeled Richmond, and 62 inches flooded Harrisburg, among other locations. The amount of fresh water pouring into the nation's largest estuary in 2019 was by far the highest ever recorded, averaging 130,750 cubic feet per second, according to U.S. Geological Survey.[2] While many people think of rain as a cleansing force, in our modern world, because of all the fertilizers on lawns and farms and the oil and antifreeze on our roads and parking lots, increased precipitation sweeps more pollution off of these surfaces and into our waterways. This results in more sediment clouding the Bay's waters and more nitrogen and phosphorus fueling algae blooms and fish-killing low-oxygen "dead zones."

Both of these recent high-water years dealt blows to Chesapeake cleanup efforts.[3] But they were not freakish events. In fact, the amount and intensity of rainfall across the whole region has been gradually creeping upward for the last century, according to data from the National Oceanic and Atmospheric Administration.[4] The burning of fossil fuels has wrapped an insulating blanket of greenhouse gases around the Earth, heating the atmosphere. Warmer air retains more moisture, leading to more precipitation in some areas, including the Chesapeake Bay watershed.



Ten year average rainfall totals from National Oceanic and Atmospheric Administration (NOAA).

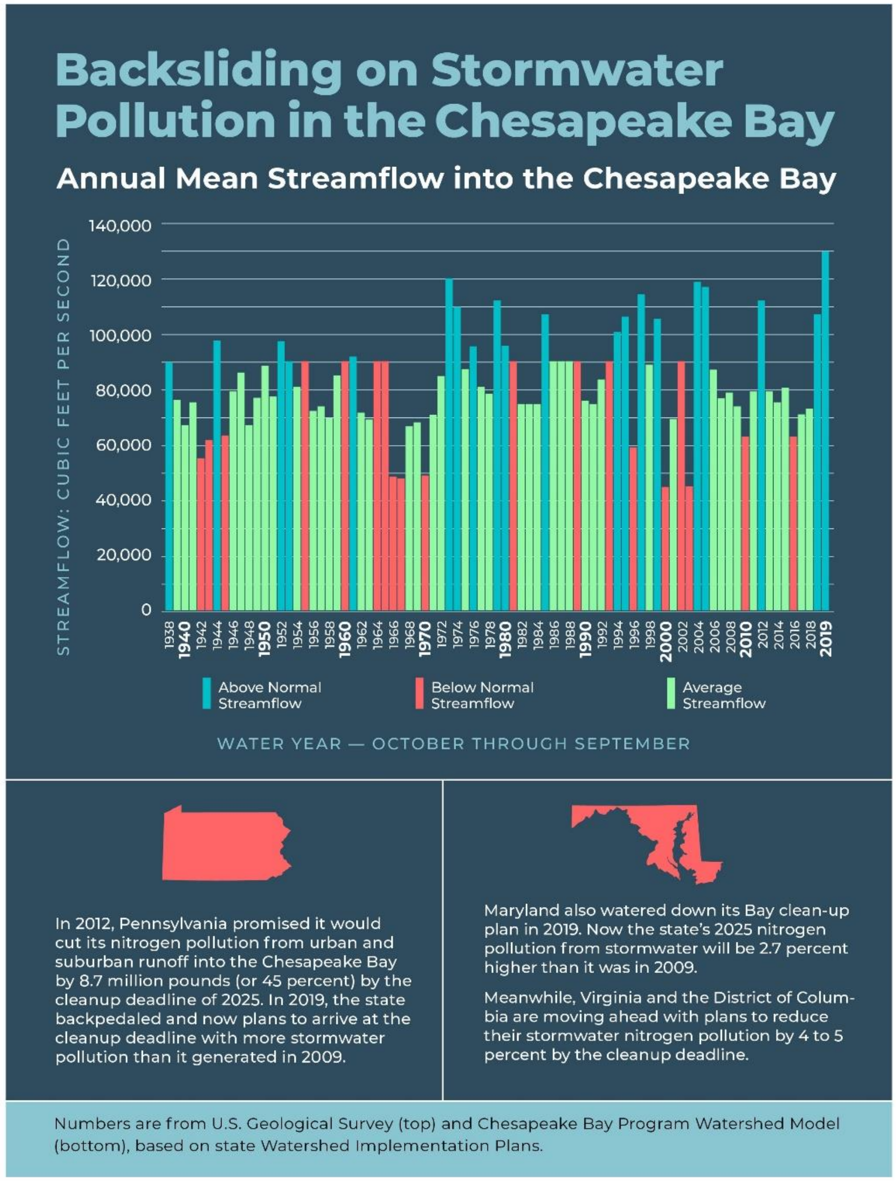
This increased runoff has created an additional challenge to the most recent Chesapeake Bay cleanup plan, launched by the U.S. Environmental Protection Agency and Bay region states in 2010, called the Bay Total Maximum Daily Load (or TMDL). The Bay TMDL requires states to implement plans by 2025 that will reduce nitrogen, phosphorus, and sediment flowing into the Bay by about a quarter. Cleanup progress has been erratic. Effluent from wastewater plants and some other sources has declined substantially. However, pollution from urban and suburban stormwater runoff has been increasing – up 5 percent for nitrogen between 2009 and 2019, up 3 percent for phosphorus and sediment over this time period, according to numbers from the EPA-led Chesapeake Bay Program.[5] In 2019, stormwater from developed land contributed 40 million pounds of nitrogen to the Bay (16 percent of the total nitrogen pollution), 2.6 million pounds of phosphorus (17 percent of total), and 1.7 billion pounds of sediment (9 percent of total).[6]

The growth of suburban sprawl and parking lots have increased the amount of runoff pollution fouling the Chesapeake Bay.

One reason for the increase in urban and suburban runoff pollution is continued real-estate development and suburban sprawl – and the failure of states to control this growth in impervious surfaces. Since 2009, the amount of developed land in the Bay watershed has increased by about 300,000 acres, or about 6 percent – an area six times the size of the District of Columbia -- adding more blacktop, roofs, and roads that accelerate runoff pollution.[7] But the other reason – as mentioned earlier – is the increase in rainfall from climate change. The Chesapeake Bay Program projects that climate change will increase annual nitrogen pollution in the Bay by 9 million pounds (or 3.6 percent) between 2018 and 2025, and increase annual phosphorus loads by 489,000 pounds (or 3 percent).[8]

Given those warnings of an increasing pollution load, the Bay region states should have incorporated more aggressive pollution control measures into their Bay cleanup plans, but two of the largest states did not. In their most recent pollution reduction plans submitted to EPA in August 2019—their Phase III "Watershed Implementation Plans" or WIPs – Pennsylvania and Maryland failed to incorporate the added pollution load attributable to climate change. Virginia, to its credit, has built the additional load from climate change into its plan and is moving forward with more projects to meet more stringent stormwater planning targets.

In contrast, Pennsylvania and Maryland retreated in their proposed efforts to reduce urban and suburban runoff. This is significant because Pennsylvania, Maryland and Virginia account for about 90 percent of the urban and suburban runoff pollution fouling the Bay. Overall, due largely to backsliding by Maryland and Pennsylvania, the Bay states' pollution reduction goals for 2025 have been scaled back significantly. The prior (Phase II) WIPs called for a watershed-wide stormwater nitrogen reduction of 7.9 million pounds by 2025, relative to the 2009 baseline. The current (Phase III) WIPs only call for a reduction of 0.5 million pounds.[9] In other words, the states have given up on 7.4 million pounds of nitrogen reductions from urban and suburban runoff. Similarly, the states have given up on 340,000 pounds of phosphorus pollution from stormwater and 382 million pounds of sediment.[10]



Meanwhile, at the local level, many cities and counties – like the states of Maryland and Pennsylvania – are not adequately planning for the increased volume of rainfall and stormwater already inundating their communities and causing flash flooding and erosion problems. As one planning consultant in Prince George's County warned: stormwater control projects "designed for current conditions will most likely fail to sufficiently treat and reduce runoff from the projected larger and more intense storm events."[11]

For this report, the Environmental Integrity Project (EIP) analyzed federal, state and county records and pollution control plans (including Phase II and III WIPs), as well as data from the Chesapeake Bay Program, U.S. Geological Survey, and other sources.

Among this report's conclusions are the following:

- Maryland and Pennsylvania's 2019 Bay cleanup plans (Phase III WIPs) set goals for nitrogen pollution entering the Bay from urban and suburban stormwater in 2025 that are *higher* than the loads back in 2009.This means these states are accepting increases in this pollution over this time period instead of planning reductions.

- Maryland's 2019 plan would allow an increase in the amount of nitrogen pollution flowing into the Bay from stormwater runoff by 249,000 pounds per year by 2025, compared to the 2009 baseline, according to the EPA-led Bay Program. Back in 2012, by contrast, Maryland had been planning for a 1.3 million-pound annual reduction.[12] Combined, that's a retreat of more than 1.5 million pounds of pollution per year.
- Compared to its 2012 plan, Maryland is now planning to build fewer stormwater-filtering projects called rain gardens (zero instead of 34,716 acres) by 2025. The state also plans to create less pavement permeable to water (zero acres instead of 350), and plant fewer forested acres along urban streams (zero instead of 26,430), among other retreats.[13]
- Pennsylvania's 2019 Bay cleanup plan will allow nearly 7 million more pounds of nitrogen pollution from urban and suburban runoff by the 2025 cleanup deadline than its 2012 plan. The new plan will increase the amount of nitrogen flowing into the bay from developed areas by 250,000 pounds by 2025, compared to the baseline of 2009, instead of decreasing it by 6.7 million pounds.
- Among other changes, the Keystone state's new plan would include replacing only replacing 202 acres of parking lots and other "impervious surfaces" instead of the 2,300 acres planned by the state back in 2012. Pennsylvania's 2019 plan would create 203,265 acres of stormwater control ponds, wetlands and other projects by 2025, instead of the 1.5 million acres of stormwater control practices planned back in 2012.[14]

Pennsylvania is dialing back its plans to build stormwater control ponds, wetlands, and permeable parking lots that would reduce flash flooding and stormwater pollution.

- By contrast, Virginia's most recent Bay cleanup plan (Phase III WIP) would reduce nitrogen pollution from urban and suburban stormwater by 408,000 pounds by 2025. Virginia would also reduce the amount of sediment flowing into the Bay from urban areas by 66 million pounds.
- To achieve these reductions, Virginia would plant 30,000 trees to absorb runoff (38 times more than the 799 trees in its last plan), and install 4,564 acres of pavement permeable to rain (instead of the 52 acres of permeable pavement proposed back in 2012), among other changes.

At the local level, EIP examined stormwater planning documents for 11 large counties in the Chesapeake Bay watershed – including Baltimore and Montgomery counties in MD; Lancaster and York counties in Pennsylvania; and Fairfax and Loudon counties in Virginia – and found all of them are planning for past rainfall averages, rather than for current and future rainfall volumes caused by climate change. We also scrutinized the plans of four cities with outdated combined sewage and stormwater systems that are planning upgrades to reduce sewage discharges and found that all of them are planning infrastructure based on outdated assumptions about rainfall. The worst case was in Cumberland, Maryland, which is planning on only 37 inches of annual rainfall as it designs an upgraded pipe system, when in reality 48 inches have been falling on that city each year over the last five years (a 27 percent difference). Washington, D.C., has a 21 percent gap between its planning for overflows and reality; Harrisburg, Pa., 15 percent; and Lynchburg, Va., 13 percent. Inadequate planning and infrastructure in some of these cities is contributing to severe local water quality problems. In Harrisburg, for example, bacteria monitoring by the Lower Susquehanna Riverkeeper in June and July of 2020 found *E. coli* bacteria concentrations in the river that averaged more than 2.5 times safe levels for swimming or water contact recreation, including just downstream from outfalls leading from the Governor's Residence and State Capitol Complex.[15]

This report looks briefly at all four of these cities, and then provides detailed case studies about what two communities – Washington, D.C., and Ellicott City, Maryland – are doing to manage increasing volumes of stormwater.

What are the solutions to the problem of rising runoff pollution and flash floods caused by climate change? EIP makes the following recommendations:

1) Broadly speaking, we should be planning for the future, not the past. There is no question that rainfall in the Bay region is increasing in both total volume and intensity. Planning at all levels – from the federal government down to the county and city level – must take these trends into account. All levels of government should start calibrating their planning and stormwater control projects and infrastructure to reflect likely future rainfall patterns, not historic averages from decades ago.
2) EPA must take a more active leadership role and require Pennsylvania and Maryland to strengthen their stormwater control plans and account for climate change. Instead of backtracking, Pennsylvania and Maryland should expand the stormwater pollution projects in their Phase III Watershed Implementation Plans.
3) EPA should require Pennsylvania to commit substantially more resources to its Bay cleanup effort, which has been far behind the other states. Federal actions could include the denial of permit approvals for major construction projects in Pennsylvania and a demand that the Commonwealth upgrade its leaky combined stormwater and sewage systems, including in Harrisburg.
4) States and municipalities across the Chesapeake region should invest more in stormwater control projects, such as the construction of artificial wetlands, ponds, rain gardens and the conversion of parking lots and other impervious surfaces to

green areas that absorb rain. These projects not only control runoff pollution, they also help address environmental justice issues by creating parks in urban areas that are often dominated by blacktop.

5) Because stormwater control projects are expensive, EPA and Congress should provide substantial federal funds to state and local governments to help pay for these projects, which create jobs. Such federal investments would be a healthy economic stimulus package to help the nation rebound from the COVID-19 recession.

With a problem as sweeping as climate change impacting all other environmental issues in the Bay watershed – from water pollution to flooding – it makes more sense to plan for their interconnectedness than to pretend they exist in isolation. Building more stormwater control infrastructure is also an ideal way to put American construction workers back to work during an economic downturn. Planting trees and building parks and green roofs on buildings to absorb rainwater also helps poorer neighborhoods in cities like Baltimore, Harrisburg, and the District of Columbia. These cities are often starved of green space and act as concrete frying pans in the summer, with temperatures several degrees hotter than wealthier and leafier suburban neighborhoods.[16] Adding greenspaces and trees will help alleviate environmental injustices, give urban neighborhoods more room to breathe, and help hold down temperatures in a warming world.

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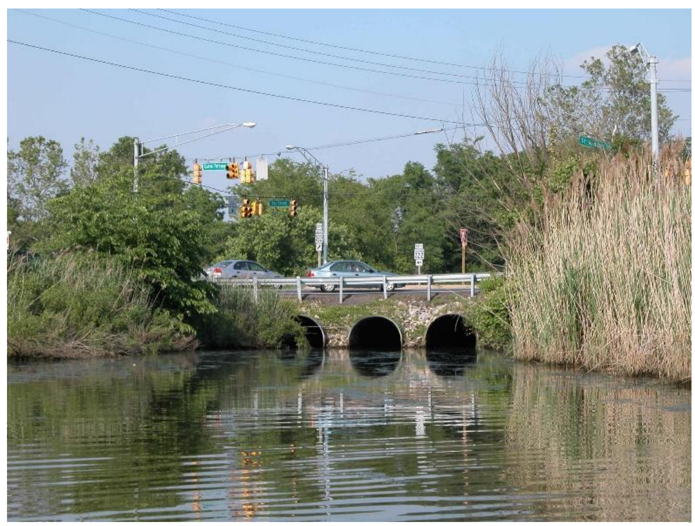
I. Background: Growing Rainfall and Suburban Sprawl

Climate change is causing increases in both total precipitation *volume* and precipitation *intensity*, or high-rainfall events. This is largely because warmer air holds more moisture.[17] As described in more detail below, the Chesapeake Bay watershed is uniquely vulnerable to these trends for three reasons. First of all, the Bay is already impaired, so there is no "buffer" that could help absorb the adverse impacts of climate change. Second, the Bay watershed is located in the northeastern United States, where precipitation intensity is increasing faster than anywhere else in the country. Third, the overall impact of climate change on the Bay includes much more than precipitation and stormwater (the focus of this report). As noted in the most recent National Climate Assessment, "[t]he Chesapeake Bay watershed is experiencing stronger and more frequent storms, an increase in heavy precipitation events, increasing bay water temperatures, and a rise in sea level."[18]

The historical trends for the northeastern United States are clear. Since 1900, total annual precipitation in the region has increased by roughly 1 cm per decade – twice as fast as the country as a whole.[19] In the Chesapeake Bay region, record-setting amounts of rain fell in 2018 in Baltimore (72 inches), Harrisburg (62 inches), Richmond (64 inches), and Washington DC (67 inches), among other locations, according to data from the National Oceanic and Atmospheric Administration (NOAA) dating back to the 1940s.[20] The upward trend has been fairly consistent over the decades, suggesting that 2018 was not a freakish year but possibly a reflection of a new normal. For example, in Baltimore, the annual average precipitation from 2010 to 2019 was 47 inches – 24 percent higher than the 38 inches per year from 1960 to 1970.[21] In Harrisburg, the 2010-2019 average was 44 inches, 22 percent more than the 36-inch average during the 1960s.[22]



Stormwater culverts discharge into a marsh along Maryland's Avon River, which empties into the Chesapeake Bay.

Beyond the sheer amount of rainfall, trends in precipitation *intensity* have been described in a variety of ways. For example, one study observed that, in the northeastern United States between 1979 and 2013, the frequency of "very wet days," and the total annual volume of precipitation falling on very wet days, increased by about 10 percent per decade.[23] Another study observed that, in the northeastern United States between 1958 and 2016, the amount of precipitation falling on the wettest days increased by 55 percent.[24] It is also worth noting that precipitation intensity has been increasing faster in the northeastern United States than anywhere else in the country.[25]

As a result, the Chesapeake Bay has been experiencing unprecedented volumes of fresh water pouring into the estuary from streams and rivers. According to data from U.S. Geological Survey, 130,750 cubic feet per second of fresh water flowed into the Bay in 2019. This was by far the highest on record since monitoring began in the 1930s.[26]

All of this extra water is washing more pollutants off parking lots, roads, suburban lawns and farm fields into the Bay, harming the estuary's health. As the amount of runoff into the bay jumped in 2018 and 2019, for example, the overall health of the Bay, as measured by the University of Maryland Center for Environmental Science's annual report card, declined from a 54 out of 100 in 2017 to a 44 out of 100 in 2019. That was a lower health score than the 52 rating in 2009, before EPA and states launched the Bay pollution diet (the TMDL cleanup process) in 2010.[27] Not coincidentally, the year with the Bay's best health on record – 2002, when it rated a 55 out of 100 – was also the year with the lowest amount of fresh-water flow into the estuary on record.[28] The trends toward increased rainfall, stormflow and runoff are expected to continue or accelerate because of climate change. According to one set of climate models, the northeastern United States will experience a faster increase than any section of the country, with a four or five-fold increase in heavy precipitation events (more than one inch of precipitation) by 2100.[29] Perhaps most troubling is the fact that we will see many more very wet days, but also more very dry days, with fewer days that we would consider normal.[30] The new reality will be, quite literally, "when it rains, it pours" – with higher levels of pollution as a result.

The combined impact of growing rainfall and increased precipitation intensity on erosion and sediment runoff was succinctly summarized by a group of Bay-area scientists ten years ago:

> *Annual sediment loading to the Chesapeake Bay is a non-linear function of annual streamflow, indicating an increase in total suspended sediment concentration as flow increases, which likely results from enhanced erosion and resuspension of sediments in the streambed. Even if the mean discharge were to remain unchanged, erosion could increase if precipitation intensity were to increase, a projection that is more certain than annual streamflow discharges.*[31]

All of this is undisputed – the EPA-led Chesapeake Bay Program and the Bay states have readily acknowledged these trends in their respective planning documents.[32] In short, everyone knows that climate change is already causing increased pollution loads, and everyone knows that the problem is going to get worse.

On top of this problem is the challenge of the growing amount of blacktop and other impervious surfaces because of suburban sprawl. Every year, development spreads over an additional roughly 32,000 acres across the Chesapeake Bay watershed.[33] This means that every year an area of land about three quarters the size of Washington, D.C. is converted to parking lots, roofs, roads, lawns, and buildings from fields and forests.[34] That means less rain is being absorbed by natural land cover and filtered by trees, and more is being funneled into Bay tributaries.

These trends make the goals of the Chesapeake Bay cleanup (the TMDL) more difficult to attain. The Bay region states will have to adjust their targets and ramp up their levels of effort. This may be especially true for the stormwater sector, which is uniquely vulnerable to changes in precipitation intensity.

A 2018 EPA analysis provides a detailed illustration of how climate change and increased rainfall in the Chesapeake Bay watershed will require local governments to build significantly more stormwater control projects than they are currently planning. EPA's National Center for Environmental Assessment wanted to estimate how climate change-induced changes in precipitation would affect the performance of stormwater pollution control projects, also known as Best Management Practices (BMPs), such as stormwater detention basins, in a variety of settings. The 2018 analysis looked at five types of developed land use in five geographic locations, and modeled BMP performance under both current precipitation patterns and projected future (mid-21st century) scenarios. Overall, EPA found that "BMPs designed for current conditions will not mitigate increases in stormwater runoff and associated downstream channel erosion and flooding under projected future conditions."[35] To accommodate future precipitation, "current practices will need greater temporary volume storage and/or reconfiguration of outlet structures to mitigate flooding and channel erosion risk."[36]

One of EPA's case studies was a hypothetical 20-acre mixed-use development site in Harford County, Maryland. EPA first determined that precipitation in this region will change dramatically by mid-century. Total annual precipitation volume will increase by 12.8 percent compared to current conditions, and the hourly precipitation volume for large storm events will increase by roughly 50 percent.[37] Perhaps most vividly, storms that now happen every ten years, on average, will be recurring every two years under future conditions.[38] Today's "ten-year storm" will be tomorrow's "two-year storm." EPA next looked at how various combinations of stormwater BMPs would perform under present and future conditions at this Maryland site. Under future conditions, the runoff volume and pollution loads using "conventional" BMPs (sand filters and dry detention basins) would increase by 50-70 percent.[39] To accommodate the added precipitation, EPA estimated that this hypothetical 20-acre site would have to add 1-2 acres of additional pollution control projects (BMP space).[40]

The rest of this report looks at whether the Bay region states are making adequate course corrections at the state level, at the county level, and at the level of individual stormwater permits. The answers, unfortunately, are not reassuring.

1. Failing the "Pollution Diet."

The Chesapeake Bay Total Maximum Daily Load (TMDL) is often described as a "pollution diet" for the Bay. If this is a diet, then the urban stormwater sector is overweight and eating ice cream.

A. TMDL Progress to Date

Since 2009, stormwater pollution loads have been increasing.[41] The Bay states have made a small amount of progress in reducing per-acre stormwater loads, but not enough to keep up with new growth and the expansion of developed acres. As a result, total stormwater nitrogen loads have increased by almost 5 percent since 2009, phosphorus has increased by about 3 percent, and sediment by almost 2 percent. The following table shows trends at the watershed scale.

Table 1: Developed Land and Stormwater Pollution in the Chesapeake, 2009-2019

	2009	2019	Change (%)
Developed acres	5,157,202	5,478,731	+6.2%
Pollution Loading Rate (pounds per developed acre)			
Nitrogen	7.36	7.26	-1.3%
Phosphorus	0.49	0.48	-3.5%
Sediment	326	315	-3.5%
Delivered Load (millions of pounds)			
Nitrogen	38.0	39.8	+4.8%
Phosphorus	2.5	2.6	+2.5%
Sediment	1,683	1,725	+2.5%

NOTE: All pollution estimates are "edge of tide," or delivered loads of pollution into the tidal Chesapeake Bay.

Appendix A shows state-level trends and reveals some state-to-state variability. For example, West Virginia has done more than enough to offset new growth, and the state's stormwater pollution loads have declined since 2009. Maryland, by contrast, has seen about the same level of growth in developed land as West Virginia (about 5 percent per year), but has also seen an increase in the per-acre loading of nitrogen and sediment. This means that nitrogen and sediment pollution in Maryland are increasing faster than new development. It is important to keep in mind that these estimates were generated using a model that assumes weather patterns from 1991-2000. See Section 3, Planning for Climate Change, below). Given changes in precipitation over the past twenty years, it's likely that the increase in stormwater loads has been even greater than the Bay program estimates.

We now turn to the Bay states' planning goals for the sector.

B. Relaxing the Goals

As part of the TMDL, the states periodically complete "Watershed Implementation Plans," or WIPs, which lay out numeric pollution reduction targets and strategies. The "Phase II" WIPs were completed in 2012. The "Phase III" WIPs were completed in 2019.[42] Each WIP provides targets in the form of loads that the states expect to see in 2025.

The following Table (Table 2, below) compares the nitrogen reductions that would have been achieved under the Phase II WIPs to the reductions that the states are now aiming for under the Phase III WIPs. This table shows that the two of the largest sources of stormwater pollution – Maryland and Pennsylvania – are backsliding on their commitments and are now planning to end the TMDL process with stormwater loads that are *higher* than when they started. As a result, and despite the fact that the other states are setting slightly more ambitious targets, the total Bay-wide stormwater load in 2025 is now expected to be higher than it would have been under the states' 2012 plans, and only about 1 percent lower than it was in 2009.

Appendix A provides parallel tables for phosphorus and sediment, which show the same thing – Maryland and Pennsylvania have dramatically relaxed their planning goals, and as a result the Bay-wide stormwater pollution loads in 2025 are now expected to be greater than they would have been under the state's 2012 plans, and not much lower than they were in 2009.

Since 2009, Bay states have made a small amount of progress in reducing per-acre stormwater loads, but not enough to keep up with new growth and the expansion of developed acres.

Table 2: Stormwater Nitrogen Pollution from Developed Land

State	2009 pollution (millions of pounds)	2025 targets (millions of pounds)		Planned change in pollution, 2009-2025	
		2012 plan	*2019 plan*	*2012 plan*	*2019 plan*
DE	0.66	0.70	0.65	+6.9%	-1.3%
DC	0.17	0.17	0.16	-4.4%	-4.8%
MD	9.01	7.69	9.26	-14.6%	+2.7%
NY	1.94	1.90	1.40	-2.0%	-28.0%
PA	14.76	8.06	15.06	-45.4%	+2.0%
VA	10.14	10.26	9.72	+1.1%	-4.1%
WV	1.23	1.23	1.17	+0.1%	-4.7%
TOTAL	**37.92**	**30.01**	**37.43**	**-20.9%**	**-1.3%**

NOTE: Pink cells above indicate a reduced level of effort. All load estimates are "edge of tide," or delivered loads of pollution. "2012 plan" and "2019 plan" loads represent the loads associated with Phase II and Phase III WIP commitments, respectively, as shown by the Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST).[43]

The following subsections look more closely at the evolving stormwater pollution strategies in Maryland, Pennsylvania, and Virginia, which together account for roughly 90 percent of the urban stormwater pollution affecting the Bay.[44]

i. Maryland's Implementation Plans

Maryland is effectively giving up and walking away from its stormwater commitments. According to the state's Phase III WIP:

> *The slower pace of restoration progress in the urban stormwater sector relative to wastewater and agriculture means that stormwater discharges will make up a larger proportion of the State's nutrient loads by 2025 - approximately 20% and 19% of the nitrogen and phosphorus loads, respectively. Reduction opportunities outside the stormwater sector will concurrently decrease, and stormwater management will become a more important part of Maryland's nutrient reduction portfolio. The result is that maintaining the statewide target pollution levels after 2025 will require continuing stormwater management implementation.*[45]

And:

> *The stormwater strategies described in this section rely on a sustained pace of implementation, recognizing that the arc of restoration will need to continue well beyond 2025 and a single permit cycle.*[46]

This language is far from clear, but reading between the lines one might conclude that Maryland is deferring action on the stormwater sector until <u>after</u> the TMDL process concludes, and potentially giving up altogether.

This is confirmed by the numbers in Maryland's WIPs. The following table compares the Phase II and Phase III WIPs with respect to (a) target pollution loads, and (b) stormwater treatment practice targets for 2025. This table shows that Maryland's planning targets have collapsed to less than 10 percent of what they once were, across the board. The reality is even worse than Maryland's Phase III WIP targets suggest. According to the EPA-led Chesapeake Bay Program, the strategies outlined in Maryland's Phase III WIP would actually lead to nitrogen and sediment load *increases* relative to 2009 loads.

Table 3: Plans for Reducing Stormwater Pollution from Developed Land in MD[47]

	2012 Bay Cleanup Plan (Phase II WIP)	2019 Bay Cleanup Plan (Phase III WIP)
Changes in Annual Pollution 2009-2025, According to Maryland's Cleanup Plans[48]		
Nitrogen (lbs)	-2,200,000	-200,000
Phosphorus (lbs)	-232,000	-10,000
Sediment (lbs)	-205 million	-11 million
Changes in Annual Pollution, 2009-2025, According to EPA-led Chesapeake Bay Program[49]		
Nitrogen (lbs)	-1,316,935	**+247,238**
Phosphorus (lbs)	-218,847	-26,625
Sediment (lbs)	-104 million	**+5.5 million**
Pollution Control Project Goals		
Abandoned Mine Reclamation (acres)	1,843	425
Bioretention/Rain Gardens (acres)	34,716	0
Bioswale (acres)	15,518	15
Dry Detention Ponds (acres)	80,803	751
Impervious Surface Reduction (acres)	31,003	1,129[50]
Stormwater Treatment (acres)	232,629[51]	42,727[52]
Permeable Pavement (acres)	350	0
Urban Filtering Practices (acres)	322,842	0
Urban Forest Buffers (acres)	26,430	0
Urban Infiltration Practices (acres)	33,872	0
Urban Tree Planting acres (acres)	15,000	1,592
Vegetated Open Channels (acres)	28,290	0
Wet Ponds/Wetlands (acres)	73,504	3,115
Erosion and Sediment Control (acres/yr)	42,642	0
Forest Conservation (acres/yr)	91,111	0
Street Sweeping (acres/yr)	9,033	37,286
Urban Nutrient Management (acres/yr)	504,053	5,700

Urban Stream Restoration (feet)	818,473[53]	1,060,015
Urban Shoreline Erosion Control (feet)	1,273,852	40,444[54]

A closely related problem is that Maryland has changed its municipal stormwater control (MS4) permits. These permits used to require the restoration of twenty percent of a county's impervious surfaces. This requirement is still part of the permits, but with a big escape clause: counties can now buy credits for pollution load reductions as an alternative form of compliance. The restoration "requirement" is no longer a requirement at all, but simply one of two options. As the Environmental Integrity Project documented in a 2019 report,[55] pollution trading, particularly in Maryland, is a misguided shell game that often involves double-counting pollution reductions that have already been made – and credited to the state – by wastewater treatment plants. Pollution trading will not get Maryland any closer to its TMDL targets, and it will certainly not reduce urban stormwater pollution.

In response to questions from EIP, the Maryland Department of the Environment (MDE) defended "nutrient trading" as a legitimate pollution control strategy and said that Maryland is relying on runoff-control projects on farms and improvements to sewage treatment plants to achieve most of the state's pollution reduction goals for 2025.[56] "The Phase III WIP envisions that Wastewater Treatment Plant upgrades and agricultural Best Management Practices will be the primary nutrient reduction drivers to achieve 2025 goals," said MDE statement says (for the full text of Maryland's response, see Appendix B.) Unfortunately, many of these wastewater treatment plant upgrades have already occurred, and Maryland has already been credited with those reductions by the EPA-led Chesapeake Bay Program's computer modeling of progress. MDE's plans therefore amount to double-counting. Moreover, even in an ideal situation, trading does not generate additional pollution reductions – it only changes where planned reductions will come from. MDE asserted that it is not retreating or giving up on stormwater pollution controls, but said it is difficult to compare 2009 pollution levels in the Bay to the amount projected for 2025 because of changes in computer modeling used by the Chesapeake Bay Program. However, this is a problem that can easily be avoided. The model has changed over time, but each new version of the model re-calculates the 2009 baseline, the estimated loads for each year, and the 2025 targets of various state plans. The data the Environmental Integrity Project examined to calculate pollution loads for the Phase II and Phase III WIPs used the same version of model – and the data still shows significant backsliding.

ii. Pennsylvania's Implementation Plans

Pennsylvania's stormwater planning is going in the same direction as Maryland's. Although Pennsylvania's WIPs are less transparent about pollution reduction goals and strategies, the Chesapeake Bay Program provides the relevant data by compiling Pennsylvania's planned implementation of BMPs and converting those plans into pollution reductions. The following Table compares BMP goals under the Phase II and Phase III WIPs. The goals for a few BMPs – urban tree planting, urban stream restoration, and storm drain cleanout – have increased, which is undeniably a good thing. On the other hand, the goals for major categories of BMPs have been slashed to a small fraction of what they once were:

- Acreage targets for the group of BMPs known as "stormwater management" (i.e., wetlands, detention ponds, and infiltration practices) have declined by 86 percent.
- Impervious surface restoration goals have declined by more than 90 percent.
- Urban forest and grass buffer goals are 88 percent lower.

The cumulative effect of these changes is that stormwater pollution loads in 2025 are likely to be much higher than they would have been under Pennsylvania's Phase II plan:

- In its Phase II plan, Pennsylvania was committed to reducing 6.7 million pounds of nitrogen from the urban stormwater sector by 2025. Under the Phase III Plan, there will be no nitrogen reduction at all – nitrogen loads will be higher in 2025 than they were in 2009.
- Phosphorus reductions under the new plan will be just 2 percent of what they would have been under the old plan.
- Sediment reductions under the Phase III WIP will be 11 percent of what they would have been under the Phase II WIP.

Table 4: Plans for Reducing Stormwater Pollution from Developed Land in Pennsylvania[57]

Target for 2025	2012 Bay Cleanup Plan (Phase II WIP)	2019 Bay Cleanup Plan (Phase III WIP)
Changes in Annual Pollution Load, 2009-2025		
Nitrogen (lbs)	-6,700,947	**+301,360**
Phosphorus (lbs)	-248,648	-5,797
Sediment (lbs)	-388,413,228	-43,139,243
Pollution Control Project Goals		
"Stormwater Management Composite" (includes wet ponds, wetlands, dry ponds, infiltration practices, etc.) (acres)	1,470,001	203,265
Erosion and Sediment Control (acres)	5,411	5,417
Impervious Surface Reduction (acres)	2,300	202
Urban Forest or Grass Buffers (acres)	25,575	3,076
Urban Tree Planting[58] (acres)	1,444	4,089
Urban Nutrient Management (acres)	333,128	123,815

Urban Stream Restoration (feet)	55,000	606,295
Storm Drain Cleanout (pounds of sediment)	0	121,269
Street Sweeping (acres)	36,200	1,016

In response to questions from EIP about the changes in their Bay cleanup plans, the Pennsylvania Department of Environmental Protection (DEP) said that the state's Phase III plan is more realistic.[59] The new plan reflects a shift, given the limited amount of money Pennsylvania has set aside for pollution control projects, toward more cost effective strategies, especially reducing runoff from farm fields instead of more expensive projects in suburban and urban areas. "Pennsylvania decided that moving forward, we need to focus our limited resources on the pollutant load sectors where nitrogen control (projects) will have the greatest impact, such as agriculture," Deborah Klenotic, Deputy Communications Director for DEP, said in an email to EIP. For DEP's full statement, see Appendix C).

It should be noted that Pennsylvania has been promising to reduce runoff from agriculture for more than a decade, with little success, in part because industrial-scale hog and poultry operations continue to grow and state regulations are weak.[60] The political influence of the farm lobby on the Pennsylvania General Assembly is strong, with state lawmakers, for example, making it illegal for the state to require farmers to fence cattle out of streams to reduce water pollution.[61]

iii. Virginia's implementation plans

Virginia, in stark contrast to Maryland and Pennsylvania, is ramping up its commitments to stormwater pollution control. Virginia's Phase III WIP increases its planning goals for most urban BMPs, in some cases by dramatic margins (e.g., permeable pavement, with a Phase III goal of 4,564 acres, up from 52 acres in the Phase II WIP). Under its Phase II WIP, Virginia would have seen increased nitrogen and sediment loads in 2025, relative to the 2009 baseline. Under its newer Phase III WIP, both pollutants will decline, and sediment reductions will be significantly greater than they would have been under the 2012 plan.

Table 5: Plans for Reducing Stormwater Pollution from Developed Land in Virginia[62]

Pollutant	2012 Bay Cleanup Plan (Phase II WIP)	2019 Bay Cleanup Plan (Phase III WIP)
Change in Annual Pollution Load, 2009-2025		
Nitrogen (lbs)	*-111,902*	-419,336
Phosphorus (lbs)	*-16,352*	-51,383
Sediment (lbs)	-30 million	-67 million
Pollution Control Project Goals (in acres, unless otherwise noted)		
Street Sweeping	24,040	0

Urban Nutrient Management	517,058	553,470
E and S	32,922	22,346
Bioretention	22,352	33,730
Bioswale	1,144	8,764
Permeable Pavement	52	4,564
Vegetated Open Channel	3,283	3,486
Dirt and Gravel Road	1,738	0
Impervious Surface Reduction	26,138	36,303
Forest Buffer Urban	4,115	9,982
Forest Conservation	14,128	18,871
Urban Tree Planting	799	30,000
Urban Stream Restoration	122,052	n.a.[63]
Dry Ponds	85,554	97,265
Extended Dry Ponds	160,081	159,030
Wet Pond Wetland	177,773	227,512
Infiltration	69,127	73,037
Filtration	65,868	58,112
Storm Drain Cleaning (pounds of sediment)	0	385,757
Other BMPs not mentioned in Phase II WIP[64]	0	39,580

3. Planning for Climate Change

As discussed in the background section of this report, there is no question that climate change is going to make it harder to meet the goals of the Bay TMDL. Yet the EPA, the Chesapeake Bay Program, and the Bay states are still in the early stages of planning for climate change impacts.

Climate change will increase rainfall and flooding across the Chesapeake Bay region, creating new stormwater management challenges for cities like Annapolis, MD.

The Bay Program and the Bay states measure TMDL progress using a set of models, including a "watershed model," which estimates nitrogen, phosphorus and sediment loads to the Bay.[65] The watershed model is based on a set of input data and assumptions. One critical set of assumptions relates to weather patterns. When the Bay Program is using the model to assess progress, it wants to know how various land use changes and pollution control strategies will affect pollution load. In order to isolate that signal, weather patterns are held constant. Regardless of the model year (i.e., a simulation of 2009 loads, 2018 loads, or 2025 loads), the model assumes weather conditions from 1991-2000.[66]

The Bay Program recognizes that weather has changed since the 1990s and will change even more between now and 2025.[67] In 2018, the Bay Program's Principles' Staff Committee provided numeric estimates of the additional pollution loads that could be expected by 2025 as a result of climate change:

Table 6: Additional Annual Pollution Attributable to Climate Change, 2018 to 2025[68]

	Nitrogen (millions of pounds)	Phosphorus (millions of pounds)
DC	0.01	0.001
DE	0.40	0.006
MD	2.19	0.114
NY	0.40	0.014
PA	4.14	0.141
VA	1.72	0.193
WV	0.24	0.019
Total	9.09	0.489

The numbers in Table 6 reflect the additional amounts of nitrogen and phosphorus (in millions of pounds) that climate change is expected to bring to the Chesapeake Bay each year between 2018 and 2025, from all sources in each state. From the perspective of planning for TMDL compliance, these numbers represent additional reductions that each state will have to make in order to reach its TMDL targets.

For the Phase III WIP planning process, the Bay Program required "a narrative strategy describing the jurisdictions' current action plans and strategies to address climate change." The Bay Program strongly encouraged, but did not require, the states to build the additional loads shown in Table 6 into their Phase III WIPs.[69] Virginia did so, but Maryland and Pennsylvania did not. According to the Bay Program, the states will be required to account for the effects of climate change on pollution loads and on BMP performance, but not until 2021-2023.[70]

The following sections provide more detail on what each of these three states has said about planning for climate change, with respect to both statewide pollution loads and the urban stormwater sector in their Phase III WIPs.

A. Climate Change in Maryland's Phase III WIP

Maryland's WIP acknowledges the climate change problem but fails to address it. As the WIP explains, "climate change impacts, including increased precipitation and storm events, are causing increased nutrient and sediment loads."[71] The WIP also acknowledges that climate change is likely to reduce the effectiveness of Best Management Practices (BMPs). For example, page 53 of the WIP states that "[t]he BMPs used to control water pollution will likely become less effective at controlling extreme storm events and be subject to damaging stresses of climate change."[72] Yet the WIP ignores the additional load that climate change will almost certainly cause, and it does not make any adjustments to its assumptions about BMP effectiveness.

The additional climate change-related loads from Maryland are expected to be 2.2 million pounds of nitrogen and 114,000 pounds of phosphorus.[73] Maryland's WIP states that the state will address these loads in 2021 and 2022.[74] This seems unwise. Deferring pollutant load adjustments will only increase the difficulty associated with planning for and meeting the adjusted targets in the future.

B. Climate Change in Pennsylvania's Phase III WIP

The Pennsylvania Department of Environmental Protection (PA DEP) acknowledges that climate change will make TMDL compliance much more difficult. An April 2020 report prepared for PA DEP by the Environment & Natural Resources Institute noted that average annual precipitation in Pennsylvania has increased by 10 percent over the past century, "heavy precipitation" has increased by 55 to 78 percent in the northeastern United States, and these trends will continue in Pennsylvania into the late 21st Century.[75] The authors of this report, like the authors of Maryland's WIP, concluded that climate change will pack a double punch. Increased precipitation intensity will increase pollution loads, and it will also decrease the effectiveness of pollution control BMPs.[76]

Yet Pennsylvania has not started planning for climate change. Its Phase III WIP does not adjust its planning targets to account for the additional climate change-related load,[77] postponing that basic step until 2022.[78] The WIP does have a section entitled "climate change and climate resiliency," but that section mainly deals with steps Pennsylvania is taking to reduce carbon emissions.[79] The WIP commits to studying the issue further, but does not commit to practical steps that might further reduce pollution.[80]

C. Climate Change in Virginia's Phase III WIP

Virginia, unlike Maryland and Pennsylvania, has explicitly accounted for the additional load attributable to climate change in its WIP:

The modeling estimates indicate that across the Bay watershed an additional 9 million pounds of nitrogen and 0.5 million pounds of phosphorus reductions are needed to offset the effects of climate change by 2025. Virginia's share of that additional load reduction is 1.72 million pounds of nitrogen and 0.19 million pounds of phosphorus. . . . Virginia's Phase III WIP includes sufficient practices and policies that when fully implemented account for these additional load reductions.[81]

Virginia's WIP adjusts targets for each basin to quantitatively account for the additional load due to climate change. For example, the following table appears on page 91 of Virginia's plan:

Table 7: Potomac River Basin WIP III Final Pollution Targets and Reductions

Potomac River Basin	2007 Progress Load	2025 Basin Target Load	Reductions Needed to Meet Target	Additional Reductions Needed to Address Climate Change	Reductions Identified in WIP III Final
Nitrogen (pounds)	17,109,000	16,000,000	1,109,000	620,000	1,729,000
Phosphorus (pounds)	1,976,000	1,892,000	84,000	82,000	302,500

Overall, Virginia's WIP states that "the sum of the regulated sectors and the [local area planning goal] loads, together with any resulting state initiatives, is expected to meet the State-Basin planning targets on 2025 base conditions and account for additional loads due to climate change."[82]

Virginia, unlike Maryland and Pennsylvania, is planning for climate change.

D. Climate Change at the County Level

We reviewed stormwater planning documents for 11 counties in the Chesapeake Bay watershed with large volumes of stormwater pollution: Anne Arundel, Baltimore, Frederick, Montgomery, and Prince George's Counties in Maryland; Lancaster and York Counties in Pennsylvania; and Augusta, Fairfax, Loudon, and Rockingham Counties in Virginia. All of these counties are planning important and commendable work to control stormwater that will provide real benefits to local communities, local ecosystems, and the Bay. However, all of the county plans are based on one critical flaw, which is that they plan for the past, rather than the future. More specifically, they assume that future rainfall patterns will resemble past rainfall patterns, when we know that the future will see more rain and more heavy rain events.

Most stormwater infrastructure design standards adopt local precipitation assumptions from a National Oceanic and Atmospheric Administration atlas of precipitation frequency across the U.S.[83] The problem with using this document, called "Atlas 14," and the data it contains, is neatly spelled out in a 2015 peer review comment:

> *The reality is that public and private infrastructure sized using the new Atlas 14 may become undersized at some point in the future . . . because Atlas 14 only represents current climate, not future climate. Also, the effort to update Atlas 14 will likely not happen again in the near future given potential lack of federal and state funds. Providing a sister tool to predict future design storm intensity … would allow states and engineers engaged in land development the opportunity to design to future conditions, versus current conditions, to extend the longevity of public and private infrastructure.*[84]

In response, NOAA basically said: we don't know if it's a good idea, but we'll look into it. As of the latest progress report in 2019, the agency was still studying the problem.[85] (NOAA's words were "we still do not have a definite answer to whether a non-stationary approach is advantageous for the NA14 process," and "we continue the investigation on this topic.")[86]

To take another example, Maryland's stormwater pollution control permits for counties and cities ("MS4 permits") require "environmental site design" to the "maximum extent practicable."[87] That's legalese for providing treatment (meaning filtration and absorption capacity) for stormwater from the maximum 24-hour rainfall that can be expected once a year.[88] The problem is that these design storm estimates are based on past data, not predictions of future rainfall. In 2025, the amount of rain falling over a 24-hour period once per year will likely be much greater than it was in, for example, the late 20th Century.

Or consider a typical county annual stormwater report, and how that report presents monitoring data. The 2019 annual report (MS4 report) for Baltimore County includes a detailed discussion of a stream, the Scotts Level Branch in the Gwynns Falls watershed.[89] At one monitoring location (site SL-01), the report indicates that the total phosphorus pollution load was 3,002 pounds in 2018. However, the report adjusts that number to what the pollution load *would have been* if the area had seen "average rainfall." Adjusted, the load was only 1,751 pounds.[90] The reality was far different. In fact, 2018 was a year of rainfall totals that were far above average, and therefore pollution loads that were also far above average. That truth becomes obscured by the adjustment to "average" rainfall. The report goes on to compare pollution in 2018 to what the EPA-led Chesapeake Bay Program's computer modeling predicted that year for the same watershed. For monitoring location SL-01, the model predicted a phosphorus load of 1,215 pounds.[91] The real 2018 load was therefore at least 2.5 times greater than the model assumes.[92] Yet one could easily miss that fact by only looking at the "adjusted" load.[93]

As explained earlier this in this report, 2018 was a year of record-breaking rainfall across the Bay watershed. As measured at Baltimore Washington International Airport, the precipitation total that year was higher than it had ever been since rainfall data were first collected in 1871. This leads to an important policy question. Should the record-setting 2018 rainfall be treated as an aberration, or as something that Baltimore County and other jurisdictions should be planning to accommodate more often in the future? When counties adjust their pollution reporting to reflect the amounts in "average" rainfall years, they are embedding an assumption into their plans, and the assumption is that future rainfall patterns will be similar to what they were in the past.

Ironically, the counties in the Bay watershed do frequently think about the future – just not future precipitation. In Virginia, for example, Fairfax County's Watershed Management Plan contemplates "future conditions," but that only refers to future land cover.[94] For precipitation and weather, the plan uses historic data.[95]

Only rarely do counties assume a more forward-looking posture toward the climate and rainfall. Montgomery County, Maryland, for example, is in the midst of a community-based climate workgroup process that should lead to a "climate action and resilience plan" sometime in 2021.[96] Although this process is generally focused on greenhouse gas emissions reduction, it does specifically identify the problem of basing forward-looking stormwater plans on backward-looking rainfall data. The goals and recommendations developed by the climate workgroups include:

- "Reduce risks and impacts of more intense storms."[97]
- "Improve hydrological and meteorological data collection and analysis of wet weather and storms, considering climate change over the next 30 to 100 years, and incorporating trends in land use/land cover change."[98]
- "Work with Maryland and NOAA to ensure that NOAA's outdated and inadequate Atlas 14 precipitation statistics for Maryland are updated and recalculated, and ensure that Maryland update and revise stormwater, floodplain, and other codes and regulations."[99]

And a consultant for Prince George's County said the following:

> *Although average annual precipitation in Maryland has increased by approximately 5 percent in the past century, precipitation from extremely heavy events has increased in the eastern United States by more than 25 percent since 1958 (USEPA 2016). The amount and frequency of precipitation is projected to continue increasing, which could lead to more flooding such as past flooding in Upper Marlboro. Average precipitation is expected to increase during winter and spring, which will cause snow to melt earlier and intensify flooding during those seasons.*[100]
>
> *BMPs designed for current conditions will most likely fail to sufficiently treat and reduce runoff from the projected larger and more intense storm events. That failure could cause stormwater to overflow or damage BMPs; the BMPs would not treat all the*

runoff and would not reduce runoff volume reaching the County's water bodies. That situation, in turn, could result in downstream channel erosion and flooding.[101]

Unfortunately, these salient observations were buried in a sediment restoration plan for the Patuxent River watersheds, and are not reflected in county-level policy.

There is no question that the counties should be planning for more rain, more storms, and more flooding. One path forward, given the complexity and breadth of climate modeling, is to advocate for better federal guidance, such as a forward-looking replacement for NOAA's "Atlas 14" guide on rainfall frequency across the U.S. Another strategy – one that would be much easier to implement – would be to use available resources (such as Atlas 14), but to plan for the storms that we used to think of as rare. It's well-known that high-precipitation storms are becoming more common. Southern New Hampshire recently saw 100-year floods three years in a row.[102] (These are floods that are supposed to have a one in one hundred chance of happening in any given year.) Ellicott City, Maryland experienced two 1,000-year storms in three years (see page 28).[103] An EPA modeling exercise for Harford County, Maryland estimated that today's ten-year storm will be tomorrow's two-year storm.[104] If that's the case, then perhaps it would be wise for counties (and states) to simply replace references to "two-year storms" in their planning documents with references to "ten-year storms." This way, they would be planning for the 2-year storms of the future. More generally, it may be time to start building capacity for 1,000-year storms.[105]

There is no question that counties and cities can and should be planning for larger storms. But local governments – on their own, without state and federal assistance – cannot be expected to unilaterally take responsibility for the added impacts of climate change on the Chesapeake Bay. A typical county or city is already working to prioritize and implement stormwater management policies within the constraints of tight budgets that have become more strained because of the Covid-19 economic crash. The EPA and the Bay region states set the Bay cleanup targets for the counties. So the federal and state governments should also take responsibility for leading counties and cities in planning for how climate change will affect Bay cleanup progress.

When planning for stormwater capacity needs, counties too often look backward at historical rainfall patterns when they should be looking ahead.

Beyond the progress of the Bay cleanup, another area where planning for increased rainfall from climate change is important is sewage overflows, which is more of a local public health issue than a major source of nitrogen and phosphorus pollution in the Chesapeake. Sewage overflows are not the same as the stormwater problem we have been discussing, but they are related in cities that have combined sewage and stormwater systems.

Growing Rainfall and Sewage Overflows in Cities

More than 50 cities and towns in the Chesapeake Bay watershed have antiquated, combined sewage and stormwater systems. This means the same pipes that were built under the streets to carry human waste to sewage treatment plants were also designed – whenever there is a significant rainstorm – to carry rainwater runoff mixed with human waste into nearby rivers and streams.[106] Thirty-one of these old-fashioned, leaky systems are in Pennsylvania, including the state capital, Harrisburg.

EPA and state environmental agencies require cities with combined sewer and stormwater systems to comply with the Clean Water Act by creating and following what are called Long-Term Control Plans.[107] These plans lay out improvements and procedures to reduce and minimize their sewage overflows, which often contain fecal bacteria and dangerous pathogens that can render local waterbodies unsafe for contact and recreation.

More than 50 cities and towns in the Chesapeake Bay watershed have antiquated, combined sewage and stormwater systems in need of major overhaul.

Long-Term Control Plans often use studies of past rainfall conducted by the city or precipitation data from state or federal sources to calibrate the size of their pipes and infrastructure improvements for future storm events. EIP gathered and analyzed these plans for four cities in the Chesapeake Bay watershed – Harrisburg, Pa; Cumberland, Md., Washington, D.C., and Lynchburg, Va. -- to determine if their long-term plans account for increases in rainfall that have been happening in recent years and reasonably project future increases in precipitation and storm intensity due to climate change.

Methods for determining typical year precipitation vary between cities. Some rely on complex modelling, national weather data, local monitoring, or a combination of these methods. EIP identified the typical year of rainfall assumption for each city's long-term control plan and compared it to the most recent five-year average calculated using data from the National Oceanic and Atmospheric Administration (NOAA). The results are below:

Table 8: Rainfall Assumptions in Long-Term Control Plans for Cities with Combined Sewage and Stormwater Systems

City, State	Annual Rainfall in Plan (inches)	Actual Annual Rainfall from 2015-2019	% Difference
Cumberland, MD	36.5	47.73	27%
Washington, DC	38.95	48.14	21%
Harrisburg, PA	39.8	46.22	15%
Lynchburg, VA	42.35	48.45	13%

Table 1: Annual rainfall in plan reflects rainfall depth in inches derived from the combined sewage and stormwater Long Term Control Plans for Washington, D.C., Harrisburg, Pa., and Lynchburg, Va. Rainfall depth assumptions for Cumberland are from the City's 2013 Comprehensive Plan. Harrisburg's rainfall depth has a standard deviation of 8.08. Rainfall depth is a parameter included in the calibration of a city's sewer system and used as a means to make assumptions comparable for the purposes of this report. Actual annual rainfall numbers are NOAA five-year averages, and are calculated from Global Summary of the Year precipitation records for 2015-2019.

As can be seen in the chart above, the cities' long-term plans are based on outdated rainfall assumptions, and underestimate recent rainfall by between 13 and 27 percent, meaning that their infrastructure improvements and stormwater controls were designed for less precipitation than has been falling – and much less than will fall in the future as climate change impacts grow.

Cumberland, Maryland: The greatest discrepancy between assumptions in a city's long-term plan and recent data was in Cumberland. In 2018, the city released 103 million gallons of sewage mixed with stormwater into tributaries to the Potomac River and Chesapeake Bay.[108] To help deal with this problem, the city had planned improvements for their combined sewage and stormwater system, including boosting the capacity of their pumping stations and building a stormwater retention facility that could hold 10 million gallons of overflow per day.[109] However, the city's plans were based on smaller annual rainfall projections than have been actually hitting the region in recent years. Cumberland used climatological data that assumes that the city receives 36.5 inches of rainfall per year.[110] This is 27 percent less than the most recent five-year average, which is 47.73 inches of rain per year, according to NOAA (see table above).[111,112] EIP sent written questions to Cumberland officials about this planning gap, but did not receive a response.[113]

Washington, D.C.: The nation's capital has invested far more to control stormwater and solve its sewage overflow problems than most cities (see detailed discussion on pages 25-28). The city's nearly $3 billion[114] in construction projects include the construction of two massive underground stormwater storage tunnels (with capacities of 77 million and 49 million gallons). DC Water is also separating sewage and stormwater outfalls, building new pumping stations, constructing a major sewer line, and installing rain gardens and other rain-absorbing "green" infrastructure. Some of these projects were completed by March 2018, others are still under construction, and the building of green infrastructure will continue through 2030.[115] As a result, discharges of stormwater mixed with sewage to the Potomac and Anacostia rivers have fallen substantially, including from 180,000 gallons in 2018 to 32,000 gallons through the first 10 months of 2019.[116]

However, even DC's massive project was based on rainfall data and projections that are no longer accurate. The city's 2002 long term control plan, which has a 40-year implementation timeline, used rainfall data from the monitoring station at Ronald Reagan National Airport and 1988-1990 as the forecast period. The average amount of rainfall during that period was 38.95 inches,[117] which is 21 percent lower than the most recent five-year average (2015-2019) using NOAA data.[118] This means almost ten inches more rain per year is entering the system than expected.[119] DC Water said that their rainfall assumptions were "developed in accordance with EPA guidelines."[120] This highlights the need for updated EPA guidelines that take climate change into account, as articulated in the conclusion of this report. (For DC Water's full response, see Appendix D.)

Harrisburg, Pennsylvania: Pennsylvania's state capital last year released 902 million gallons of sewage mixed with stormwater into the Chesapeake Bay's biggest tributary, the Susquehanna River, and 1.4 billion gallons in 2018, according the reports of the local water authority, called Capital Region Water.[121] This overflow – driven in part by growing rainfall and resulting stormwater – is causing severe local water quality problems. Bacteria monitoring by the Lower Susquehanna Riverkeeper along the Harrisburg waterfront in June and July of 2020, for example, found *E. coli* bacteria concentrations in the Susquehanna that averaged more than 2.5 times safe levels for swimming or water contact recreation, including just downstream from outfalls leading from the Governor's Residence and State Capitol Complex.[122]

To address the sewage and stormwater overflow problem, Capital Region Water signed a partial consent decree with the Pennsylvania Department of Environmental Protection (DEP) in 2015 that required more stormwater planning. Capital Region Water in 2018 released a plan that proposes for Harrisburg area residents to pay $315 million over 20 years improve the maintenance of the long-neglected combined sewage and stormwater pipes. The Harrisburg plan also includes the upgrade of a pumping plant, the repair and rehabilitation of sewer lines, improvements to outfall regulation devices, as well the planting of trees and rain gardens and the creation of other "green infrastructure" to help soak up rainwater.[123] Since Capital Region Water signed its limited consent decree with the state, however, the amount of effluent being piped into the river has increased from what had been an average of about 800 million gallons a year.[124] Harrisburg's control plan uses a median expected annual rainfall of about 40 inches per year, based on historic figures in a 57-year record from Harrisburg's two airport gauges.[125] But that is about 15 percent less than the average 46 inches of rain the region has experienced from 2015 to 2019, based on NOAA data. However, it should be recognized that Harrisburg's plan states that their annual rainfall predictions could vary by as much as 8 inches. That would suggest that its estimates of precipitation totals might be within an acceptable range of reality.[126] In response to questions sent by EIP, Harrisburg Capital Region Water said it was following EPA guidelines when it created its plan.[127] For the full text of Harrisburg's response see Appendix E.)

Lynchburg, Virginia: Lynchburg's combined sewer and stormwater system has 132 outfalls that released 65 million gallons of overflows in 2019.[128] To address the problem, the city has a long term control plan that includes closing 87 percent of the outfalls, increasing the capacity of the local wastewater treatment plant, building a storage tank and installing "green" infrastructure.[129] Many of these projects are either under construction or complete. However, this whole plan, updated in 2014, was created with what are now outdated annual estimates of rainfall. The plan used the period of 1993-1995 to create a "typical year" rainfall assumption of 42.35 inches. That's about 13 percent less than the average of 48.45 inches that fell from 2015-2019, according to NOAA data. Lynchburg's Director of the Department of Water Resources, Timothy Mitchell, defended the city's use of older rainfall averages as being "fully in accordance with applicable EPA guidance."[130] As mentioned earlier, this underscores the need for updated federal guidance that takes into account increasing rainfall from climate change. (For his full statement, see Appendix F.)

Looking to the future across the whole Chesapeake region, rainfall has turned out to be much higher than predicted, and in some recent years double historic averages. A 2020 report by NOAA states that this trend is expected to continue.[131] With this growing volume of rainfall in mind, many cities with combined sewage and stormwater systems may be unprepared for current rainfall conditions, much less the dramatic increases that could occur in the future.

In the next section of this report, we look at two case studies of local governments. One has been struggling mightily with stormwater and flash flooding: Ellicott City, Maryland. The other has been building larger and more expensive stormwater control facilities than almost any other city: Washington, D.C.

Examples of Cities Dealing with Stormwater Control Issues

CASE STUDY: ELLICOTT CITY, MARYLAND

250-year-old Mill Town Confronts Rising Flood Vulnerability

Founded in 1772, Ellicott City's historic downtown is home to the oldest surviving train station in the country. But while this quaint city on the edge of the Baltimore metropolitan area may be ideally situated for a railroad track, it's in a highly inopportune spot when it comes to flooding. The historic district is nestled within steep, rocky valleys and is part of a three-and-a-half-square-mile watershed that includes four tributaries — the Tiber, Hudson, Autumn Hill, and New Cut rivers — that empty into the Patapsco River, which runs straight through downtown. When it rains, it pours.

Flood damage along Main Street in Ellicott City on August 10, 2016. The suburban developments that have sprung up all around the town over the last 50 years have heightened flood risk during storm events by preventing natural drainage.

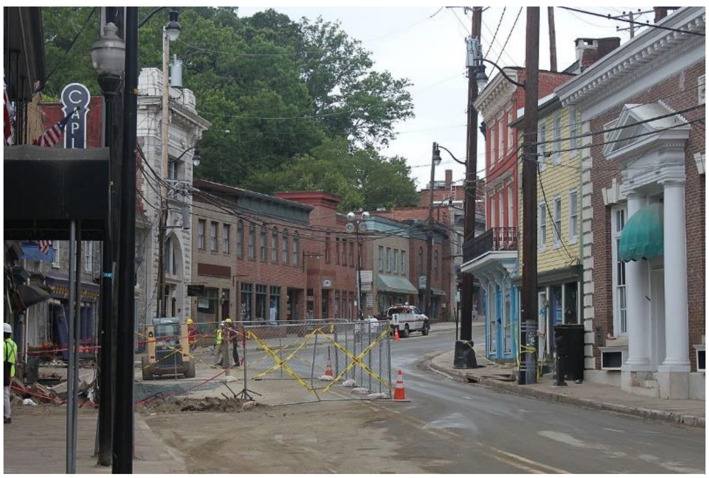
In the last decade, rainfall in the valley has been hitting new highs, as predicted by climate change models showing increased precipitation across the Northeast. The town was slammed by two 1,000-year storms in the span of two years — the first on July 30, 2016, and the second on May 27, 2018. Storms as intense as these are only supposed to have a 1 in 1,000 probability of occurring in any year. But climate change appears to be rewriting this math. Both these devastating downpours released flash floods upon the city's dense center, causing extensive damage and three deaths. During these heavy rains, torrents of water rushed downhill along Main Street, toward the Patapsco River.

Many of the same businesses were damaged by both floods and the same residents displaced. This caused uncertainty among community members about whether rebuilding and remaining in the town was a wise decision. While the town, which is built entirely in a 100-year floodplain, has had at least 18 major floods since it started recording them in 1789, something about the intensity and frequency of these two floods, as well as another major 2011 flood during Tropical Storm Lee, felt like a new kind of crisis.[132]

In March 2020, the Maryland General Assembly approved more than $8 million for additional stormwater control projects in Ellicott City. The money will fund a multi-year "Safe and Sound" plan that includes the construction of new stormwater tunnels to divert water away from Ellicott City's Main Street. The plan also features expanded culverts and new retention ponds higher up the watershed to reduce flooding. The Howard County government is purchasing all but one of ten flood-prone buildings around Main Street, at least four of which will be torn down due to their extreme susceptibility to flooding.[133]

County Executive Calvin Ball said he wants the "Safe and Sound" plan to be recognized as dealing with the realities of climate-driven precipitation increases and flood risks, and to be viewed as an example of how to preserve the character of a small city while prioritizing public health.[134]

The plan not only addresses aging infrastructure lacking adequate drainage, but also more recent suburban sprawl that's greatly expanded the impervious paved environment. All this pavement upends natural systems and directs more water into already overflowing rivers and stormwater channels. The unincorporated community's population has exploded in recent decades to over 75,000, and around two-thirds of the watershed's land is developed, with more than a fifth being covered by pavement, rooftops, and other hard, impervious surfaces.[135]



Recovery efforts along Main Street in Old Ellicott City during the summer of 2016. Before the 2016 flood, more than 100 businesses lined Main Street and generated some $200 million in annual revenue.

Stormwater regulations within the watershed today only require new developments to be capable of handling runoff from 100-year storms, which means eight inches in 24 hours. A 1,000-year storm such as the one in May 2018 released eight inches in just three hours,[136] and nearly double that over the course of the day.[137]

David Wood, the stormwater coordinator for the Chesapeake Stormwater Network, which is based in Ellicott City, said even the most drastic improvement to the town's local infrastructure would only solve part of the flooding problem.

"Topography, past development practices, and other factors play a big role," he said. "While improving the design of stormwater infrastructure will mitigate the impacts of somewhat more frequent flooding events—up to 100-year storms—the historically large events will likely remain beyond the control of typical stormwater infrastructure."

With two 1,000-year storms occurring within the space of three years, it's clear that the solution to the town's flooding problem must include much more than just adjustments to the city's stormwater tunnels and culverts. As the city continues to secure financing, build support for its current plans, and envision even bolder future actions, stopgap measures are underway. These include clearing debris out of stormwater channels and making sure stormwater management requirements are met and enforced without exception. The city has also installed a public-alert system with loud beeping to indicate imminent or likely flooding along with signs pointing the way toward higher ground.

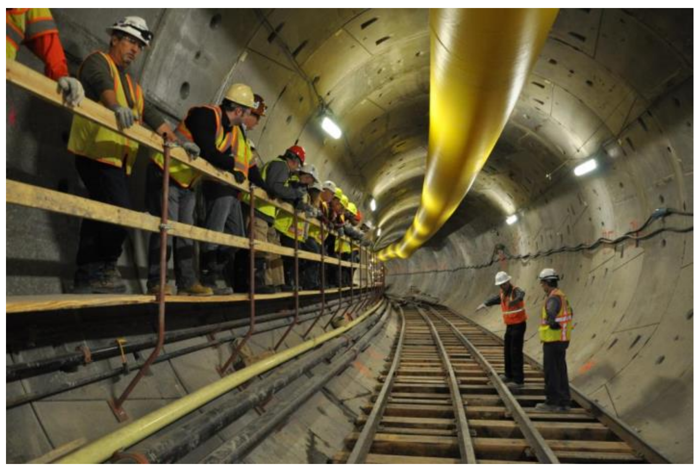
Wood said cities and counties across the Bay watershed, including Ellicott City, are just beginning to plan for the expected increases in rain volume and intensity due to climate change.

"Communities are often balancing budgets on a shoestring while trying to achieve both quantity and quality objectives," he said. "Understanding the changing climate conditions has a significant impact on future stormwater planning and design."

CASE STUDY: WASHINGTON, DC

From Massive Tunnels to Curbside Planters: A Complete Stormwater Infrastructure Overhaul

Washington, D.C., is in the midst of an ambitious and expensive stormwater infrastructure project that is designed to drastically reduce sewage overflows into the Anacostia and Potomac rivers.



When the entire DC Clean Rivers Project is completed in 2030, average combined sewage discharges to the three major District waterways—Anacostia and Potomac rivers and Rock Creek—will be reduced by 96 percent overall.

The goal is to make the waterways – once infamous for their contamination – healthy enough for swimming. Known as the Clean Rivers Project,[138] the construction project hinges on three massive underground tunnels that will be able to accommodate large rainfalls and prevent damaging nuisance flooding across the city, the result of a dated and overburdened drainage system based on 19th-century technology.

According to DC Water, the project will reduce combined sewer overflows by 96 percent overall and will essentially remove overflows of the city's combined sewage and stormwater system – called combined sewage overflows, or "CSOs" -- as a source of pollution to the Potomac.[139] The project will also reduce peak flows to wastewater treatment plants, making nutrient removal more effective and thus reducing pollution into the Chesapeake Bay. The first phase of the tunnel system went into operation in March 2018. By May of 2020, it had prevented over 7.7 billion gallons of sewage and stormwater from running into the District's waterways.

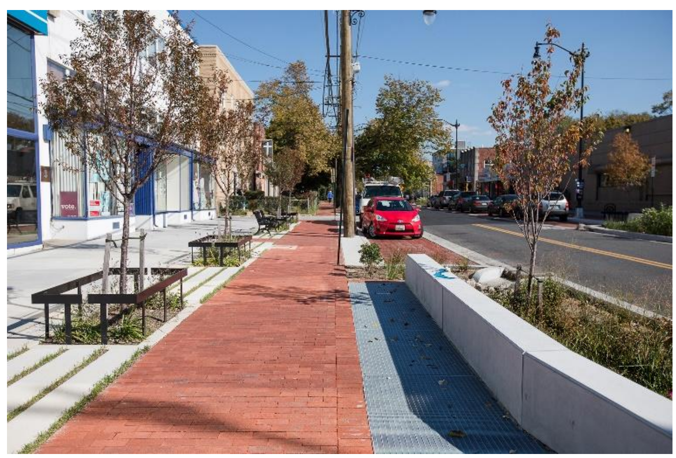
The overhaul of the system is the result of a twenty-year-old lawsuit filed by the Anacostia Watershed Society against DC Water over sewage pollution. DC Water agreed to build the massive sewer tunnels as part of a 2005 consent decree with the Environmental Protection Agency.[140]

More than 700 other cities around the country have similarly antiquated combined sewage and stormwater systems in need of major updating. Many of these cities must not only address dated infrastructure unable to accommodate today's sprawling urban landscapes dominated by impermeable surfaces, which exacerbate flooding, but also increased rainfall and other long-term weather changes driven by climate change.

Kimberly Isom, DC Clean Rivers Project Program Coordinator, said projects like DC's are long-term, expensive, and difficult to implement. With a price tag approaching $3 billion, the project is one of the largest and costliest building projects in the region's history.

"It's important that a comprehensive and defensible plan is developed at the beginning to establish schedule, budget, and performance," she said. "It is equally critical to obtain buy-in on the plan from the start from key stakeholders including regulators, environmental groups, and agency and political leaders."

Getting environmentalists' buy-in necessarily means addressing the storm on the horizon: climate change. The Washington region is forecast to get warmer and wetter.[141] Washington experienced its wettest year on record[142] in 2018, and its wettest 365-day stretch[143] from mid-2018 to mid-2019. More than 71 inches of rain fell between May 12, 2018, and May 12, 2019; almost five inches more than the record-setting 2018 calendar year total of 66.3 inches. Isom said Blue Plains Advanced Wastewater Treatment Plant, where DC's water is pumped out and treated, can be expanded in the future to increase the system's performance in the face of climate change, increasing growing rainfall, or other factors. She also said the tunnel system has been extended to provide additional storm conveyance capacity to historically flood-prone neighborhoods such as Bloomingdale and LeDroit Park.



The Kennedy Street revitalization project in northwest Washington added more than 13,000 square feet of green space to a city block. It will help reduce combined sewer overflows into nearby Rock Creek Park during major rainfall events.

The Clean Rivers Project consists of many different coordinated elements. Aside from the 18 miles of tunnels, dug deep underground at a rate of 50 feet per day, there's also a vast network of smaller green infrastructure projects to help mitigate rainfall and prevent overflows.

One of these efforts along the 100 block of Kennedy Street in the city's northwest quadrant won the Chesapeake Stormwater Network's award for "Best Ultra-Urban BMP (Best Management Practice) in the Bay in 2019.[144] The one-block project entails 33 green infrastructure projects, including enhanced tree canopy, permeable pavement (including along parking lanes), bioretention ponds, and curb extensions and planters that store water. Combined, these elements create three "lines of defense"—above-ground rainfall capture by the trees, street-level landscape enhancements and permeable pavements, and below-ground storage drywells.

By designing the infrastructure elements to work in a series, the overall system becomes even more resilient. When stormwater overwhelms one infiltration element it overflows to another, and then to another. This conveyance greatly slows the flow of the water, making it easier to capture before it spills over and causes flooding. The system removes 9,000 square feet of impervious surface from the 1.14-acre site and can accommodate nearly 60,000 gallons of stormwater, enough to mitigate a rainfall event of over two inches.

At the ribbon cutting for the Kennedy Street Project in June 2018, Washington Mayor Muriel Bowser celebrated the project for not only addressing chronic flooding issues, but improving public safety and making the city more beautiful.[145]

"We are proud to celebrate this tremendous revitalization," Mayor Bowser said. "Projects like this one are how we build a safer, stronger DC, and ensure that our neighborhoods continue to meet the needs of a growing city."

Isom pointed to the revitalization happening along Anacostia River waterfront as another example of a major civic improvement made possible in part by the stormwater upgrades.

"After decades of pollution from a variety of sources, the Anacostia River is being reclaimed as the community centerpiece that it can and should be," she said.

"These same benefits are also being experienced by wildlife," she continued. "DC Water has received numerous reports from river users of a surge in aquatic life since commissioning of the tunnel system. Adequate sewer infrastructure, including the tunnel system, is critical to achieving the goal of making the District's waterways fishable and swimmable."

Conclusion and Recommendations:

Even without the effects of climate change, state and local governments across the Chesapeake Bay region have been struggling with the challenge of urban and suburban runoff pollution. As some communities – like Washington, D.C. – have started to invest in permeable pavement and stormwater pollution control devices like bioretention ponds, others have moved in the opposite direction by continuing to allow sprawling developments with acres of blacktop. Since the most recent Bay cleanup agreement was signed in 2009, the amount of developed land in the Bay watershed has increased by about 291,629 acres – an area six times the size of the District of Columbia -- adding more blacktop, roofs, and roads that accelerate runoff pollution. As a result, while many types of pollution into the Chesapeake Bay have declined – notably, from sewage treatment plans – runoff of nitrogen and phosphorus from urban and suburban areas has increased.

On top of this urban planning problem is the much broader crisis of a global climate that's been thrown out of balance by the burning of fossil fuels. Record-breaking rainfall pummeled most of the Chesapeake region in 2018, and the next year, a record-setting volume of fresh water flowed into the Bay – carrying with it runoff pollution from subdivisions, cities and farms.

As the Chesapeake region states try to execute an ambitious 2010 Bay cleanup agreement, one might think that they would be motivated to address this growing rainfall problem and redouble their plans to build stormwater pollution control systems. These projects, after all, not only soak up the rainwater flushing over parking lots, but also create greenspace in urban areas – including through the planting of trees and the conversion of parking lots to parks. Virginia and the District of Columbia are taking this forward-looking approach. By contrast, Pennsylvania and Maryland are moving in the opposite direction. In their most recent Watershed Implementation Plans, they retreated by weakening their urban and suburban stormwater pollution targets and scaling back their plans for implementing pollution control projects. This is unacceptable, especially at a critical time when a 2025 deadline for the Bay cleanup is just around the corner.

State and federal environmental agencies have also failed to provide enough guidance and grant money to county and city governments struggling with the problem of increased and more intense precipitation.

This report recommends the following solutions:

1) Broadly speaking, we should be planning for the future, not the past. There is no question that rainfall in the Bay region is increasing in both total volume and intensity. Planning at all levels – from the federal government down to the county and city level – must take these trends into account. All levels of government should start calibrating their planning and stormwater control projects and infrastructure to reflect likely future rainfall patterns, not historic averages from decades ago.

2) EPA must take a more active leadership role and require Pennsylvania and Maryland to strengthen their stormwater control plans and account for climate change. Instead of backtracking, Pennsylvania and Maryland should expand the stormwater pollution projects in their Phase III Watershed Implementation Plans.
3) EPA should require Pennsylvania to commit substantially more resources to its Bay cleanup effort, which has been far behind the other states. Federal actions could include the denial of permit approvals for major construction projects in Pennsylvania and a demand that the Commonwealth upgrade its leaky combined stormwater and sewage systems, including in Harrisburg.
4) States and municipalities across the Chesapeake region should invest more in stormwater control projects, such as the construction of artificial wetlands, ponds, rain gardens and the conversion of parking lots and other impervious surfaces to green areas that absorb rain. These projects not only control runoff pollution, they also help address environmental justice issues by creating parks in urban areas that are often dominated by blacktop.
5) Because stormwater control projects are expensive, EPA and Congress should provide substantial federal funds to state and local governments to help pay for these projects, which create jobs. Such federal investments would be a healthy economic stimulus package to help the nation rebound from the COVID-19 recession.

During a time when people are especially concerned about public health and employment, there's no better investment than putting American laborers to work transforming parking lots to parks, installing gardens in our cites, planting wetlands and trees, fixing pipes and culverts, and cleaning sewage out of our rivers, streams, and Chesapeake Bay. Controlling stormwater also creates greenspaces that absorb heat and improve the quality of life in densely-packed urban areas. This helps to alleviate environmental injustice by making cities more livable during an era of climate change.

APPENDIX A: Additional Tables

Table A1: Developed land and stormwater loads from **Delaware**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Change (%)
Developed acres	57,457	60,133	+4.7%
Loading rate (pounds per developed acre)			
Nitrogen	11.40	10.99	-3.6%
Phosphorus	0.43	0.40	-8.2%
Sediment	27.17	27.27	+0.4%
Delivered load (pounds)			
Nitrogen	654,975	660,945	+0.9%
Phosphorus	24,840	23,877	-3.9%
Sediment	1,561,310	1,640,009	+5.0%

NOTE: All load estimates are "edge of tide," or delivered loads.

Table A2: Developed land and stormwater loads from the **District of Columbia**, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	31,312	32,621	+4.2%
Loading rate (pounds per developed acre)			
Nitrogen	5.45	5.30	-2.7%
Phosphorus	0.47	0.44	-6.0%
Sediment	689	642	-6.9%
Delivered load (pounds)			
Nitrogen	170,637	172,914	+1.3%
Phosphorus	14,652	14,347	-2.1%
Sediment	21,586,001	20,941,874	-3.0%

Table A3: Developed land and stormwater loads from **Maryland**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	1,240,341	1,302,377	5.0%
Loading rate (pounds per developed acre)			
Nitrogen	7.26	7.28	+0.3%
Phosphorus	0.55	0.54	-3.1%
Sediment	313	323	+3.4%
Delivered load (pounds)			
Nitrogen	9,007,360	9,484,662	+5.3%
Phosphorus	685,400	697,536	+1.8%
Sediment	388,067,503	421,219,826	+8.5%

Table A4: Developed land and stormwater loads from **New York**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	338,546	366,185	+8.2%
Loading rate (pounds per developed acre)			
Nitrogen	5.74	5.71	-0.5%
Phosphorus	0.22	0.21	-5.2%
Sediment	341	322	-5.6%
Delivered load (pounds)			
Nitrogen	1,942,778	2,091,431	+7.7%
Phosphorus	73,450	75,283	+2.5%
Sediment	115,389,621	117,781,261	+2.1%

Table A5: Developed land and stormwater loads from **Pennsylvania**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2018	Rate of change (% per year)
Developed acres	1,562,739	1,646,813	+5.4%
Loading rate (pounds per developed acre)			
Nitrogen	9.48	9.29	-2.0%
Phosphorus	0.28	0.26	-6.4%
Sediment	337	298	-11.7%
Delivered load (pounds)			
Nitrogen	14,811,711	15,301,338	+3.3%
Phosphorus	433,501	427,701	-1.3%
Sediment	526,727,009	489,980,766	-7.0%

Table A6: Developed land and stormwater loads from **Virginia**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	1,759,898	1,895,626	+7.7%
Loading rate (pounds per developed acre)			
Nitrogen	5.76	5.74	-0.3%
Phosphorus	0.70	0.69	-1.8%
Sediment	308	309	+0.4%
Delivered load (pounds)			
Nitrogen	10,131,975	10,885,541	+7.4%
Phosphorus	1,237,305	1,309,242	+5.8%
Sediment	541,559,575	585,890,045	+8.2%

Table A7: Developed land and stormwater loads from **West Virginia**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)

Developed acres	166,910	174,975	+4.8%
Loading rate (pounds per developed acre)			
Nitrogen	7.38	6.78	-8.2%
Phosphorus	0.44	0.33	-24.1%
Sediment	529	499	-5.7%
Delivered load (pounds)			
Nitrogen	1,232,166	1,185,806	-3.8%
Phosphorus	73,023	58,072	-20.5%
Sediment	88,292,675	87,255,613	-1.2%

Table A8. Stormwater phosphorus loads from developed land (highlighted cells indicate a reduced level of effort)

	2009 load (millions of pounds)	2025 targets (millions of pounds)		Planned change in load, 2009-2025	
		2012 plan	*2019 plan*	*2012 plan*	*2019 plan*
DE	0.02	0.03	0.02	+8.4%	+0.1%
DC	0.01	0.01	0.01	-0.9%	-10.6%
MD	0.69	0.47	0.66	-31.9%	-3.9%
NY	0.07	0.07	0.05	-6.5%	-34.8%
PA	0.43	0.18	0.43	-57.6%	-1.3%
VA	1.24	1.26	1.19	+1.3%	-4.1%
WV	0.07	0.06	0.05	-23.6%	-30.5%
TOTAL	**2.55**	**2.07**	**2.41**	**-18.5%**	**-5.2%**

NOTE: *All load estimates are "edge of tide," or delivered loads. "2012 plan" and "2019 plan" loads represent the loads associated with Phase II and Phase III WIP commitments, respectively, as shown by the Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST).*[146]

Table A9. Stormwater sediment loads from developed land (highlighted cells indicate a reduced level of effort)

	2009 load (millions of pounds)	2025 targets (millions of pounds)		Planned change in load, 2009-2025	
		2012 plan	*2019 plan*	*2012 plan*	*2019 plan*
DE	1.57	1.77	1.67	+13.2%	+6.7%
DC	22.19	19.47	19.77	-12.3%	-10.9%

MD	388.26	284.04	393.79	-26.8%	+1.4%
NY	115.39	95.41	67.94	-17.3%	-41.1%
PA	524.52	136.11	481.38	-74.1%	-8.2%
VA	542.33	511.89	475.68	-5.6%	-12.3%
WV	88.30	97.94	88.47	+10.9%	+0.2%
TOTAL	**1,682.56**	**1,146.63**	**1,528.72**	**-31.9%**	**-9.1%**

NOTE: *All load estimates are "edge of tide," or delivered loads. "2012 plan" and "2019 plan" loads represent the loads associated with Phase II and Phase III WIP commitments, respectively, as shown by the Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST).*[147]

APPENDIX B: Statement from the Maryland Department of the Environment

In response to questions from the Environmental Integrity Project, Jay Apperson, Deputy Director in the Office of Communications for the Maryland Department of the Environment, emailed the following statement on July 29, 2020:

"Maryland's commitment to reducing polluted urban and suburban stormwater runoff is unwavering. It is important to understand the importance of this being done not in a vacuum but in coordination with work to reduce nutrient and sediment pollution from all sectors for the best results as part of the broad Chesapeake Bay restoration plan. The numbers attached to this work may evolve due to changes reflected in improved modeling, an increasing use of calculations that consider growth and the effects of climate change and an understanding that this work does not end in 2025 and must be sustainable for the long run. Maryland's Phase III WIP includes nutrient targets that represent a substantial increase in effort over the Phase II WIP, with an additional million pounds of nitrogen reductions required by 2025. To reduce stormwater runoff It is crucial that the state gain the buy-in of stakeholders – including local governments that are responsible for planning, paying for and installing BMPs -- by helping them to understand the opportunities for restoration and the opportunities to solve multiple problems (for co-benefits such as reduced flooding, for example) to justify the costs. As a state, Maryland continues to be a leader in reducing nutrient and sediment pollution to our waterways and in restoring the Chesapeake Bay.

Question 1. In Maryland's Phase III Watershed Implementation Plan (WIP), submitted to EPA in August 2019, Maryland promised to do less to control stormwater from urban and suburban areas than it pledged back in 2012 in its Phase II WIP. Why the retreat on concrete commitments and projects to reduce urban and suburban stormwater pollution into the bay?

Response 1: The Phase III WIP envisions that WWTP upgrades and agricultural BMPs will be the primary nutrient reduction drivers to achieve 2025 goals and that stormwater restoration will need to continue in the future to maintain the 2025 Bay nutrient caps, offset the impact of climate change and to restore local rivers and streams.

The Phase III WIP expects to maintain a pace of restoration of impervious surfaces that would lead to 30% cumulative restoration by 2025 and almost 40% by 2030. There has been no retreat. Restoration of impervious surfaces with little or no stormwater management is largely implemented through the MS4 permits, which regulate more than 90% of the impervious surfaces in the state. In the last decade, the MS4 jurisdictions combined impervious surface restoration (concrete commitments on impervious surfaces with little or no stormwater management) has averaged about 2% per year or 20% by 2019. Continuing at this 2% pace represents a continuation of the most challenging and expensive component of Bay restoration goals in Maryland.

Question 2: Maryland's Phase III WIP set numeric goals for nitrogen pollution entering the Bay from urban and suburban stormwater in 2025 that are higher than the nitrogen loads from this sector back in 2009. The Phase III WIP would increase the amount of nitrogen pollution flowing into the Bay from stormwater runoff each year by 247,000 pounds by 2025, compared to the 2009 baseline. This suggests the state is not planning to make any net reductions at all in nitrogen from urban and suburban stormwater by 2025 and is instead accepting increases from this sector. Why?

Response 2: With respect to the 2009 comparison, as a result of Chesapeake Bay model changes, improvements in data reporting, load estimates are not comparable. The Phase III WIP reports that between 2017 and 2025 stormwater nitrogen, phosphorus and sediment pollution is expected to decrease. This will result from the combined effect from pollution mitigation and land conservation strategies on future development in addition to restoration of developed land with little to no existing stormwater management practices. The Phase III WIP, unlike the previous WIPs, accounts for growth to 2025 by factoring in the future population and land use (See Section VI). As land is developed, it is subject to many state laws, such as Environmental Site Design, Forest Conservation, Critical Area, Program Open Space, Tier II Waters, and wetland mitigation as well as local ordinances.

Question 3. Compared to Maryland's Phase II WIP (back in 2012), Maryland is now planning in its Phase III WIP to build fewer rain gardens (zero acres of rain gardens instead of 34,716 acres) by 2025. The state also plans to create less permeable pavement (zero acres instead of 350 acres), and plant fewer forested buffers along urban streams (zero new acres instead of 26,430 acres), among other retreats in urban and suburban stormwater commitments. Why?

Response 3: In the Phase III WIP, the stormwater restoration is estimated using different parameters than the Phase II WIP, thus a direct comparison is flawed. The change reflects that implementation of the strategies, or specific practices, occurs through the MS4 permits. Thus, the MS4 jurisdiction has the flexibility to determine the best practices given the land use, geology and environmental priorities of the county or city, while still meeting the restoration requirements in the WIP and the permit. In the draft MS4 permit expected out later this year, permit incentives have increased for forest buffers, green infrastructure and capturing and treating more runoff volume. These incentives will support growth of green infrastructure that align with local needs and Bay restoration goals.

Question 4: Is Maryland essentially giving up on the urban/suburban stormwater sector because of its high cost, compared to other strategies for reducing pollution in the Bay?

Response 4: Maryland has strengthened its effort on stormwater restoration in the Phase III WIP and recognizes that restoration will continue past 2025 to restore local streams and rivers and the Chesapeake Bay. This is a long-term commitment. Stormwater restoration is expensive but local communities also invest in co-benefits including increasing flood resiliency, increasing groundwater supplies and greenspace, to name a few.

Maryland's large and medium MS4 jurisdictions have established themselves as national leaders by collectively investing $685 million in clean water infrastructure. As a result, 35,000 impervious acres have been restored, reducing more than 67,000 pounds of phosphorus, 270,000 pounds of nitrogen, and 30,000,000 pounds of sediment annually to local waters and the Chesapeake Bay. The Chesapeake Bay Trust has awarded $36.5 million in grants to MS4 programs that are ensuring a cleaner, greener, and healthier Chesapeake Bay. MDE's Water Quality Finance Administration guaranteed $107 million in low-interest loans for MS4 restoration projects and another $135 million in low-interest loans are pending for additional projects.

To suggest we are giving up is absurd. We are as committed as ever to our nationally acclaimed stormwater permitting program. We continue to successfully defend it against challenges by governments and regulated entities who believe it's too aggressive or costly all the way up to the US Supreme Court and we continue to insist on greater environmental results to meet our Clean Water Act commitments.

Question 5: Is Maryland deferring action on the urban/suburban stormwater sector until after 2025? If so, why?

Response 5: Maryland is preparing to issue five Phase I Large MS4 permits by the end of this calendar year. These permits will result in a cumulative restoration of 30% by 2025, successfully meeting our phase III WIP Goals. Further, the permits represent a significant effort to engage with local governments. Local support is the key to long term success of restoration goals since planning, funding and execution of BMPs is a local responsibility.

Question 6: Maryland has changed its MS4 stormwater permits, which used to require counties and cities to restore 20 percent of a municipality's impervious surfaces. Counties and cities can now buy pollution trading credits as an alternative to restoring 20 percent of their impervious surfaces. Why? Is this switch to the pollution trading option one of the reasons Maryland's Phase III WIP contains fewer commitments for urban and suburban stormwater projects?

Response 6: Urban and suburban stormwater projects are as high a priority as ever, and we are doing more than ever to encourage and support the multiple co-benefits of such projects including climate adaptation and resiliency.

No matter how many times you say it, our nutrient and sediment credit trading programs are not "pollution trading," a misleading label to imply pollution is only getting spread around. Nutrient and sediment credit trading is an increasingly important tool in the Chesapeake Bay watersheds around the country to accelerate the pace of actual restoration and bring more partners to the table without letting polluters off the hook. It can increase cost effectiveness and stronger partnerships to meet our Bay restoration goals. In addition to permit compliance, trading done right provides permittees with incentives to explore more cost effective, innovative solutions to achieve their pollution reduction goals, and incorporate other co-benefits into their implementation goals. It's an important tool that can help the Bay and local water quality as long as regulatory accountability, transparency, and public support are joined with it.

APPENDIX C: Statement from Pennsylvania Department of Environmental Protection

In response to questions from EIP, Deborah Klenotic, Deputy Communications Director for the Pennsylvania Department of Environmental Protection, emailed the following answers on July 24, 2020:

"Question: In its Phase III Watershed Implementation Plan (WIP), submitted to EPA in August 2019, Pennsylvania promised to do less to control stormwater from urban and suburban areas than it pledged back in 2012 in its Phase II WIP. Why the retreat on concrete commitments to reduce urban and suburban stormwater pollution into the bay?

Answer: The Phase 3 WIP is based on updated and far more sophisticated technical analyses than were possible in 2012, which allows DEP to focus on pursuing the most impactful as well as implementable pollution reduction efforts. The primary difference between the Phase 2 and 3 WIPs is the level of certainty Pennsylvania has with respect to implementation. We are certain we'll accomplish more in urban stormwater load reductions in 2020-2025 than occurred in 2012-2019. The urban stormwater pollutant load reduction goals in the Phase 3 WIP are based on multiple planned actions: stormwater best management practices (BMPs) specified by Municipal Separate Storm Sewer System (MS4) municipalities in the Pollutant Reduction Plans (PRPs) and Total Maximum Daily Load (TMDL) Plans they have submitted for National Pollutant Discharge Elimination System (NPDES) permit requirements; the establishment of forest buffers in urban environments; ongoing efforts to manage post-construction stormwater runoff for development projects; and reductions in illicit discharges to MS4s as required by NPDES permits. These planned actions were simulated in the EPA Phase 6 Chesapeake Bay Model to determine reductions in the Phase 3 WIP and will play a crucial part in meeting our 2025 goals.

That said, while nitrogen is the critical pollutant of concern to the Bay, urban areas generate low concentrations of nitrogen and urban stormwater BMPs are generally inefficient at removing nitrogen. It would serve no purpose to continue using load reduction goals proposed in the past that weren't based on accurate technical understanding, realistic data, or regulatory mechanisms. Pennsylvania decided that moving forward, we need to focus our limited resources on the pollutant load sectors where nitrogen control BMPs will have the greatest impact, such as agriculture.

The focus of the MS4 program is to address the local water quality impairments caused by impervious urban areas. The rate and flow from these areas causes gullies and erodes stream banks and beds. Pollutants wash off because runoff cannot infiltrate the ground. Reduced groundwater recharge causes urban streams to dry up and/or have increased temperatures in the summer. Illicit discharges (e.g., oil, chemicals and sewage from leaky pipes) hurt aquatic life. These are the issues that our urban water quality programs are addressing. In developing Pennsylvania's MS4 General NPDES Permit (PAG-13) in 2015-2016, DEP also anticipated that more would be expected of the urban stormwater sector as part of its Phase 3 WIP. This is why PAG-13 requires PRPs and TMDL Plans. The focus of these plans is on attaining millions of pounds of sediment reductions to improve local waterways, but hundreds of thousands of pounds of nitrogen reductions will also occur to assist our efforts to clean up the Chesapeake Bay. It is true that it's not cost-effective for urban stormwater management to treat exclusively for nitrogen, but nitrogen is also reduced as sediment is reduced.

Pennsylvania's Phase 3 WIP was developed by over 1,000 Pennsylvanians. Farmers, local municipal and community leaders, foresters, academic experts, environmental organizations, and state government agencies contributed their expertise. This process produced a plan that is realistic, grounded in data and technical knowledge, and is actually going to reduce nitrogen, phosphorus, and sediment in the watershed.

Additionally, DEP is delegated the NPDES Construction Stormwater program from EPA, and we work directly with conservation districts in implementing this program. Our state regulations require that erosion and sediment control and post-construction stormwater management (PCSM) BMPs are implemented and maintained for earth disturbance activities where there is an NPDES permit requirement (equal to or greater than one acre of disturbance). Our state regulations require that the net change in rate, volume, and water quality (pollutant loading), comparing pre-construction to post-construction conditions, is addressed through PCSM. The data submitted quarterly by conservation districts and through our triennial review of the program were analyzed as part of the Phase 3 WIP development process.

Question: Pennsylvania's Phase III WIP set numeric goals for nitrogen pollution entering the Bay from urban and suburban stormwater in 2025 that are higher than the nitrogen loads from this sector back in 2009. The Phase III WIP would increase the amount of nitrogen pollution flowing into the Bay from stormwater runoff each year by Pennsylvania's by 301,360 pounds by 2025, compared to 2009. Back in 2012, in the state's Phase II WIP, Pennsylvania committed to decreasing nitrogen pollution from urban and suburban stormwater into the Bay by 6.7 million by 2025. Why the change?

Answer: Efforts to curb nitrogen loading to the Bay from urban and suburban stormwater sources will yield smaller results than pursuing nitrogen reductions in other sectors. The Phase 3 WIP will achieve a reduction of 34 million pounds of nitrogen loading by 2025 while accounting for changes in strategy. See above for additional details.

Among other changes, Pennsylvania's Phase III WIP would replace only 202 acres of impervious surfaces instead of the 2,300 acres planned by the state back in 2012 in the Phase II WIP. Pennsylvania's Phase III WIP would create 203,265 acres of stormwater control ponds, wetlands and other projects by 2025, instead of the 1.5 million acres of stormwater control practices planned in the Phase II WIP back in 2012. Is Pennsylvania backing away from these urban/suburban stormwater projects because of their high cost, compared to other strategies for reducing pollution in the Bay?

The Phase 3 WIP provides a more credible estimate of reductions to be achieved from real stormwater projects identified in MS4 Pollutant Reduction Plans and TMDL plans, as well as industrial stormwater projects.

Question: Is Pennsylvania essentially deferring action on the urban/suburban stormwater sector until after 2025? If so, why?

Answer: DEP is not deferring action on the urban stormwater sector. Quite the opposite. The 2018 MS4 General Permit established a challenging pollutant load reduction requirement for hundreds of Pennsylvania MS4-permitted municipalities. Those municipalities are actively implementing PRPs now, in many cases at substantial cost. Their required BMPs must be operational, and their pollutant load reductions attained, within 5 years after their plans were approved. Those are today's requirements for the urban sector, and they are significant. The nutrient load reductions we'll achieve through the MS4 permit requirements put in place starting in 2018 will be orders of magnitude greater than any nutrient load reductions achieved through prior MS4 permits (which were essentially none), regardless of what load reduction goals were proposed in prior WIPs.

APPENDIX D: Statement from DC Water

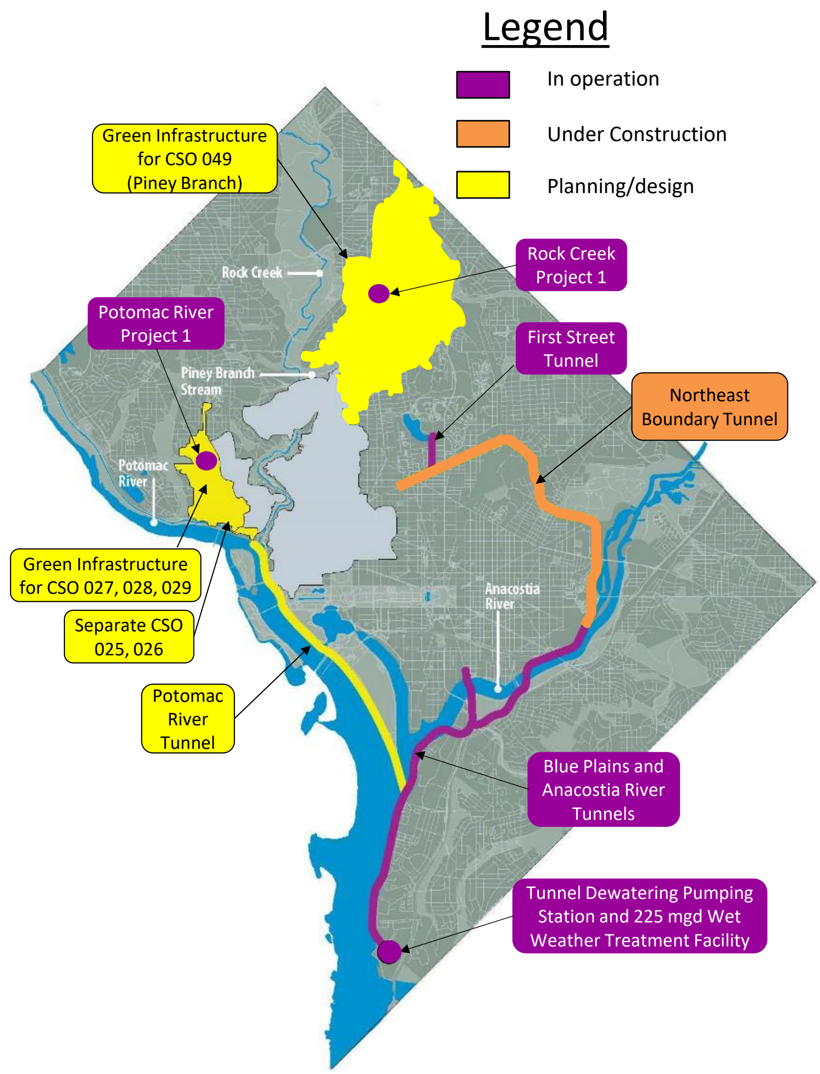
In response to written questions from the Environmental Integrity Project, Tamara Stevenson, Senior Manager of Marketing, Production and Operations at DC Water, emailed the following statement on July 24, 2020:

[Question 1: In DC's 2002 long term control plan, why does the city assume an average amount of rainfall of 38.95 (the average of the forecast period of 1988-1990), when the most recent five-year average from NOAA is significantly higher, 48.14?]

Answer: As rainfall depths can vary widely from year to year, the Long-Term Control Plan (LTCP) was developed in accordance with EPA guidelines for CSO planning using "system-wide annual average" rainfall conditions. In preparation of the LTCP, DC Water reviewed 50 years of rainfall data at Ronald Reagan National Airport. The average rainfall over this 50 period was 38.95" per year. The rainfall for the periods 1988-1990 was selected as representative of average conditions for use in evaluation of CSO controls. This three-year period averaged 40.97" per year, and included one year each drier than, approximately equal to, and wetter than the long-term average, allowing for evaluation of CSO control performance across a variety of climatic conditions.

[Question 2: Was the construction of the two underground stormwater storage tunnels (capacities of 77 million and 49 million gallons) outlined in the 2002 long term control plan completed? If not, what is their status? In addition, where is DC in the building of additional pumping stations, a new interceptor, green infrastructure, and separating sewage and stormwater outfalls?]

Answer: DC Water is completing the LTCP projects in accordance with the schedule stipulated in its federal consent decree, amended in 2016. Completion of the entire LTCP is required by 2030. The figure below shows the status of the major elements of the program.



DC Clean Rivers Project Status

[Question 3: If the above construction projects have been completed, when?]

Answer: The status and completion dates for each project associated with the LTCP is available in the DC Water's Long Term Control Plan Consent Decree Status Report. The most recent report (Q1 2020), is available here.

APPENDIX E: Statement from Harrisburg Capital Region Water

In response to written questions from the Environmental Integrity Project, Harrisburg Capital Region Water External Affairs Manager Rebecca J. Laufer sent the following statement via email on July 29, 2020:

"Question 1: In Capital Region Water's long term control plan for CSO's, why does the plan use a median expected annual rainfall of about 40 inches per year, based on historic figures in a 57-year record from Harrisburg's two airport gauges? That's about 15 percent less than the annual average of 46 inches of rain the region actually experienced from 2015 to 2019, based on NOAA data. Given that climate change is increasing rainfall across the region – and scientists expect those increases to continue into the future – why didn't Capital Region Water use more recent and higher rainfall averages to plan for its infrastructure improvements?

Answer 1: CRW's City Beautiful H2O Program Plan (CBH2OPP) follows the EPA guidance requirement to establish a "typical rainfall year" that is calculated from the historical rainfall record at the Harrisburg airport (dating back to 1948). The analysis is an averaging process that includes both wetter- and drier-than average years within the historical record. While it is true that 2017 and 2018 rainfall totals were higher than average, their incorporation would not significantly impact the typical year calculation results. Refer to CRW's Combined Sewer System Characterization Report, Section 2 Characterization of Precipitation Patterns, for CRW's EPA approved "Typical Year" statistical evaluation methodology and conclusion (https://capitalregionwater.com/wp-content/uploads/2018/01/CSS-Characterization-Report_v.2.0-FINAL-FOR-WEBSITE.pdf).

Question 2: Capital Region water's long-term plan calls for the upgrade of a sewage pumping plant, improvements to CSO outfall regulation devices, the lining and repair of long-neglected combined sewage and stormwater pipes, as well the planting of trees and rain gardens and the creation of other "green infrastructure" to help soak up rainwater. For which of these specific projects has construction already begun?

Answer 2: See attached document from Capital Region Water.

Question 3: Specifically which of these projects are now complete? And on what dates were they finished?

Answer 3: The attached tables summarize projects undertaken by CRW since submission of CBH2OPP. Each entry includes a brief description and an estimated date of completion. If the project has been completed, it is so noted (and italicized).

APPENDIX F: Statement from Lynchburg Department of Water Resources

In response to written questions from the Environmental Integrity Project, Timothy A. Mitchell, Director Lynchburg's Department of Water Resources, emailed the following statement on July 21, 2020:

"We very proud of our efforts on our award winning CSO Program. We have aggressively worked for over 3 decades to reduce and eliminate CSO overflow points, volume, and pollutants. To date, since 1993, the City has spent and/or appropriate over $400 million on CSO and Water Quality projects (over $20,000 per household). We anticipate being fully complete with our program within the next 5 years. Of the 10 LTCP Priority Projects identified in the 2014 LTCP, the first 6 are either complete or under construction. It is important to note that prior to the 2014 LTCP Update, we were doing massive separation projects. Specifically, answers to your questions follow:

[Question 1: In Lynchburg's long term control plan, why does the city assume an average amount of rainfall of 42.35, using the period of 1993-1995 as "typical year", when the most recent five-year average from NOAA is significantly higher, 48.45?]

Answer 1: According to the CSO Policy, CSO control alternatives should be assessed on a "system-wide, annual average basis". Our 2014 LTCP complies with this guidance by using a typical hydrologic period for all model applications during the long-term control plan (LTCP) development. The typical hydrologic period used for the 2014 LTCP was selected in 2012 to represent the average hydrologic condition in Lynchburg based on a comprehensive analysis of 63 years (1949-2011) of historical rainfall data and other hydrologic parameters (such as receiving water body flows), as described in detail in Section C.6 of Appendix C of the LTCP. In addition to annual average rainfall depth, rainfall intensity, duration and number of back-to-back events were also considered during the selection process. This standard methodology is widely accepted across the country for CSO LTCPs.

For comparison, the historical annual average rainfall depth from 1949 to 2011 is 40.52 inches, whereas the selected three-year period (1993-1995) has an annual average rainfall depth of 42.35 inches, which provides a conservative representation of the average condition. Even with the more recent rainfall from 2012-2019 included, the annual average rainfall from 1949-2019 is 40.82 inches, still below the annual average rainfall of 42.35 inches for the selected three year period. Similarly, the most recent 30-year annual average rainfall (1990-2019) is 41.68 inches, also below the annual average rainfall of 42.35 for the selected three year period. Therefore, the selected three-year period used in our LTCP is fully in accordance with applicable EPA guidance for LTCP development.

[Question 2: Has the city begun construction of the new storage tank, green infrastructure, and increase in capacity for the local wastewater treatment, as outlined in the long term control plan?]

Answer 2: Yes, all the projects at the WWTP including the storage and pumping facility are currently under construction. It is anticipated that construction will be complete and these facilities online in early 2021. Green infrastructure was fully evaluated but in our situation determined not to be a cost effective alternative due to the steep terrain and limited public area in which it could be implemented. That said, green infrastructure is incorporated into any municipal project when possible but is not part of our LTCP strategy.

[Question 3: If the above construction projects have been completed, when?]

Answer 3: See above.

END NOTES

[1] Data from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information website, accessed 6/5/2020. Link: https://www.ncdc.noaa.gov/cag/city/time-series/USW00093738/pcp/12/12/1920-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000

[2] U.S. Geological Survey streamflow data from USGS "Freshwater Flow into Chesapeake Bay" web page, accessed 6/1/20. Link: https://www.usgs.gov/centers/cba/science/freshwater-flow-chesapeake-bay?qt-science_center_objects=0#qt-science_center_objects

[3] University of Maryland Center for Environmental Science annual "ECOCHECK" report cards on the Chesapeake Bay's health show an overall health rating falling from 54 out of 100 in 2017 to a 44 out of 100 in 2019. Link: https://ecoreportcard.org/report-cards/chesapeake-bay/bay-health/

[4] Data from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information website, accessed 6/5/2020. Link: https://www.ncdc.noaa.gov/cag/city/time-series/USW00093738/pcp/12/12/1920-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000

[5] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/

[6] Ibid.

[7] Ibid.

[8] Chesapeake Bay Program, 2025 Chesapeake Bay Climate Change Load Projections (Apr. 30, 2018), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwieqtXxzeHqAhUXoHIEHbT1CpYQFjAAegQIBhAB&url=https%3A%2F%2Fwww.naturalresources.virginia.gov%2Fmedia%2Fgovernorvirginiagov%2Fsecretary-of-natural-resources%2Fpdf%2F2025-Chesapeake-Bay-Climate-Change-Load-Projections.pdf&usg=AOvVaw0z4vRZfDQvZUnwhgW9dRvn.

[9] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/

[10] Ibid.

[11] Tetra Tech, Restoration Plan for Nontidal Sediment in the Patuxent River Lower and Middle Watersheds at 2-3 (July 31, 2019).

[12] Pollution projections from Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/ Maryland Phase III Watershed Implementation Plan (WIP) available at: https://mde.maryland.gov/programs/Water/TMDL/TMDLImplementation/Pages/Phase3WIP.aspx . Maryland has different projections for pollution impact of its WIP than the Bay Program. These numbers reflect the EPA-led Bay Program's estimates.

[13] Numbers compare Maryland's Phase II Watershed Implementation Plan (WIP), approved in 2012, to the state's Phase III WIP, approved in 2019

[14] The pollution control project goals in this category of Pennsylvania's Phase III WIP are "Stormwater Management Composite" includes wet ponds, wetlands, dry ponds, infiltration practices, etc.

[15] Water quality monitoring performed by Susquehanna Riverkeeper on 20 dates in June and July of 2020. Analysis for E coli bacteria performed by ALS Environmental in Middletown, PA.

[16] EPA website, "Learn About Heat Islands," accessed August 5, 2020. Link: https://www.epa.gov/heatislands/learn-about-heat-islands

[17] *See, e.g.*, D.R. Easterling et al., Precipitation change in the United States, pages 218 – 219. In: Climate Science Special Report: Fourth National Climate Assessment, Volume 1. U.S. Global Change Research Program, Washington DC (2017).

[18] *See, e.g.*, L.A. Dupigny-Giroux et al., Northeast, page 705. In: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington DC (2018).

[19] Environment & Natural Resources Institute, Pennsylvania Climate Change Impacts Assessment Update at 132 (April 2020), prepared for PA DEP, available at http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/ClimateChange/2020ClimateChangeImpactsAssessmentUpdate.pdf.

[20] Data from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information website, accessed 6/5/2020. Link:

https://www.ncdc.noaa.gov/cag/city/time-series/USW00093738/pcp/12/12/1920-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000
[21] Ibid. Precipitation numbers from Baltimore from Baltimore Washington International Airport (BWI).
[22] Ibid.
[23] M. Hoerling et al., Characterizing Recent Trends in U.S. Heavy Precipitation, 29 Journal of Climate 2313, 2319, 2328 (Apr. 2016). "Very wet days" are defined as "days exceeding the 95th percentile of precipitation falling on a wet day precipitation occurrence exceeding 1 mm." *Id*. at 2315. The northeastern United States, for purposes of this study, included all of the Chesapeake Bay states other than Virginia.
[24] D.R. Easterling et al., Precipitation change in the United States, page 212, Fig. 7-4. In: Climate Science Special Report: Fourth National Climate Assessment, Volume 1. U.S. Global Change Research Program, Washington DC (2017). "99th percentile" days are defined as "daily events that exceed the 99th percentile of all non-zero precipitation days." The northeastern United States, for purposes of this study, included all of the Chesapeake Bay states other than Virginia.
[25] *Id*.
[26] U.S. Geological Survey streamflow data from USGS "Freshwater Flow into Chesapeake Bay" web page, accessed 6/1/20. Link: https://www.usgs.gov/centers/cba/science/freshwater-flow-chesapeake-bay?qt-science_center_objects=0#qt-science_center_objects
[27] University of Maryland Center for Environmental Sciences annual ECOHEALTH report card on the Bay, accessed 6/08/20. Link: https://ecoreportcard.org/report-cards/chesapeake-bay/bay-health/
[28] Ibid.
[29] J.M. Thibeault and A. Seth, Changing Climate Extremes in the Northeast United States: Observations and Projections from CMIP5, 127 Climatic Change 273-287, 275 (2014).
[30] D.R. Easterling et al., Precipitation change in the United States, page 221, Figure 7.8. In: Climate Science Special Report: Fourth National Climate Assessment, Volume 1. U.S. Global Change Research Program, Washington DC (2017).
[31] R.G. Najjar et al., Potential climate-change impacts on the Chesapeake Bay, 86 Estuarine, Coastal and Shelf Science 1, 5 (2010).
[32] *See, e.g.*, Chesapeake Bay Program Principals' Staff Committee, 2025 Chesapeake Bay Climate Change Load Projections at slides 3 and 6 (Mar. 2, 2018) (showing "increased precipitation volume and intensity"); Maryland 10 ("Impacts of climate change, including increased precipitation and storm events, are causing heightened nutrient and sediment loads to the Chesapeake Bay").
[33] Chesapeake Bay Program numbers
[34] Ibid.
[35] U.S. EPA, Improving the Resilience of Best Management Practices in a Changing Environment: Urban Stormwater Modeling Studies, EPA/600/R-17/469F at xix (May 2018).
[36] Id.
[37] Id. at 32.
[38] Id.
[39] Id. at 36. Runoff and pollution loads associated with a mix of both "conventional" BMPs and "green infrastructure" such as permeable pavement and infiltration basins would more than double under future conditions, but they would be starting from a much lower baseline than the conventional BMPs alone. For example, runoff volume using conventional BMPs would increase from 7.04 inches/year (current conditions) to 10.96 inches/year (future conditions), while runoff volume from the green infrastructure BMP mix would increase from 1.52 to 3.40 inches per year.
[40] Id. at 39.
[41] As of 2018, stormwater loads from developed land represented at least 16 percent of total nitrogen loads, 18 percent of total phosphorus loads, and 9 percent of total sediment loads. CAST, May 7, 2020. We say "at least" a certain percentage of total loads because the Chesapeake Bay Program's model outputs attribute part of the stormwater load to the "natural" category. To be more specific, the models assume that some amount of stormwater pollution will settle out in streams and rivers, and then be re-suspended and carried to the Bay. These re-suspended pollution loads are attributed to the "streams" category, which is part of the broader natural source category, even though the pollution originally came from developed land. See Environmental Integrity Project, The

State of Chesapeake Bay Climate Modeling at 24-27 (July 25, 2019), available at https://environmentalintegrity.org/reports/the-state-of-chesapeake-bay-watershed-modeling/ .

[42] U.S. EPA, Chesapeake Bay Watershed Implementation Plans, https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-watershed-implementation-plans-wips.

[43] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020.

[44] Id. In 2018, Maryland, Pennsylvania and Virginia accounted for 90 percent of the urban stormwater nitrogen load, 93 percent of the phosphorus load, and 87 percent of the sediment load.

[45] Maryland Phase III WIP at B-32.

[46] Maryland Phase III WIP at B-33.

[47] Nutrient targets were taken from pages 27-33 of the Phase II WIP and pages 24-25 of the Phase III WIP. BMP implementation estimates were taken from Table 10 of the Phase II WIP and Appendix C of the Phase III WIP.

[48] Maryland Phase II WIP, page 27; Maryland Phase III WIP, page 24.

[49] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020.

[50] "Runoff Reduction" in the Phase III WIP. Again, Maryland's WIP conflicts with Chesapeake Bay Program model outputs, which show Maryland's 2025 load as being greater than the 2009 load, for a net increase of roughly 5 million pounds. See Table A9 below.

[51] "MS4 Permit Stormwater Retrofit" and "Stormwater Management Generic BMP" in Phase II WIP.

[52] "Stormwater Treatment" in Phase III WIP.

[53] Described as "Urban Stream Restoration (interim" in Phase II WIP.

[54] "Urban Shoreline Management" in Phase III WIP

[55] Environmental Integrity Project, Pollution Trading in the Chesapeake Bay (Aug. 19, 2019), available at https://environmentalintegrity.org/reports/pollution-trading-in-the-chesapeake-bay/.

[56] Email to EIP from Jay Apperson, Deputy Director of the Office of Communications for the Maryland Department of the Environment on July 29. 2020.

[57] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020.

[58] Includes both "Urban Tree Planting" and "Urban Forest Planting" BMPs.

[59] Email from Deborah Klenotic, Deputy Communications Director from the Pennsylvania Department of Environmental Protection to EIP on July 24, 2020.

[60] Environmental Integrity Project report, "Unsustainable Agriculture: Pennsylvania's Manure Hot Spots and their Impact on Local Water Quality and the Chesapeake Bay," August 31, 2017. Link: https://environmentalintegrity.org/wp-content/uploads/2017/08/Unsustainable-Agriculture_revised.pdf

[61] Chesapeake Bay Commission Report, "Healthy Livestock, Healthy Streams," May 2015, p. 17. Link: https://www.chesbay.us/library/public/documents/Policy-Reports/Healthy-Livestock-Healthy-Streams.pdf

[62] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020; BMP implementation targets from Virginia's Phase II WIP (Table A.1) and Phase III WIP (Appendix D).

[63] VA's Phase III WIP commits to over one million feet of stream restoration, but places that BMP within the "natural" land use category.

[64] These include "stormwater performance standard" BMPs (21,796 acres), "advanced grey infrastructure nutrient discovery program" (17,306 acres), "floating treatment wetland" (377 acres), and "filter strip runoff reduction" (100 acres). Virginia Phase III WIP Appendix D.
[65] Chesapeake Bay Program, Watershed Model Documentation, Overview at 1-4, https://cast.chesapeakebay.net/Documentation/ModelDocumentation.
[66] *Id*. at 12-1.
[67] *See, e.g.*, Chesapeake Bay Program, Draft Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, 2, ("The averaging period [1991-2000] and critical period [1993-1995] represent long-term climate norms that will no longer be representative of average conditions or a 10-year recurrence interval condition").
[68] Chesapeake Bay Program, Principals' Staff Committee, 2025 Chesapeake Bay Climate Change Load Projections (Mar. 2, 2018), https://www.chesapeakebay.net/channel_files/26045/v._2025_chesapeake_bay_climate_change_load_projections_explanation_revised_02.28.18.pdf.
[69] Chesapeake Bay Program, Draft Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, 2.
[70] Chesapeake Bay Program, Draft Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, 3.
[71] WIP at 9.
[72] WIP at 53.
[73] Chesapeake Bay Program Principals' Staff Committee, 2025 Chesapeake Bay Climate Change Load Projections (Mar. 2, 2018), https://www.chesapeakebay.net/channel_files/26045/v._2025_chesapeake_bay_climate_change_load_projections_explanation_revised_02.28.18.pdf; *see also* WIP at 39.
[74] See WIP at 43 ("Maryland is committed to adopting improved climate science by including refined nutrient reduction goals in 2021, and BMP efficiency into a future WIP addendum, and/or two-year milestone commitments in 2022.
[75] Environment & Natural Resources Institute, Pennsylvania Climate Change Impacts Assessment Update at 132-133 (April 2020), prepared for PA DEP, available at http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/ClimateChange/2020ClimateChangeImpactsAssessmentUpdate.pdf.
[76] *Id*. at 3-4.
[77] Phase III WIP at 28.
[78] Id. at 180.
[79] Id. at 182-185.
[80] Id. at 185-186.
[81] Commonwealth of Virginia, Chesapeake Bay TMDL Phase III Watershed Implementation Plan at 24-25 (Aug. 23, 2019).
[82] Id. at 31.
[83] NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, vol. 10, version 3.0, Northeastern United States at A.4-12 (2015). *See also, e.g.*, Virginia Stormwater Management Program regulations, 9 VAC 25-870-72; Virginia Runoff Reduction Method at 66 (May 2, 2016), https://www.swbmp.vwrrc.vt.edu/vrrm/; York County, Pennsylvania Model Stormwater Ordinance at pages 12 to 13, https://www.ycpc.org/320/Water-Quality-Stormwater-Management; Prince George's County, Maryland Stormwater Management Design Manual at Section 8.2 and Appendix 8-8 (Sep. 2014), https://www.princegeorgescountymd.gov/1478/Design-Manuals. Many local and state regulations also refer to U.S. Department of Agriculture precipitation planning tools, but those tools just incorporate NOAA Atlas 14 data. *See, e.g.*, USDA NRCS, TR-55 DOS version, TR-55 Documentation Appendix B, https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/home/?cid=stelprdb1042925.
[84] NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, vol. 10, version 3.0, Northeastern United States at A.4-12 (2015).
[85] Hydrometeorological Design Studies Center, Progress Report for Period October 2018 to March 2019 (Apr. 2019), available at https://www.nws.noaa.gov/oh/hdsc/current_projects.html.

[86] Ibid.
[87] These permits are called MS4 or Municipal Separate Storm Sewer System permits.
[88] *See, e.g.*, Maryland Department of the Environment, Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Appendix J (Dec. 2019).
[89] Baltimore County, NPDES – Municipal Stormwater (MS4) Discharge permit, 2019 Annual Report at 9-3 (Jan. 22, 2020). The report notes that the Chesapeake Bay TMDL requires 29 percent nitrogen and 45.1 percent phosphorus load reductions for the that the Scotts Level Branch in the Gwynns Falls watershed.
[90] Id. at 9-11.
[91] Id. at 9-24.

[93] Id.
[94] *See, e.g.*, Fairfax County, Difficult Run Watershed Management Plan at 2-15.
[95] *See, e.g.,* Accotink Watershed Management Plan at 2-5 ("Based on many years of rainfall data collected, storms of varying strength have been established based on the duration and probability of that event occurring within any given year").
[96] Montgomery County Department of Environmental Protection, Montgomery County Climate Workgroup, Overview of Recommendations, https://www.montgomerycountymd.gov/green/climate/climate-workgroup-recommendations.html.
[97] Montgomery County Department of Environmental Protection, Montgomery County Climate Workgroup Recommendations at 36, https://www.montgomerycountymd.gov/green/climate/climate-workgroup-recommendations.html.
[98] Id.
[99] *Id*. at 47.
[100] Tetra Tech, Restoration Plan for Nontidal Sediment in the Patuxent River Lower and Middle Watersheds at 2-3 (July 31, 2019).
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[102] University of New Hampshire, Trends in Extreme Precipitation Events for the Northeastern United States, 1948-2007 at 1(2010).
[103] *See, e.g.*, Erin B. Logan, Proposals to ease development's impact on Ellicott City flooding draw opposition from industry, Baltimore Sun, Sep. 17, 2019.
[104] *See* U.S. EPA, Improving the Resilience of Best Management Practices in a Changing Environment: Urban Stormwater Modeling Studies, EPA/600/R-17/469F at 32(May 2018).
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[114] EPA report, "DC Water's Environmental Impact Bond," April 2017. Link: https://www.epa.gov/sites/production/files/2017-04/documents/dc_waters_environmental_impact_bond_a_first_of_its_kind_final2.pdf
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APPENDIX B

Expert Report of Dr. Robert Roseen

EXPERT REPORT

Concerns Regarding the Draft 2020 Municipal Separate Storm Sewer System (MS4) permits for Baltimore City (20-DP-3315) and Anne Arundel (20-DP-3316), Baltimore (20-DP-3317), and Montgomery (20-DP-3320) Counties

Prepared for:
Chesapeake Accountability Project

On Behalf of:
Chesapeake Legal Alliance, Center for Progressive Reform, Environmental Integrity Project, Choose Clean Water Coalition, and the Chesapeake Bay Foundation

Prepared by:
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January 20, 2021

Robert M. Roseen, Ph.D., PE, DWRE

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Acronyms

Acronym	Definition
ASCE	AMERICAN SOCIETY OF CIVIL ENGINEERS
BMP	STORMWATER BEST MANAGEMENT PRACTICE
CAST	CHESAPEAKE ASSESSMENT SCENARIO TOOL
CBP	CHESAPEAKE BAY PROGRAM
CFR	CODE OF FEDERAL REGULATIONS
CPV	CHANNEL PROTECTION VOLUME
CWA	CLEAN WATER ACT
DWRE	DIPLOMATE, WATER RESOURCES ENGINEER
EPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
EWRI	ENVIRONMENTAL WATER RESEARCH INSTITUE
EMC	EVENT MEAN CONCENTRATION
ESD	ENVIRONMENTAL SITE DESIGN
FR	FEDERAL REGISTER
FRCP	FEDERAL RULES OF CIVIL PROCEDURE
GIS	GEOGRAPHIC INFORMATION SYSTEMS
IC	IMPERVIOUS COVER
IA	IMPERVIOUS AREA
LA	LOAD ALLOCATION
LID	LOW IMPACT DEVELOPMENT
MDE	MARYLAND DEPARTMENT OF ENVIRONMENT
MDSWM	MARYLAND STORMWATER MANUAL
MSGP	MULTI-SECTOR GENERAL PERMIT
NCDC	NATIONAL CLIMATE DATA CENTER
NHD	NATIONAL HYRDOGRAPHY DATA
NRCC	NORTHEAST REGIONAL CLIMATE CENTER
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
NPDES	NATIONAL POLLUTION DISCHARGE ELIMINATION PERMITS
PE	PROFESSIONAL ENGINEER
PLA	POLLUTANT LOADING ANALYSES
PLER	POLLUTANT LOAD EXPORT RATES
SWM	STORMWATER MANAGEMENT
TMDL	TOTAL MAXIMUM DAILY LOAD
TN	TOTAL NITROGEN
TP	TOTAL PHOSPHOROUS
TSS	TOTAL SUSPENDED SOLIDS
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
USGS	UNITED STATES GEOLOGICAL SURVEY
UWRCC	URBAN WATER RESOURCES RESEARCH COUNCIL
WLA	WASTE LOAD ALLOCATION
WQV	WATER QUALITY VOLUME

1. Executive Summary

This report focuses on the adequacy of the draft 2020 Municipal Separate Storm Sewer System (MS4) permits for Baltimore City (20-DP-3315) and Anne Arundel (20-DP-3316), Baltimore (20-DP-3317), and Montgomery (20-DP-3320) counties released on October 23, 2020.

We commend the MDE for the advancements of the draft MS4 permits and in particular for incentivizing the use of green infrastructure and Best Management Practices (BMPs) that contribute to climate resiliency.

However, significant concerns exist. An underemphasis on volumetric controls and allowance of Alternative BMPs has large implications for sediment removal, phosphorus removal, and climate resiliency. To exemplify the concerns and shortcomings of these draft MS4 permits, they have been evaluated, in part, in the context of the Gwynns Falls watershed (HUC8# 02130905) including the Gwynns Falls Sediment TMDL[1] and the Bay TMDL. The Gwynns Falls Sediment TMDL falls entirely within Baltimore County.

The draft MS4 permits direct the restoration of impervious acres for the reduction of nutrients and sediments and implementation of pollution reduction plans targeting specific pollutants that impair local waters. As written, impervious acre restoration credit is allowed for direct or equivalent stormwater runoff treatment. This allows for credits for Alternative BMPs including street sweeping, tree planting, stream restoration, and others that do not provide direct runoff reduction or volumetric controls.

The allowance for effective impervious acres (EIA) reductions for restoration credits with Alternative BMPs[2] that do not include volume reduction, and focus specifically on pollutant load removal, neglects the fact that stream erosion caused by elevated impervious cover represents a significant component of the sediment load (77% in Gwynns Falls[1]), the phosphorus load (74%), and nitrogen load (11%) only to be exacerbated by changing climate conditions causing increased runoff and stream erosion. The Bay Model quantifies the land river segment contribution of sediment and nutrients due to stream erosion as a function of impervious cover and altered stream hydrology[3]. Restoration of altered stream hydrology will not be accomplished by non-volumetric BMPs and instead requires runoff reduction and infiltration.

This is not to detract from the important role that Alternative BMPs will play in watershed management. These practices are going to be essential, and valuable, and very cost effective on a nutrient removal basis. ***However, the hierarchy of BMP prioritization and usage must reflect the fact that achieving the necessary pollutant load reduction for nutrients and sediments can only be accomplished with restoration of altered hydrology through the reduction of effective impervious areas by use of runoff reduction and volumetric structural controls that will in***

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[1] MDE (2015). Total Maximum Daily Load of Sediment in the Gwynns Falls Watershed, Baltimore City and Baltimore County, Maryland, Revised Final. Baltimore, MD, Maryland Department of the Environment.

[2] See Table 1. EIA_f and Load Reductions for Alternative BMPs, MDE (2020). Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits, Maryland Department of the Environment.

[3] Section 9.3.2: Streambank Erosion Due to Impervious Cover, Stream-to-River, Chesapeake Bay Program Phase 6 Watershed Model, Final Model Documentation for the Midpoint Assessment – 10/1/2018

turn reduce stream erosion associated pollutant loads. Structural controls that will reduce storm volume through infiltration and recharge must be required for stream erosion to be reduced. The allowance of other practices must only be allowed in a manner that prioritizes BMPs with the greatest removal of pollutant load and volumetric controls.

An important example of the flawed crediting equivalence of alternative and runoff reduction BMPs is the City of Baltimore's heavy reliance on street sweeping. In 2019 the City of Baltimore street sweeping and storm draining cleaning accounted for 3,955 acres of impervious restoration credits[4] amounting to 86% of the required restoration. While these practices are an important component of nutrient control plans, alternative BMPs such as street sweeping, catch basin cleaning, nutrient credit trading, and others are not truly equivalent. Without the requirement of runoff reduction and volumetric controls, in the case of Gwynns Falls, the BMPs are left to manage only 23% of the sediment load (the non-stream erosion derived load) and 26% of phosphorus load and will neglect the well-established importance of channel protection.

Of additional significance is the role of runoff reduction and volumetric controls (or lack thereof) in the mitigation of the future impact of climate change and pollutant loading. For the same reasons mentioned previously, volumetric controls are necessary for the reduction of streambank erosion. An analysis of near-future climate trends by CBP[18] indicated an increase of approximately 3% in average annual rainfall volumes over the last 100 years. A similar analysis[17] showed an increase in Maryland of 3.1% by the year 2025 and 6.7% by the year 2055. An analysis of hypothetical changes in streambank erosion in the absence of runoff reduction showed an increase in the erosional sediment contribution by the year 2025 from 77.5% to 79.8% or the equivalent of increasing the percent impervious cover (%IC)) from 33% to 36%, and by the year 2055 an increase to 82.7% or the equivalent of increasing the %IC from 33% to 41%. Any future increases in rainfall would result in corresponding increases in runoff, stream erosion and subsequent pollutant loading. Volumetric structural control practices are the most effective BMPs for runoff reduction regardless of whether increases are a result of IC cover or climate change. This relates to both management of pollutant loads and climate resiliency and drainage infrastructure vulnerability.

For this reason, the allowance of alternative BMPs and impervious acre restoration credits on the basis of pollutant load, and the lack of prioritization of runoff reduction and structural volumetric controls, is inconsistent with MDE's stated goal to make significant and continued progress toward achieving the Chesapeake Bay's WLAs as well as local nutrient and sediment TMDLs.

1.1. Report Objectives

Waterstone Engineering PLLC has been retained to conduct the following scope of services:

1. To provide a pollutant loading analysis (PLA) such that CAP may evaluate the effectiveness of the proposed Clean Water Act permits in the Chesapeake Bay watershed;
2. Review available documentation including permits and related studies;

[4] MDE (2019). Annual Report on Financial Assurance Plans and the Watershed Protection and Restoration Program. 20019, Maryland Department of the Environment**:** 81.

3. Development and analysis of a spreadsheet model to evaluate concerns and adequacy of the MS4 based on pollutant loading, land use, and BMP pollutant load reduction and for TMDL attainability;
4. Establish opinions related to draft MS4 permit adequacy based on impervious acre restoration by direct or equivalent stormwater runoff treatment crediting.

1.2. Facts and Data Considered

The following opinions are based on:

1. Review of the draft 2020 Baltimore County (20-DP-3317) and Baltimore City (20-DP-3315) MS4 permits
2. Review of reports and related information by the Chesapeake Bay Program and MDE including the 2015 Total Maximum Daily Load of Sediment in the Gwynns Falls Watershed, Baltimore City and Baltimore County, Maryland and the Bay TMDL loading report from CAST.
3. Review of Chesapeake Bay Program Phase 6 Watershed Model, Final Model Documentation for the Midpoint Assessment– 10/1/2018.
4. Review of the 2020 Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits, by the Maryland Department of the Environment.
5. Review of TMDL maps and GIS data including HUC-8 watershed delineation, HUC-12 watershed delineation, Chesapeake Bay segments, Chesapeake Bay land-river segments, impervious cover, land use land cover, soil types, TMDL boundaries, county boundaries, NPDES regulated stormwater systems, MS4 delineation, and impairments for the study area from the Maryland Department of the Environment (MDE), state planning office, and the USGS.
6. Review of the 2018 USGS study titled Factors Affecting Long-Term Trends in Surface-Water Quality in the Gwynns Falls Watershed, Baltimore City and County, Maryland, 1998-2016.
7. Review of other relevant citations noted throughout the report and listed in References.

1.1. Qualifications and Compensation

1.1.1. Education

Dr. Roseen received a Bachelor of Arts in Environmental Science/Chemistry from Clark University in 1994. Dr. Roseen received a Master of Science in Environmental Science and Engineering from the Colorado School of Mines in 1998 and a Doctor of Philosophy (Ph.D.) in Civil and Waste Resources Engineering from the University of New Hampshire in 2002. Dr. Roseen served as the Director of the University of New Hampshire Stormwater Center from 2004 through 2012, and served as a Research Assistant Professor from 2007-2012. Dr. Roseen is a licensed Professional Engineer in the states of New Hampshire, Massachusetts, and Maine, and is a Diplomat of Water Resources Engineering ("D.WRE"), the highest professional engineering distinction in this area, through the American Academy of Water Resources Engineers.

1.1.2. Professional Experience

Dr. Roseen provides many years of experience in water resources investigations and most recently, led a project team in the development of an Integrated Plan for nutrient management for stormwater and wastewater. This plan has received provisional approval by EPA and would be one of the first in the nation. Rob is a recognized industry leader in green infrastructure and watershed management, and the recipient of Environmental Merit Awards by the US Environmental Protection Agency Region 1 in 2010, 2016, and 2019. He consults nationally and locally on stormwater management and planning and directed the University of New Hampshire Stormwater Center for 10 years and is deeply versed in the practice, policy, and planning of stormwater management. Rob has over 25 years of experience in the investigation, design, testing, and implementation of innovative approaches to stormwater management and specializing in green infrastructure, nutrient control planning, and climate vulnerability analyses. Rob has led the technical analysis of dozens of nutrient and contaminant studies examining surface water pathways, system performance, management strategies, and system optimization.

Dr. Roseen provides Clean Water Act expert consultation, analysis, modeling, advice, reports and testimony in regards to compliance with TMDLs and Nutrient Control Planning, Construction General Permits, Municipal Separate Storm Sewer System (MS4) Permits, and Multi Sector General Permits. As a consultant, Dr. Roseen has worked for private clients engaged in site development involving project permitting, design, erosion and sediment control plans, construction management plans, construction inspections, construction inspection and reporting, water quality performance monitoring and more.

He also served as Research Assistant Professor for five years. His areas of expertise include water resources engineering, stormwater management (including low impact development design), and porous pavements. He also possesses additional expertise in water resource engineering including hydrology and hydraulics evaluations, stream restoration and enhancement alternatives, dam removal assessment, groundwater investigations, nutrient and TMDL studies, remote sensing, and GIS applications.

Dr. Roseen has taught classes on Stormwater Management and Design, Fluid Mechanics, and Hydrologic Monitoring and lectures frequently on these subjects. He is frequently called upon as an expert on stormwater management locally, regionally, and nationally.

Notable professional activities include active membership with the New Hampshire Rivers Council Board of Directors, the NH Rivers Management Advisory Council, Piscataqua Regions Estuary Program Management Council, and the American Rivers Science and Technical Advisory Committee. He was past chair of the ASCE EWRI 2016 International Low Impact Development Conference, an annual event that draws participants from around the world to discuss advances in water resources engineering, and participating until 2017 as a Control Group member for the ASCE Urban Water Resources Research Council (UWRRC). He has also served on the ASCE Task Committee on Guidelines for Certification of Manufactured Stormwater BMPs, EWRI Permeable Pavement Technical Committee, and the Hydrology, Hydraulics, and Water Quality Committee of the Transportation Research Board. Dr. Roseen has been the author or co-author of over two dozen professional publications on the topics of stormwater runoff, mitigation measures, best management practices (BMPs), etc. He has extensive experience working with local, state, and regional agencies and participates on a national level for USEPA Headquarters, WEF, and the White Council on Environmental Quality on urban retrofit innovations and next generation LID/GI technology and financing solutions.

His resume, including a list of all publications over the past 10 years and all cases in which he has served as an expert in for the past 4 years, is provided in Appendix A: Expert Witness Resume, Publications Authored in Previous 10 years, Expert Witness Experience

1.1.3. Cases During the Previous 4 Years I have Testified as an Expert at Trial or by Deposition, or Provided Expert Witness Services

State Municipal Stormwater Permit Challenge

Dr. Roseen is currently providing (1) written direct expert testimony and (2) live expert testimony in the adjudication hearings before an unnamed Pollution Control Board in a challenge to municipal stormwater permits. This includes written expert testimony (including research, document review, discovery), response to discovery of other parties, hearing preparation, appearance and live testimony at hearing, and rebuttal testimony.

Low Impact Development Review for Proposed Residential Subdivision

Dr. Roseen is providing expert witness, review, and testimony with respect to Low Impact Development on behalf a private client for a proposed subdivision. The review sought to identify both LID broadly and in keeping with the local zoning ordinance, the use of the LID Crediting criteria relevant to the MA Stormwater Handbook and the 2016 MA Small MS4 Permit.

Climate Change Vulnerability Analyses for Industrial Facilities

Dr. Roseen is currently providing expert consultation, analysis, modeling, advice, and reports in regard to the vulnerability of industrial facilities to climate change and sea level rise for a major east coast port. Evaluations include severe weather events driven by climate change and the exposure of coastal terminals and risk of industrial spills to flooding from storm surge and forecasts for future sea level rise. Such services may include sworn to written or oral expert testimony regarding such matters in Court.

TMDL and Nutrient Control Attainability Analyses and Clean Water Act Expert Services

Dr. Roseen is currently providing expert consultation, analysis, modeling, advice, reports and testimony in regards to TMDL and nutrient control attainability. This includes watershed modeling, pollutant load analyses, BMP optimization, and parcel-based analyses. Such services include sworn to written or oral expert testimony regarding such matters in Court. This service is being provided for the plaintiff for three (3) case of significant size geographically and in project scope.

State Clean Water Permit Review

Dr. Roseen has provided expert consultation, advice, reports and testimony regarding stormwater discharges for proposed clean water permits for multiple states. Review and analyses include evaluation of stringency of proposed permits for low impact development for new development, redevelopment, and retrofits. This includes the stringency of performance standards, for projects of varying size, exemptions, and permit "trigger" conditions to name a few.

Construction General Permit (CGP), and Clean Water Act Expert Services

Dr. Roseen has provided expert consultation, analysis, modeling, advice, reports and testimony in regards to construction general permit compliance, erosion and sedimentation control, and monitoring. Such services include sworn to written or oral expert testimony regarding such matters in Court, and on-site inspections of defendants' facilities.

Municipal Separate Storm Sewer System (MS4) Permit and Clean Water Act Expert Services

Dr. Roseen has provided expert consultation, analysis, modelling, advice, reports and testimony regarding stormwater discharges in regards to MS4 violations under the Clean Water Act. Such services may include sworn to written or oral expert testimony regarding such matters in Court, and on-site inspections of defendants' facilities. This service is being provided for the plaintiff for two (2) cases of significant size geographically and in project scope.

Multi Sector General Permit, Stormwater Pollution Prevention Plan, and Clean Water Act Expert Services

Dr. Roseen has provided expert consultation, analysis, modelling, advice, reports and testimony regarding stormwater discharges in regards to MSGP under the Clean Water Act. Such services may include sworn to written or oral expert testimony regarding such matters in Court, and on-site inspections of facilities. This service is being provided for the plaintiff for over ten (10) separate cases in the northeastern United States.

Expert Study and Testimony for Erosion and Sediment Control Litigation

Dr. Roseen is currently providing expert study and testimony in defense of an undisclosed Federal Client in a $25-million-dollar lawsuit from a private entity. The plaintiff alleges impacts from upstream channel erosion and sediment transport. The efforts examine urban runoff and off-site impacts to a downstream channel and subsequent erosion and sediment transport into the downstream storm sewer system.

1.1.4. Compensation

The flat rate for all work including future deposition and testimony is $145 per hour. The compensation for this effort is entirely unrelated to the outcome of this matter.

2. Introduction

The Maryland Department of the Environment released draft MS4 permits for Baltimore City and Anne Arundel, Baltimore, and Montgomery counties on October 23, 2020. The permits are based on the Stormwater Management Act of 2007 and focus on environmental site design (ESD) to the maximum extent practicable (MEP) on all new development and redevelopment projects. Central components of ESD rely on restoration of impervious areas using green infrastructure, low impact development (LID), and runoff reduction practices to manage stormwater runoff at its source. The ultimate goal of ESD and LID stormwater management is maintaining or restoring predevelopment hydrology. As per §402(p)(3)(B)(iii) of the CWA, MS4 permits must require stormwater controls to reduce the discharge of pollutants to the MEP. Under 40 CFR §122.44, BMPs and MS4 programs must be consistent with applicable stormwater WLAs developed under EPA established or approved TMDLs.

The draft MS4 permits directs the restoration of impervious acres for the reduction of nutrients and sediments and implementation of pollution reduction plans targeting specific pollutants that impair local waters. As written, impervious acre restoration credit is allowed for direct or equivalent stormwater runoff treatment. This allows for credits for Alternative BMPs including street sweeping, tree planting, stream restoration, and others that do not provide direct runoff reduction or volumetric controls.

The draft permits allow for credits for Total Nitrogen, Total Phosphorus, and Total Suspended Solids for impervious acre restoration. Impervious acre restoration crediting is based on reducing 18.08 pounds of TN, 2.23 pounds of TP, and 806[5] pounds of TSS per year. It is important to note that crediting on the basis of nutrient reduction may be very different than crediting based on volume reduction. Similarly, performance for alternative BMPs such as street sweeping and catch basin cleaning, that would reduce solid pollutants, will not reduce volume and thus should be limited in the permit. Pollutant load and volume reduction, in this instance, are strongly correlated because of the contribution of stream erosion. ***Only runoff reduction and green infrastructure BMPs that reduce runoff volume can provide channel protection thus mitigating the impacts of urbanization on stream health.***

As part of the evolution of stormwater management, efforts to improve the feasibility and affordability of stormwater management for NPDES permit compliance have led to a large toolbox of valuable BMPs and nutrient control strategies including structural BMPs, non-structural BMPs, and alternative BMPs. The large array of BMPs enables the goal of nutrient reduction to be broadly applied in a range of conditions (ultra-urban to residential) for a range of projects (new development to retrofits) to manage implementation costs. Notably, BMP performance for pollutant and runoff volume reduction differs for structural (aka built practices), non-structural, and alternative BMPs. BMP crediting is based on the 2020 *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits (*2020 Accounting Guidance), which incorporates the Phase 6 Chesapeake Bay Watershed Model. BMP designs are required to use the 2000 Maryland Stormwater Design Manual.

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[5] The draft permit list TSS impervious acre restoration credit as 8,046 lbs/ac/yr which is believed to be a typo at 806 lbs/ac/yr

3. Watershed Characteristics

As noted prior, the Gwynns Falls watershed was examined in the context of the draft MS4 permits to exemplify identified shortcomings. It would be expected, and MDE[1] and EPA[6] have demonstrated, that the same relative impacts from urbanization IC and stream erosion can be expected in urban streams. As per the 2015 Sediment TMDL, Gwynns Falls (HUC8# 02130905) is a 65.2 sqmi watershed with a stream that flows southeast for 25 miles through Baltimore County and into Baltimore City into the tidal Patapsco River of the Chesapeake Bay. The Patapsco River is a sub-basin of the Chesapeake Bay watershed. Of the 5 major tributaries within the watershed[7], Red Run is a "high quality" (Tier II) stream segment which triggers the state antidegradation policy.

An analysis of the 2010 state land use and land cover[8], demonstrated in Figure 1, shows that residential housing is the dominant land use accounting for nearly 50%, 15% forested, and nearly equal amounts of commercial, institutional, and industrial. The watershed has approximately 33% impervious cover as of the 2009 Sediment TMDL publication. Figure 2 illustrates the increasing urbanization and density of development of the watershed towards the Bay.

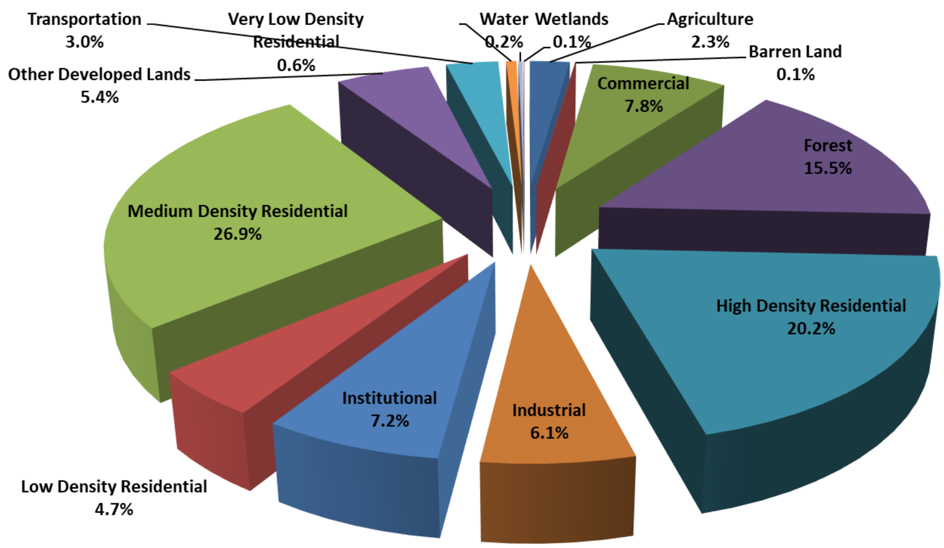

Figure 1: Land Use and Land Cover Distribution for Gwynn's Falls (HUC8# 02130905)

The Gwynns Falls watershed was 303(d) listed in 1996 by MDE as impaired for sediment from nonpoint sources. A sediment TMDL was developed for the watershed in 2009 and revised in 2015[1]. The TMDL baseline sediment load is 22,049 ton/yr of which 77% (16,977 ton/yr) was determined to be due to streambank erosion from elevated impervious cover as detailed in Table 1 and Table 2.

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6 USEPA (2010). Chesapeake Bay Phase 5.3 Community Watershed Model. Annapolis MD, U.S. Environmental Protection Agency, Chesapeake Bay Program Office.

7 Red Run, Horsehead Branch, Scotts Level Branch, Dead Run, and Maidens Choice Creek

8 Land Use Land Cover 2010, Maryland GIS Data Catalog, https://geodata.md.gov/imap/rest/services/PlanningCadastre/MD_LandUseLandCover/MapServer/1

Table 1: TMDL Baseline Sediment Loads for Gwynns Falls

BASELINE LOAD	NONPOINT SOURCE BL	NPDES STORMWATER BL	PROCESS WATER BL
ton/yr	ton/yr	ton/yr	ton/yr
22,049	1,759	20,076	213

Note: BL= baseline

Table 2: Sediment Load Source Contribution from Urban Activities and Streambank Erosion

COMPONENT	BASELINE SEDIMENT LOAD	% SEDIMENT LOAD
	ton/yr	
Total	22,049	100%
Urban Load	5,071	23%
Streambank Erosion	16,977	77%

4. Pollutant Load Analysis

For this report a pollutant loading analysis (PLA) was conducted for the purpose of distinguishing between the total pollutant load, the load due to streambank erosion, and the remaining urban sources that would be the primary focus of BMPs. The PLA method used is an entirely different approach than the Bay Model because the two models serve different purposes yet should result in similar outcomes. Concerns have been reported on multiple occasions regarding model reliability and reconciling model estimates with observations.[9, 10] In the scientific community the weight of evidence is the idea that multiple approaches and forms of inquiry will result in similar outcomes. The use of different forms of analysis to confirm similar findings is especially valuable in that different methods tend to have different errors and biases. In this instance, less important than if the loads are identical is the consistency of findings and the ability to identify the significance of different land uses and BMPs. The PLA method is described in detail in Appendix B: Pollutant Load Analysis.

The volume and quality of stormwater runoff generated from each major land use within the study watershed was characterized through the use of a PLA method that is a variation on the unified stormwater sizing criteria from the 2000 MD Stormwater Manual as shown in Equation 1 for calculation of the water quality volume. The PLA method, shown in Equation 2, uses a runoff coefficient (R_v)[11] based on hydrologic soil group and land use in the calculation of runoff volume, and the event mean concentration (EMC) of a specific land use to determine pollutant loads. This enables the development of a simple land development model to examine loads specific to land use and soil type combinations.

Equation 1: Water Quality Volume $WQV = P \ x \ R_v \ x \ A$

P = Average annual runoff (inches)

R_v = Runoff coefficient (unitless)

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[9] Whoriskey, P. (2004). Bay Pollution Progress Overstated. Washington Post. Washington DC.

[10] Boesch, D. F. (2020). It's time to match cleanup assumptions with results, not give up. Bay Journal.

[11] Adapted from Table 7.9 from McCuen, R. H. (2004). Hydrologic Analysis and Design. Upper Saddle River, New Jersey, 07458, Prentice Hall.

A = Area

Equation 2: Pollutant Load $L_{LU} = P\ x\ R_{LU}\ x\ A_{LU}\ x\ C_{LU}$

L_{LU}= Land-use specific pollutant load (lbs)
P = Average annual runoff (41.18 inches)
R_{LU} = Land-use specific runoff coefficient (unitless)
A_{LU} = Land-use specific area
C_{LU} = Land-use pollutant concentration or EMC

Table 3 summarizes the calculated pollutant loads from urban sources for TSS, TP, and TN by land use for the watershed *excluding* the contribution from streambank erosion. Pollutant load export rates (PLER) for TSS, TP, and TN were determined for the subset of 14 land uses excluding agriculture, forest, water, and wetlands and are mapped in Figure 3 through Figure 5 for urban sources and exclude streambank erosion sources. PLERs were developed by combining the EMCs with the computed runoff volume for each specific land use and soil type combination.

Table 3: Gwynns Falls Pollutant Loads for Urban Sources for Total Suspended Solids, Phosphorus, and Nitrogen Excluding Contribution from Streambank Erosion

LAND USE	AREA (MI^2)	% AREA	TOTAL SUSPENDED SOLID LOAD (TONS/YR)	TOTAL PHOSPHORUS LOAD (TONS/YR)	TOTAL NITROGEN LOAD (TONS/YR)
Agriculture	1.5	2.3			
Barren Land	0.0	0.1	0.75	0.00	0.01
Commercial	5.1	7.8	767.61	2.13	17.59
Forest	10.1	15.5			
High Density Residential	13.2	20.2	980.45	4.74	26.88
Industrial	4.0	6.1	702.96	2.26	26.91
Institutional	4.7	7.2	1,249.47	2.27	19.12
Low Density Residential	3.0	4.7	164.14	0.79	4.50
Medium Density Residential	17.6	26.9	1,152.10	5.57	31.59
Other Developed Lands	3.5	5.4	205.91	0.99	5.65
Transportation	1.9	3.0	297.89	0.72	9.43
Very Low Density Residential	0.4	0.6	19.40	0.09	0.53
Water	0.2	0.2			
Wetlands	0.1	0.1			
Total	65.2	100.0	5,540.7	19.6	142.2

Note: Agriculture, Forest, Wetlands, and Open Water land uses were not analyzed.

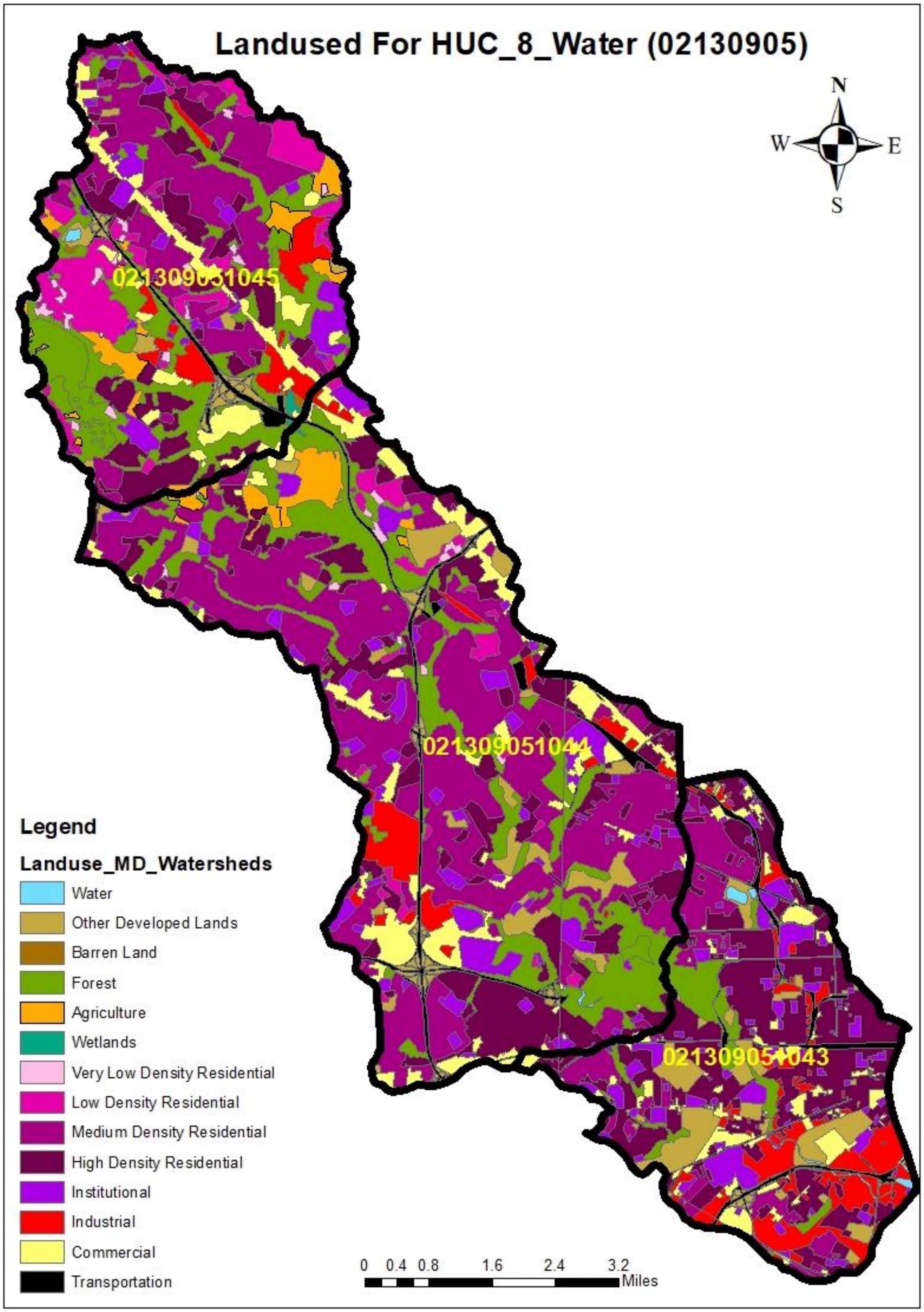

Figure 2: Land Use and Land Cover for Gwynn's Falls (HUC8# 02130905)

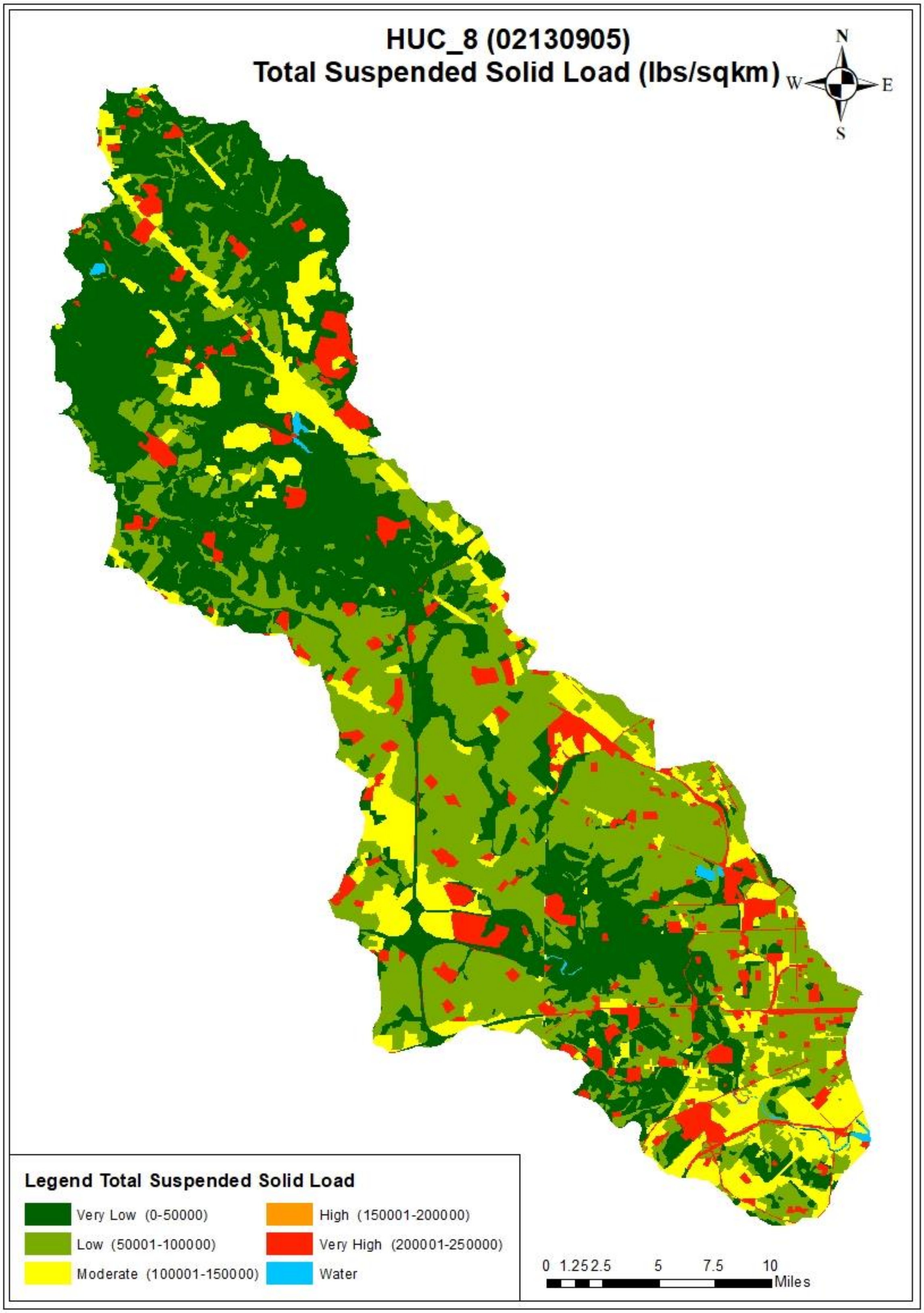

Figure 3: Total Suspended Solids Load Export Rates by Land Use for Gwynn's Falls

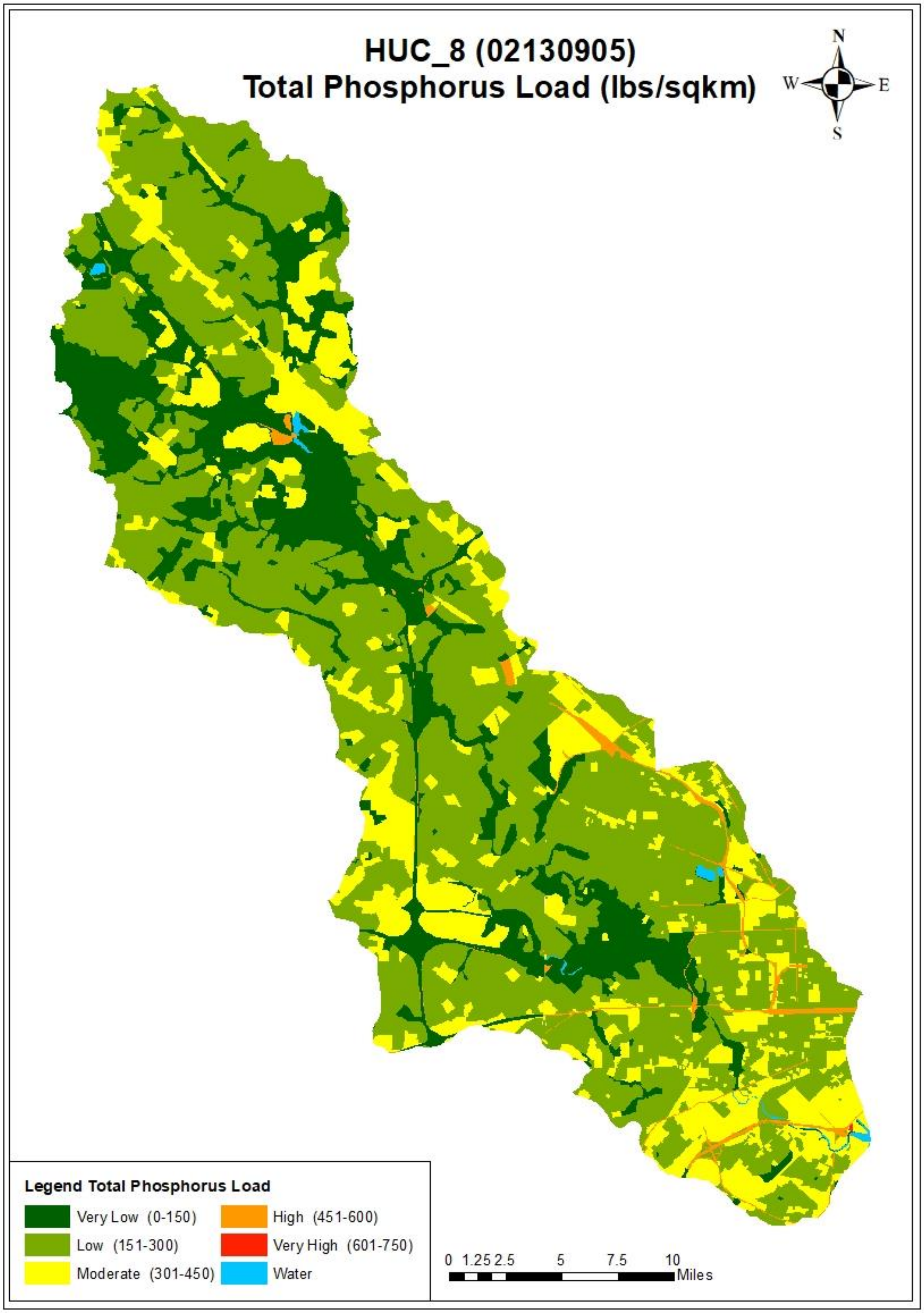

Figure 4: Total Phosphorus Load Export Rates by Land Use for Gwynn's Falls

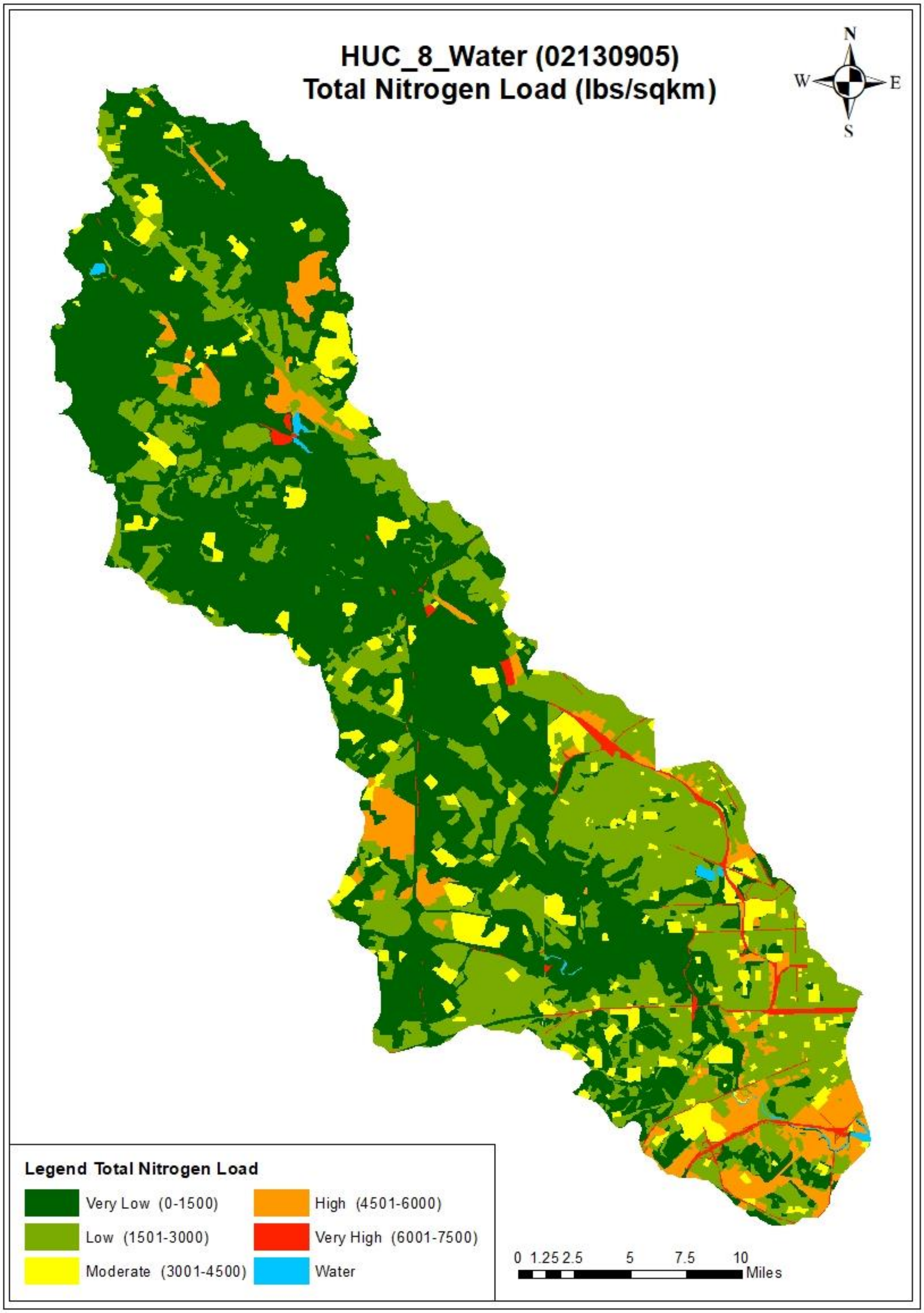

Figure 5: Total Nitrogen Load Export Rates by Land Use for Gwynn's Falls

5. Stream Erosion and Impervious Cover

In the 2015 sediment TMDL, MDE distinguished between sediment sources from urban development and stream erosion. "*Many studies have documented the relationship between high amounts of connected impervious surfaces, increases in storm flows, and stream degradation in the form of streambank erosion (Schueler 1994; Arnold and Gibbons 1996)*" (MDE 2015). Based on prior studies elsewhere MDE developed a relationship between impervious cover and sediment load due to streambank erosion. This was calculated as the difference between the target edge of forest sediment loads and loads within urbanized stream segments. This relationship enables the estimation of the percent of stream sediment load that could be attributed to the streambank erosion and urban development sources.

Figure 6 is a re-creation of the MDE erosional sediment and impervious cover relationship for the TMDL. For Gwynns Falls, with an impervious cover of 33%, MDE determined that approximately 77% of the sediment load was due to streambank erosion. The Phase 6 Bay Model further develops this relationship between impervious cover and edge of stream sediment loading rates[3] as is demonstrated in Figure 7.

Phase 6 Model documentation lists streambank erosion flux rates for TSS, TP, and TN as shown in Table 4. It is noted that the Phase 6 sediment target represents the edge of stream sediment load from urban development and does not include load sourced by streambank erosion. The pollutant load due to streambank erosion is determined by the stream length as noted in the National Hydrography Dataset (NHD).

For this study, streambank erosional pollutant loads were calculated, as detailed above from the Phase 6 documentation, from the TSS, TN, and TP erosional flux rates and total watershed stream length. Watershed stream length was then measured using the NHD. The pollutant sources (streambank erosional pollutant loads, urban loads calculated by PLA) were then examined in the context of observed watershed loads reported by the USGS from 1998-2016[12]. Table 5 lists the calculated loads by source and relative contribution to total load. This analysis demonstrates the significant contribution of streambank erosion to sediment and phosphorus loading (75% and 71% respectively) and to a lesser degree nitrogen (11%) and the importance of runoff reduction in managing total loads.

[12] Majcher, E. H., E. L. Woytowitz, et al. (2018). Factors affecting long-term trends in surface-water quality in the Gwynns Falls watershed, Baltimore City and County, Maryland, 1998-2016, U.S. Geological Survey**:** 27.

Table 4: Streambank Erosion Flux Rates and Loads for TSS, TN, and TP for the Gwynns Falls Watershed

CONSTITUENT	FLUX RATE[13] (lbs/ft/yr)	CALCULATED EROSIONAL SEDIMENT LOAD (tons/yr)
Sediment	62.69	11,298.8
Nitrogen	0.093	16.8
Phosphorus	0.31	55.9

Note: Loads calculated based on NHD total watershed stream length of 360,466 ft.

Table 5: Calculated and Observed Pollutant Loads by Source for TSS, TN, and TP in the Gwynns Falls Watershed

CONSTITUENT	STREAMBANK LOAD (tons/yr)	URBAN LOAD BY PLA (tons/yr)	% STREAMBANK LOAD	TOTAL LOAD (tons/yr)	OBSERVED LOAD[12] (tons/yr)
Sediment	16,977.3	5,540.7	75%	22,518.0	N/A
Nitrogen	16.8	142.2	11%	159.0	119.9
Phosphorus	55.9	19.6	74%	75.4	3.9

[13] Table 9-3 from Section 9.3.1: Streambank Erosion Due to Impervious Cover, Stream-to-River, Chesapeake Bay Program Phase 6 Watershed Model, Final Model Documentation for the Midpoint Assessment – 10/1/2018

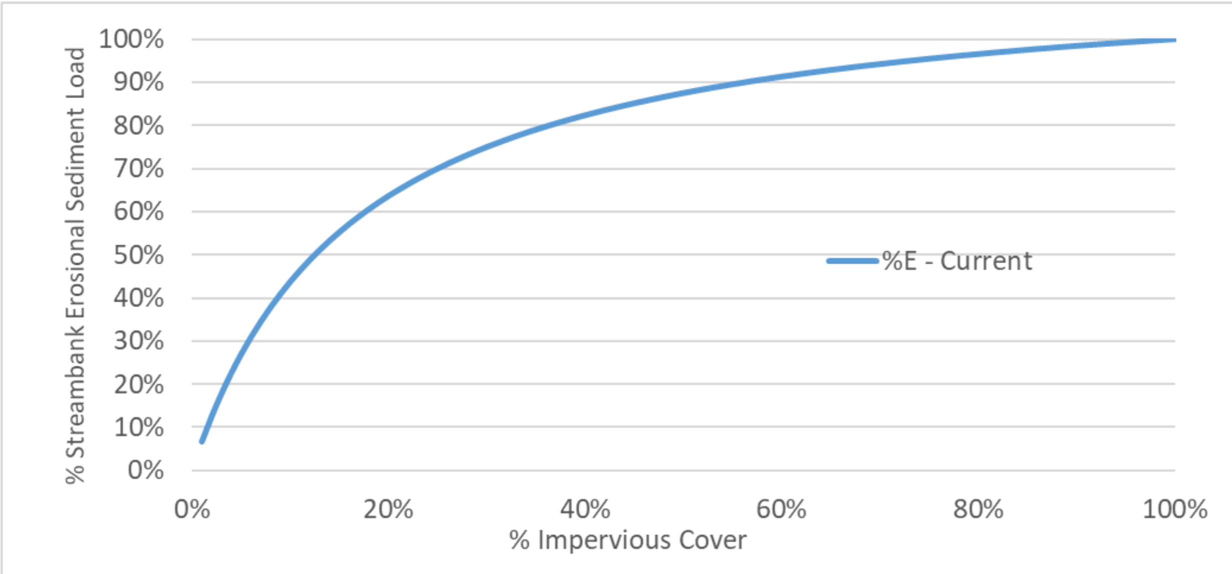

Figure 6: Streambank Erosional Sediment % Contribution Vs. Impervious Cover (Adapted from MDE 2015)

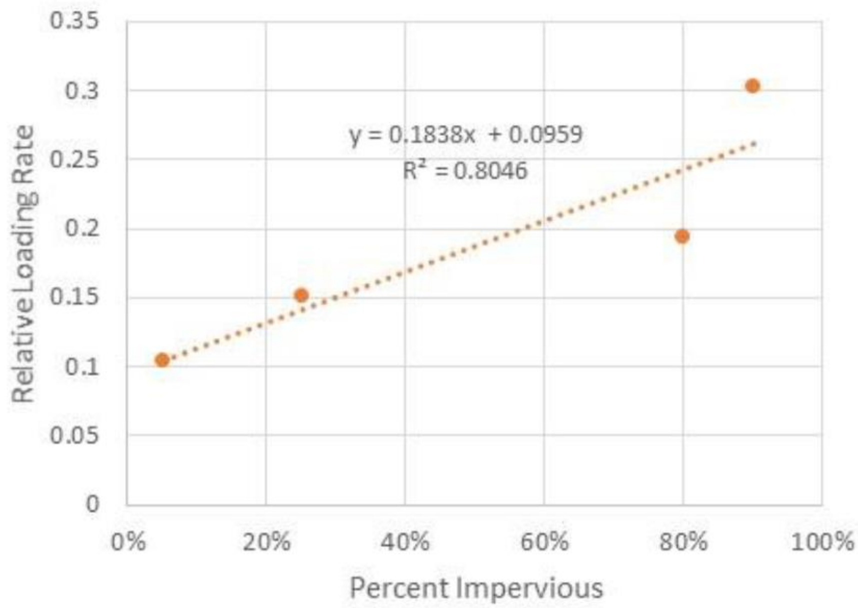

Figure 7: Relation Between Percent Impervious Cover and Edge-Of-Stream Sediment Loading Rate[14]

[14] Figure 9-5 from Section 9.3.2: Streambank Erosion Due to Impervious Cover, Stream-to-River, Chesapeake Bay Program Phase 6 Watershed Model, Final Model Documentation for the Midpoint Assessment – 10/1/2018

6. Impervious Acre Restoration Equivalence

The use of impervious acre restoration equivalence on a pollutant load basis, as is the case for the draft MS4 permits, is not equivalent when applied to pollutants that have a significant streambank erosion component. The essence of environmental site design (ESD) is the maintenance or restoration of predevelopment hydrology and runoff curve number reduction. This is exemplified in the Environmental Site Design Sizing Criteria detailed in the 2000 Maryland Stormwater Design Manual[15]. ESD sizing is based on the need to reduce runoff volume equivalent to predevelopment hydrology to address the channel protection volume (Cp_v).

As evident in the sediment TMDL for Gwynns Falls, and other urban streams, it is necessary to account for the sources of sediment and phosphorus loading to distinguish between urban land uses (residential, commercial, transportation, etc) and those derived by stream bank erosion that are caused as a result of increased imperviousness and runoff volumes. ***The source of pollutant load must influence the type of BMP that will be needed and most effective for load reduction.*** For example, pollutants derived from urban land uses such as sediment and phosphorus associated with transportation activities could be managed by street sweeping of roadways and parking lots. Whereas pollutants derived from streambank erosion that is caused by increased imperviousness and corresponding runoff volume will not benefit from street sweeping. Only BMPs that reduce runoff volume through infiltration and filtration practices will effectively reduce impervious cover as measured hydrologically.

As detailed in Table 5, in Gwynns Falls 75% of the sediment load, 74% of phosphorus, and 11% of the nitrogen load would go unmanaged in absence of runoff reduction and associated structural controls. The significant source contribution for streambank erosion illustrates the shortcomings of the impervious acre restoration equivalence on a pollutant load basis in replacement of runoff reduction. ***The absence of required runoff reduction to manage the channel protection volume would result in a fundamental inability to address the total loads for sediment and phosphorus, and to a lesser degree nitrogen.***

7. Climate Change Resiliency and Structural BMPs for Runoff Reduction

The draft MS4 permits discuss the importance of implementing green stormwater infrastructure to increase the use of natural filters and BMPs for climate resiliency. Similarly, the permit references the 2020 Accounting Guidance and the CBP expert panels desire to provide increased climate resilience and green infrastructure credits. The use of runoff reduction by volumetric controls (or lack thereof) has important implications for the mitigation of future impacts of climate change and resultant pollutant loading as described prior. For the reasons mentioned previously, ***runoff reductions are necessary for the reduction of streambank erosion***. An analysis of near-future climate trends by CBP[16] indicated an increase of approximately 3% average annual rainfall volumes over the last 100 years. A similar analysis showed an increase in Maryland of 3.1% by the year 2025 and 6.7% by the year 2055 based on a mid-range emissions

[15] Section 5.2.2 Environmental Site Design Sizing Criteria, 2000 Maryland Stormwater Design Manual, Chapter 5 Environmental Site Design, Maryland Department of the Environment.

[16] CBP (2019). Chesapeake Bay Program Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, Chesapeake Bay Program.

scenario.[17] Future increases in rainfall would result in corresponding increases in runoff, stream erosion and subsequent pollutant loading. Runoff reductions and related structural control practices are the most effective BMPs for management of increases in runoff regardless of whether increases are a result of impervious cover or climate change. This relates to both management of pollutant loads and climate resiliency and drainage infrastructure vulnerability.

Figure 8 illustrates the hypothetical change in the streambank erosional sediment relationship with impervious cover developed by MDE with a 3.1% and 6.7% increase in rainfall depths for the years 2025 and 2055. As noted previously, there is a predictable relationship between increasing IC and streambank erosion. Streambank erosion then functions as another source of pollutants in addition to those derived from typical urbanization activities. Streambank erosion produces sediment, phosphorus, and nitrogen (to a lesser degree). Thus, streambank erosional sediment as a pollutant source can only be managed by BMPs that achieve runoff reduction and impervious cover restoration as measured hydrologically. Table 6 details the current streambank erosional sediment for current, future year 2025, and future year 2055 conditions. It can be seen that the current erosional sediment is equal to 77.5% and by the year 2025 would increase to 79.8% or the equivalent of increasing the %IC from 33% to 36% for the watershed. By the year 2055 the current erosional sediment contribution would increase to 82.7% or the equivalent of increasing the %IC from 33% to 41% for the watershed. The same hypothetical increase in erosional sediment was applied to the calculated loads for TSS, TP, and TN as discussed previously. The hypothetical future increased pollutant loads due to streambank erosion are shown in Table 7. This demonstrates that ***accelerating erosional sediment and nutrient loads are and will be a product of increased precipitation for current and future years*** (2025 and 2055). The exact relationship between increase in rainfall and the impact in the erosional sediment is unknown but is likely to follow a similar linear trend as discussed here.

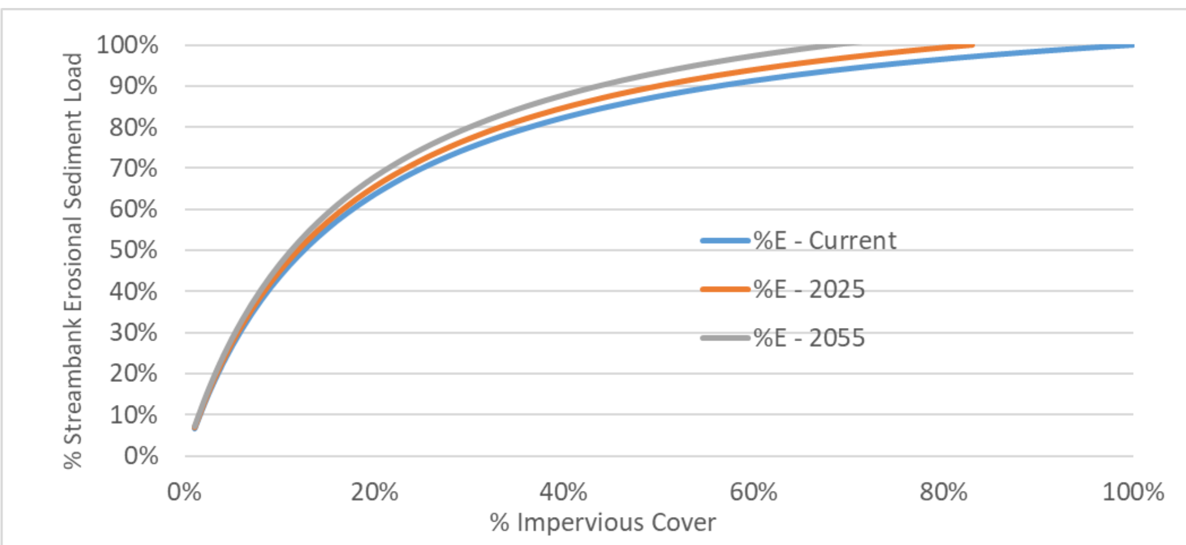

Figure 8: Streambank Erosional Sediment Vs. Impervious Cover with Climate Change (Adapted from MDE 2015)

[17] Wood, D. (2020). Review of Recent Research on Climate Projections for the Chesapeake Bay Watershed, Chesapeake Stormwater Network.

Table 6: Streambank Erosional Sediment % for Gwynns Falls for Current Conditions and with 3% Future Precipitation Increase

% IMPERVIOUS COVER	$\%E_{CURRENT}$	$\%E_{FUTURE}$	$\%E_{2055}$
30.0%	75.0%	77.3%	80.0%
31.0%	75.9%	78.2%	81.0%
32.0%	76.7%	79.0%	81.9%
33.0%	77.5%	79.8%	82.7%
34.0%	78.3%	80.6%	83.5%
35.0%	79.0%	81.4%	84.3%
36.0%	79.7%	82.1%	85.1%
37.0%	80.4%	82.8%	85.8%
38.0%	81.1%	83.5%	86.5%
39.0%	81.7%	84.2%	87.2%
40.0%	82.4%	84.8%	87.9%
41.0%	82.9%	85.4%	88.5%

Table 7: Pollutant Loads Due to Streambank Erosion for Current and Future Years 2025 and 2055

CONSTITUENT	STREAMBANK LOAD CURRENT (tons/yr)	STREAMBANK LOAD 2025 (tons/yr)	STREAMBANK LOAD 2055 (tons/yr)
Sediment	16,977.3	17,486.7	18,114.8
Nitrogen	16.8	17.3	17.9
Phosphorus	55.9	57.5	59.6

8. Discussion and Conclusion

MDE has made some important advancements of the draft 2020 Baltimore County (20-DP-3317) and Baltimore City (20-DP-3315) MS4 permits, in particular the use of green infrastructure and BMPs that contribute to climate resiliency.

However, significant concerns exist. The use of impervious acre restoration equivalence on a pollutant load basis is not equivalent when applied to pollutants that have a significant streambank erosion component. The essence of environmental site design (ESD) is the maintenance or restoration of predevelopment hydrology and runoff curve number reduction to address the channel protection volume (Cpv). An underemphasis on runoff reduction and volumetric controls and allowance of Alternative BMPs has large implications for sediment removal, phosphorus removal, and climate resiliency.

As exemplified in the Gwynns Falls watershed and other similar urban watersheds with elevated impervious cover, an allowance of restoration credits on the basis of pollutant load removal, neglects the fact that stream erosion represents a significant component of the sediment load (77% in Gwynns Falls[1]), the phosphorus load (74%), and nitrogen load (11%) only to be exacerbated by changing climate conditions causing increased runoff and stream erosion. Without the prioritization of runoff reduction and volumetric controls the BMPs are left to manage only 23% of the sediment load (the non-stream erosion derived load) and 26% of phosphorus load and will never achieve permit requirements for sediment and nutrient reductions.

Commitments to climate resiliency, reduction of infrastructure vulnerability, and pollutant load impacts resulting from future changes in precipitation will similarly require a prioritization of runoff reduction practices. An analysis of near-future climate trends by CBP[18] indicated an increase of approximately 3% average annual rainfall volumes over the last 100 years. A similar analysis showed an increase in Maryland of 3.1% by the year 2025 and 6.7% by the year 2055 based on a mid-range emissions scenario. An analysis of hypothetical changes in streambank erosion in the absence of runoff reduction showed an increase in the erosional sediment contribution by the year 2025 from 77.5% to 79.8% or the equivalent of increasing the %IC from 33% to 36%, and by the year 2055 an increase to 82.7% or the equivalent of increasing the %IC from 33% to 41%. Volumetric structural control practices are the most effective BMPs for runoff reduction regardless of whether increases are a result of impervious cover or climate change. This relates to both management of pollutant loads and climate resiliency and drainage infrastructure vulnerability. Volumetric structural control practices are the most effective BMPs for runoff reduction regardless of whether increases are a result of impervious cover or climate change.

For this reason, the allowance of alternative BMPs and impervious acre restoration credits on the basis of pollutant load, and the lack of required runoff reduction and structural volumetric controls, is inconsistent with MDE’s stated goal to make significant and continued progress toward achieving the Chesapeake Bay’s WLAs as well as local nutrient and sediment TMDLs.

[18] CBP (2019). Chesapeake Bay Program Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, Chesapeake Bay Program.

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10.APPENDICES

Appendix A: Expert Witness Resume, Publications Authored in Previous 10 years, Expert Witness Experience

Appendix B: Pollutant Load Analysis

Appendix A: Expert Witness Resume, Publications Authored in Previous 10 years, Expert Witness Experience

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Waterstone Engineering, Owner, Stratham, NH, 2016-Present
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Diplomate of Water Resources Engineering, American Academy of Water Resources Eng., No. 00556

CAREER SUMMARY

Dr. Roseen provides many years of experience in water resources investigations and most recently, led a project team in the development of an Integrated Plan for nutrient management for stormwater and wastewater. This plan has received provisional approval by EPA and would be one of the first in the nation. Rob is a recognized industry leader in green infrastructure and watershed management, and the recipient of Environmental Merit Awards by the US Environmental Protection Agency Region 1 in 2010, 2016, and 2019. He consults nationally and locally on stormwater management and planning and directed the University of New Hampshire Stormwater Center for 10 years and is deeply versed in the practice, policy, and planning of stormwater management. Rob has over 25 years of experience in the investigation, design, testing, and implementation of innovative approaches to stormwater management and specializing in green infrastructure, nutrient control planning, and climate vulnerability analyses. Rob has led the technical analysis of dozens of nutrient and contaminant studies examining surface water pathways, system performance, management strategies, and system optimization.

Dr. Roseen provides Clean Water Act expert consultation, analysis, modeling, advice, reports and testimony in regards to compliance with TMDLs and Nutrient Control Planning, Construction General Permits, Municipal Separate Storm Sewer System (MS4) Permits, and Multi Sector General Permits.

He also served as Research Assistant Professor for five years. His areas of expertise include water resources engineering, stormwater management (including low impact development design), and porous pavements. He also possesses additional expertise in water resource engineering including hydrology and hydraulics evaluations, stream restoration and enhancement alternatives, dam removal assessment, groundwater investigations, nutrient and TMDL studies, remote sensing, and GIS applications.

Dr. Roseen has taught classes on Stormwater Management and Design, Fluid Mechanics, and Hydrologic Monitoring and lectures frequently on these subjects. He is frequently called upon as an expert on stormwater management locally, regionally, and nationally.

Notable professional activities include chairing the ASCE EWRI 2016 International Low Impact Development Conference, an annual event that draws participants from around the world to discuss advances in water resources engineering, and participating until 2017 as a Control Group member for the ASCE Urban Water Resources Research Council (UWRRC). He has also served on the ASCE Task Committee on Guidelines for Certification of Manufactured Stormwater BMPs, EWRI Permeable Pavement Technical Committee, and the Hydrology, Hydraulics, and Water Quality Committee of the Transportation Research Board. Dr. Roseen has been the author or co-author of over two dozen professional publications on the topics of stormwater runoff, mitigation measures, best management practices (BMPs), etc. He has extensive experience working with local, state, and regional agencies and participates on a national level for USEPA Headquarters, WEF, and the White Council on Environmental Quality on urban retrofit innovations and next generation LID/GI technology and financing solutions.

SELECT EXPERT WITNESS EXPERIENCE OVER THE PAST 10-YEARS

Chesapeake Bay Program MS4 and Industrial Permit Review

Dr. Roseen is currently providing expert testimony and technical analysis and review for the Chesapeake Accountability Project which seeks to review draft MS4 and Industrial Stormwater Permits. The goal is to provide a pollutant loading analysis (PLA) tool and concurrent documentation to evaluate the effectiveness of both existing and proposed Clean Water Act permits to protect water quality in the Chesapeake Bay watershed.

State Municipal Stormwater Permit Challenge

Dr. Roseen is currently providing (1) written direct expert testimony and (2) live expert testimony in the adjudication hearings before an unnamed Pollution Control Board in a challenge to municipal stormwater permits. This includes written expert testimony (including research, document review, discovery), response to discovery of other parties, hearing preparation, appearance and live testimony at hearing, and rebuttal testimony.

Low Impact Development Review for Proposed Residential Subdivision

Dr. Roseen is providing expert witness, review, and testimony with respect to Low Impact Development on behalf a private client for a proposed subdivision. The review sought to identify both LID broadly and in keeping with the local zoning ordinance, the use of the LID Crediting criteria relevant to the MA Stormwater Handbook and the 2016 MA Small MS4 Permit.

Climate Change Vulnerability Analyses for Industrial Facilities

Dr. Roseen is currently providing expert consultation, analysis, modeling, advice, and reports in regard to the vulnerability of industrial facilities to climate change and sea level rise for a major east coast port. Evaluations include severe weather events driven by climate change and the exposure of coastal terminals and risk of industrial spills to flooding from storm surge and forecasts for future sea level rise. Such services may include sworn to written or oral expert testimony regarding such matters in Court.

State Clean Water Permit Review

Dr. Roseen has provided expert consultation, advice, reports and testimony regarding stormwater discharges for proposed clean water permits for multiple states. Review and analyses include evaluation of stringency of proposed permits for low impact development for new development, redevelopment, and retrofits. This includes the stringency of performance standards, for projects of varying size, exemptions, and permit “trigger” conditions to name a few.

TMDL and Nutrient Control Attainability Analyses and Clean Water Act Expert Services

Dr. Roseen is currently providing expert consultation, analysis, modeling, advice, reports and testimony in regards to TMDL and nutrient control attainability. This includes watershed modeling, pollutant load analyses, BMP optimization, and parcel-based analyses. Such services include sworn to written or oral expert testimony regarding such matters in Court. This service is being provided for the plaintiff for three (3) case of significant size geographically and in project scope.

Construction General Permit (CGP), and Clean Water Act Expert Services

Dr. Roseen has provided expert consultation, analysis, modeling, advice, reports and testimony in regards to construction general permit compliance, erosion and sedimentation control, and monitoring. Such services include sworn to written or oral expert testimony regarding such matters in Court, and on-site inspections of defendants' facilities. This service is being provided for the plaintiff for one (1) case of significant size geographically and in project scope.

Municipal Separate Storm Sewer System (MS4) Permit and Clean Water Act Expert Services

A team lead by Dr. Roseen is currently providing and has provided expert consultation, analysis, modelling, advice, reports and testimony regarding stormwater discharges in regards to MS4 violations under the Clean Water Act. Such services include sworn to written or oral expert testimony regarding such matters in Court, and site and facility inspections. This service is being provided for the plaintiff for three cases of significant size geographically and in project scope.

Multi Sector General Permit (MSGP), Stormwater Pollution Prevention Plan, and Clean Water Act Expert Services

A team lead by Dr. Roseen is currently providing expert consultation, water quality monitoring, analysis, modelling, advice, reports and testimony regarding stormwater discharges in regards to MSGP under the Clean Water Act. Such services include sworn to written or oral expert testimony regarding such matters in Court, and on-site inspections of defendants' facilities. This service is being provided for the plaintiff for over ten (10) separate cases in the northeastern United States.

Multi Sector General Permit (MSGP) and Clean Water Act Expert Services

A team lead by Dr. Roseen provided expert consultation, analysis, modelling, advice, reports and testimony regarding the operations of a scrap metal and automotive recycling facility in relation to Multi Sector General Permit, Safe Drinking Water Act, and National Water Quality Criteria violations of the Clean Water Act. Such services include sworn to written or oral expert testimony regarding such matters in Court, and on-site inspections of facilities. This service was provided for a single location in the northeastern United States.

Expert Study and Testimony for Erosion and Sediment Control Litigation

A team lead by Dr. Roseen is currently providing expert study and testimony in defense of an undisclosed Federal Client in a $25-million-dollar lawsuit from a private entity. The plaintiff alleges impacts from upstream channel erosion and sediment transport. The efforts examine urban runoff and off-site impacts to a downstream channel and subsequent erosion and sediment transport into the downstream storm sewer system.

Participation in National Expert Meeting by the White House Council on Environmental Quality and Environmental Protection Agency

Dr. Roseen participated in a national meeting of experts entitled "Municipal Stormwater Infrastructure: Going from Grey to Green". This meeting purpose was to engage stakeholders in developing options and solutions that result in wider implementation of green infrastructure practices to manage municipal stormwater.

SELECT OTHER PROJECTS

Great Bay Nitrogen Control Plan Feasibility Study, Seacoast, NH (2019-Current) Dr. Roseen lead a study to determine the feasibility and cost for regulated 16 communities in the Great Bay watershed to implement the optional non-point source and stormwater point source nitrogen reduction pathway outlined in EPA's draft Total Nitrogen General Permit. Feasibility was based on both an assessment of methods to implement nitrogen controls and a corresponding cost analysis. By looking at land use categories and modeled nutrient loads the analysis determined how to optimize nitrogen reductions through a variety of structural and non-structural stormwater Best Management Practices (BMPs).

Examination of Proposed Timber Harvesting Flood Impacts in the Mill Brook Valley (2018-2019) Dr. Roseen led a study to examine flood impacts from proposed timber harvesting in a heavily forested watershed and populated with residential homes. This study included 1) examining proposed timber harvesting impacts in relation to current flooding, 2) a review of the Town's FEMA awards, and 3) development of a watershed model to assess current and future land use management and climate change impacts in relation to regulatory floodplains and bank erosion.

Little Hale Pond Stormwater Management and Nutrient Control Design, Durham, NH (2019-Current) Dr. Roseen is leading a design for two BMPs for stormwater management and nutrient controls as part of a larger stream crossing and culvert replacement design for a low head impoundment. This project involves drainage design, pollutant load analysis, BMP costing. The installations will be implemented in spring of 2019

Nutrient Control Planning for Mill Pond, Durham, NH (2018-Current) Dr. Roseen lead a nutrient control study to identify restorative actions that will be effective within the life expectancy of the dam and at the same time help address declining water quality in Mill Pond and NPDES permitting requirements. Aspects of this study are intended to be consistent (in part) with the 2017 MS4 permit. This includes source identification reporting, BMPs to be optimized for pollutant removal , retrofit inventory and priority ranking, BMP design and costing. This project is intended to lay the groundwork for broader watershed and implementation planning.

Integrated Permitting for MS4 and Wastewater in Burlington, VT (2016-Current), Dr. Roseen is currently leading the stormwater services for a 5-firm engineering team for integrated planning beginning in 2016. The integrated planning effort is the first in the northeastern United States for a municipally funded effort. This project seeks to develop an integrated plan for stormwater, wastewater, and nonpoint sources for a phosphorous TMDL.

Commercial Street Porous Pavement Design, Provincetown, MA (2009-Current) Since 2009, Dr. Roseen has been the technical expert for a project team led by GHD Inc. on porous pavement design for the construction over 12,000' of the first "Porous Municipal Main Street". The project addressed existing infrastructure problems with flooding and drainage along a main thoroughfare that had tremendous traffic during the busy tourist season. Through the use of widespread infiltration, the design sought to help Provincetown address their need to manage stormwater and beach impairments which occur from the discharge of untreated runoff from many outfalls. Beach closures have been reduced by nearly 90% since 2011. The design also considered the long-term maintenance aspect of the pavement with respect to the town's current maintenance routine.

Rollins Hill Conservation Development, Stratham, NH (2015-Present) Rollins Hill is a Low Impact Development designed to integrate homes with the landscape and provide protection for water quality and habitat with over 50 acres of conservation land in a 104-acre development. Dr. Roseen has provided design and construction quality assurance for structural and non-structural BMP design for the various ongoing construction phases and continues to supervise the implementation of long-term O&M with permeable pavements, raingardens, and rooftop infiltration to protect water quality and habitat, recharge groundwater, and reduce the need for stormwater ponds and drainage.

Lincoln Street Subwatershed Nutrient Control Planning, Phase I and Phase II of the Exeter (WISE) Integrated Plan, (2016-2017, Phase I),(2017-2018 Phase II Project of Special Merit). Dr. Roseen is the lead for these 2 phased projects to focus on climate resiliency and the development of nutrient controls plans for the towns largest subwatershed. This includes watershed modeling, planning, BMP design, and costing of green infrastructure for nutrient controls and climate change resiliency. Up to 15 BMP designs and operations and maintenance manuals were developed.

***Building Resilience to Flooding and Climate Change in the Moonlight Brook Watershed**, (2015-Current), New Hampshire Coastal Program. This project focuses on the subwatershed modeling, planning and design of green infrastructure for climate change resiliency. Dr. Roseen was the lead author and Project Director in partnership with the Town of Newmarket.

Water Integration for the Squamscott Exeter (WISE), (2013-2015), Dr. Roseen was the lead author and Project Director and Principal Investigator for this two-year project to develop an Integrated Plan for nutrient management for stormwater and wastewater amongst 3 communities and 5 wastewater and stormwater NPDES permits. This plan has received provisional approval by EPA and would be one of the first in the nation.

Urban Watershed Renewal in Berry Brook: Building a Cultural of Watershed Stewardship (2009-2012), *Aquatic Resource Mitigation Fund of the NHDES and ACOE*. Dr. Roseen led this >$750,000 grant project between 2009-2012. Implementation in Berry Brook had a combination of LID stormwater management, stream restoration improvements, and community engagement and included 11 BMP designs, costing, and construction supervision. This project fostered clean water and habitat restoration through urban watershed renewal to achieve less than 10% effective impervious cover.

SELECT PEER REVIEWED PUBLICATIONS

ASCE, D. K. Hein, et al. (2018). ASCE/T&DI/ICPI 68-18 Permeable Interlocking Concrete Pavement Standard. Reston, VA, ASCE Transportation and Development Institute, Interlocking Concrete Pavement Institute.

Bean, E. Z. and R. Roseen (2018). Permeable Pavement Design. Alexandria, Virginia, ASCE Continuing Education, American Society of Civil Engineers.

Bean, E., R. Roseen, et al., Eds. (2017). Permeable Pavements Design Construction And Maintenance. Guided Online Course. Arlington, VA, American Society of Civil Engineers.

Medina, D., R. Roseen, et al., Eds. (2017). Low Impact Development: A Holistic Approach To Urban Stormwater Management. Guided Online Course. Arlington, VA, American Society of Civil Engineers.

ASCE, E. Z. Bean, et al., Eds. (2015). Permeable Pavements. Manual of Practice on Recommended Design Guidelines for Permeable Pavements, American Society of Civil Engineers, The Permeable Pavements Technical Committee, Low Impact Development Standing Committee, Urban Water Resources Research Council, Environment and Water Resources Institute.

Potts, A. and R. M. Roseen (2015). Chapter 2, Recommended Design Guidelines for the Use of Porous Asphalt Pavements. Committee Report on Recommended Design Guidelines for Permeable Pavements: Report on Engineering Practice. B. Eisenberg, K. Lindow and D. Smith, American Society of Civil Engineers, The Permeable Pavements Technical Committee, Low Impact Development Standing Committee, Urban Water Resources Research Council, Environment and Water Resources Institute.

Roseen, R. M., T. V. Janeski, et al. (2015). "Economic and Adaptation Benefits of Low Impact Development." Low Impact Development Technology: 74.

Strecker, E., A. Poresky, et al. (2015). Volume Reduction of Highway Runoff in Urban Areas: Guidance Manual.

Roseen, R., R. Waldo, et al. (2014). Provincetown Porous Asphalt Keeps Beaches Open. Asphalt Pavement Magazine, National Asphalt Pavement Association. Sept 2014.

Roseen, R. M., T. P. Ballestero, et al. (2014). "Assessment of winter maintenance of porous asphalt and its function for chloride source control." Journal of Transportation Engineering 140(2).

Hlas, V., R. Roseen, et al. (2013). An Examination of the Reduction of Effective Impervious Cover and Ecosystem Watershed Response. Department of Civil Engineering. Durham, NH, University of New Hampshire Stormwater Center,.

Houle, J. J., R. M. Roseen, et al. (2013). "A Comparison of Maintenance Cost, Labor Demands, and System Performance for LID and Conventional Stormwater Management." Journal of Environmental Engineering(139): 932-938.

Ballestero, T. P. and R. M. Roseen (2012). Porous Pavement Performance in Cold Climates. The Stormwater Report, Water Environment Federation. Vol 2, No. 1.

Roseen, R. M., T. P. Ballestero, et al. (2012). "Water Quality and Hydrologic Performance of a Porous Asphalt Pavement as a Stormwater Treatment Strategy in a Cold Climate." ASCE Journal of Environmental Engineering: 81-89.

Roseen, R. M., T. P. Ballestero, et al. (2012). Subsurface Gravel Wetlands for Stormwater Management. The Stormwater Report, Water Environment Federation. Vol 2, No. 7.

Sample, D. J., T. J. Grizzard, et al. (2012). "Assessing performance of manufactured treatment devices for the removal of phosphorus from urban stormwater." Journal of environmental management 113: 279-291.

Gunderson, J., R. M. Roseen, et al. (2011). Cost-Effective LID in Commercial and Residential Development. Stormwater, Forrester Communications. March-April.

Roseen, R. M., T. P. Ballestero, et al. (2011). "Sediment Monitoring Bias by Autosampler in Comparison with Whole Volume Sampling for Parking Lot Runoff." Journal of Irrigation and Drainage Engineering 4: 251-257.

Scholz, A., R. M. Roseen, et al. (2011). Consequences Of Changing Climate And Land Use To 100-Year Flooding In The Lamprey River Watershed Of New Hampshire. Civil Engineering. Durham, NH, University of New Hampshire.

Peterson, J., Stone, A., Houle, J., & Roseen, R. (2010). Protecting Water Resources and Managing Stormwater: A Bird's Eye View for Communities in New Hampshire and Throughout New England. Durham, NH, NH Seagrant, UNH Stormwater Center.

RIDEM, CRMC, et al. (2010). Rhode Island Stormwater Design and Installation Standards Manual, Rhode Island Department of Environmental Management and the Coastal Resources Management Council.

Roseen, R., N. DiGennaro, et al. (2010). Preliminary Findings on Examination of Thermal Impacts From Stormwater Best Management Practices. ASCE EWRI World Environmental and Water Resources Congress, Providence, Rhode Island, ASCE, University of New Hampshire Stormwater Center, Prepared for US EPA Region 1.

Watts, A. W., T. P. Ballestero, et al. (2010). "Polycyclic Aromatic Hydrocarbons in Stormwater Runoff from Sealcoated Pavements." Environ. Sci. Technol. 44(23): 8849–8854.

Roseen, R. M., Ballestero, T. P., Houle, J. J., Avellaneda, P., Briggs, J. F., Fowler, G., and Wildey, R. (2009). "Seasonal Performance Variations for Stormwater Management Systems in Cold Climate Conditions." Journal of Environmental Engineering-ASCE, 135(3), 128-137.

Avellaneda, P., Ballestero, T. P., Roseen, R. M., and Houle, J. J. (2009). "On Parameter Estimation Of An Urban Stormwater Runoff Model." Journal of Environmental Engineering.

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Roseen, R. M., Ballestero, T. P., Houle, J. J., Avellaneda, P., Wildey, R., and Briggs, J. F. (2006). "Performance evaluations for a range of stormwater LID, conventional structural, and manufactured treatment strategies for parking lot runoff under varied mass loading conditions." Transportation Research Record: Journal of the Transportation Research Board (No. 1984), 135–147.

REPORTS AND CONFERENCE PROCEEDINGS

- Roseen, R. and J. Sahl (2020). Attainability Analysis For A Great Bay Total Nitrogen Permit: Great Bay Nitrogen Control Plan Feasibility Study For The Towns Of Rochester, Portsmouth, Dover, Exeter, Durham, Kittery, Somersworth, Pease ITP, Berwick, North Berwick, Newmarket, South Berwick, Epping, Newington, Rollinsford, Newfields, and Milton. Boston, MA, Waterstone Engineering for the Conservation Law Foundation.
- Roseen, R., R. Graham, et al. (2019). Rollins Hill: Unique Conservation Development for Improved Permitting and Added Project Value. NH Rivers Council Annual Meeting 2019, Stratham, NH.
- Roseen, R. and J. Sahl (2019). Examination of Proposed Timber Harvesting Flood Impacts in the Mill Brook Valley for the Wanosha Integrated Resource Project by the White Mountain National Forest. Thornton, NH, BCM Environmental and Land Law, Deachman and Cowie, Mill Brook Valley Maintenance Corporation.
- Roseen, R. and J. Sahl (2019). TMDL Attainability Analyses for Phosphorus and Pathogens for the Charles River Watershed, Massachusetts - Expert Report. Boston, MA, Waterstone Engineering for the Conservation Law Foundation.
- Roseen, R. and J. Sahl (2018). Mill Pond Nutrient Control Measures -Final Report. Durham, NH, Department of Public Works, Waterstone Engineering, Weston and Sampson.
- Roseen, R. and J. Sahl (2018). TMDL Attainability Analyses for Phosphorus and Enterococci for Bailey's Brook and North Easton Pond, Rhode Island - Expert Report. Providence, Rhode Island, Waterstone Engineering for the Conservation Law Foundation.
- Roseen, R. and J. Sahl (2018). TMDL Attainability Analyses for Phosphorus and Fecal Coliform for Mashapaug Pond, Rhode Island - Expert Report. Providence, Rhode Island, Waterstone Engineering for the Conservation Law Foundation.
- Roseen, R., J. Sahl, et al. (2018). Phase 1 and Phase 2: Lincoln Street Subwatershed Nutrient Control Strategies Incentivizing Resiliency Through Implementation Plans in One of Coastal New Hampshire's Fastest Growing

Communities- Final Report. Exeter, NH, Department of Public Works, Waterstone Engineering, Rockingham Planning Commission.
- Roseen, R., Watts, A., Bourdeau, R., Stacey, P., Sinnott, C., Walker, T., Thompson, D., Roberts, E., and Miller, S. (2015). Water Integration for Squamscott Exeter (WISE), Preliminary Integrated Plan, Final Technical Report. Portsmouth, NH, Geosyntec Consultants, University of New Hampshire, Rockingham Planning Commission, Great Bay National Estuarine Research Reserve, Consensus Building Institute.
- Roseen, R. (2013). Design and Sizing of Innovative Bioretention-ISR System. Stratham, NH, Waterstone Engineering: 7.
- Roseen, R. and R. Stone (2013). Evaluation and Optimization of the Effectiveness of Stormwater Control Measures for Nitrogen Removal, Final Report. Boston, MA, University of New Hampshire Stormwater Center, Geosyntec Consultants, USEPA Region 1.
- Roseen, R. M. and R. Stone (2013). Bioretention Water Quality Treatment Performance Assessment--Technical Memorandum. Seattle, WA, Seattle Public Utilities, Seattle, WA: 84.
- Roseen, R. M., R. Stone, et al. (2013). Final Report on Evaluation And Optimization Of The Effectiveness Of Stormwater Control Measures For Nitrogen And Phosphorus Removal. Boston, MA, US EPA Region 1 TMDL Program, University of New Hampshire Stormwater Center.
- Wake, C. P., S. Miller, et al. (2013). Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed of New Hampshire Resulting from Changes in Climate and Land Use. Durham, NH, University of New Hampshire.
- Wake, C. P., F. Rubin, et al. (2013). Review of Land Development (Build-out) and Climate Scenarios. Durham, NH, University of New Hampshire.
- Houle, J., R. Roseen, et al. (2012). UNH Stormwater Center 2012 Biennial Report. Durham, NH, University of New Hampshire Stormwater Center Cooperative Institute for Coastal and Estuarine Environmental Technology.
- Roseen, R. M., J. J. Houle, et al. (2012). Report On A Cold Climate Permeable Interlocking Concrete Pavement Test Facility At The University Of New Hampshire Stormwater Center. Durham, University of New Hampshire Stormwater Center Geosyntec Consultants.
- Roseen, R., J. Houle, et al. (2011). Performance Evaluation Report Of The Stormtech Isolator Row® Treatment Unit. Durham, NH, University of New Hampshire Stormwater Center.
- Roseen, R., A. Watts, et al. (2011). Final Report on Examination of Thermal Impacts From Stormwater Best Management Practices. Durham, NH, University of New Hampshire Stormwater Center Prepared for US EPA Region 1.
- Roseen, R. M., T. V. Janeski, et al. (2011). Forging the Link: Linking the Economic Benefits of Low Impact Development and Community Decisions. Durham, New Hampshire, The UNH Stormwater Center, Environmental Research Group, The University of New Hampshire: 172.
- Stack L, Simpson MH, et al. (2010). The Oyster River culvert analysis project, Syntectic International, Antioch University New England, Climate Techniques, the University of New Hampshire Stormwater Center, the Piscataqua Region Estuaries Partnership, Prepared for the EPA Climate Ready Estuaries Program.
- UNHSC, R. M. Roseen, et al. (2010). Technology Assessment Protocol (TAP) For Innovative And Emerging Technologies. Rhode Island Stormwater Design and Installation Standards Manual, Rhode Island Department of Environmental Management..
- Houle, J., Roseen, R., and Ballestero, T. (2010). "UNH Stormwater Center 2009 Annual Report." University of New Hampshire, Cooperative Institute for Coastal and Estuarine Environmental Technology, Durham, NH.
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- Roseen, R. M., Ballestero, T. P., Briggs, J. F., and Pochily, J. (2009, Revised). "UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds." University of New Hampshire Stormwater Center, Durham, NH.
- Watts, A. W., Roseen, R. M., Ballestero, T. P., Houle, J. J., and Gilbert, H. L. (2008) "Polycyclic Aromatic Hydrocarbons In Stormwater Runoff From Sealcoated Pavements." StormCon 08, Orlando, FL.

- Roseen, R. M., Ballestero, T. P., Fowler, G. D., Guo, Q., and Houle, J. (2009) "Sediment Monitoring Bias by Autosampler in Comparison with Whole Volume Sampling for Parking Lot Runoff." EWRI World Water Resources Congress, Kansas City, Mo.
- Roseen, R. M., Carrasco, E., Cheng, Y., Hunt, B., Johnston, C., Mailloux, J., Stein, W., and Williams, T. (2009)"Data Reporting Guidelines for Certification of Manufactured Stormwater BMPs: Part II." ASCE EWRI World Water Resources Congress, Kansas City, MO.
- Roseen, R. M., Houle, K. M., Briggs, J. F., Houle, J. J., and Ballestero, T. P. (2009)"Examinations of Pervious Concrete and Porous Asphalt Pavements Performance for Stormwater Management in Northern Climates." EWRI World Water Resources Congress, Kansas City, Mo.
- Roseen, R.M., Ballestero, T. P. (2008). "Porous Asphalt Pavements for Stormwater Management in Cold Climates." HMAT, National Asphalt Pavement Association.
- Roseen, R. M., Houle, J. J., and Ballestero, T. P. (2008). "Final Report On Field Verification Testing Of The Downstream Defender And Upflo Filter Treatment Units." The University of New Hampshire Stormwater Center.
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- UNHSC, Roseen, R., T. Ballestero, and Houle, J. (2008). "UNH Stormwater Center 2007 Annual Report." University of New Hampshire, Cooperative Institute for Coastal and Estuarine Environmental Technology, Durham, NH.
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- Roseen, R., and Stone, R. (2013). "Evaluation and Optimization of the Effectiveness of Stormwater Control Measures for Nitrogen Removal, Final Report." University of New Hampshire Stormwater Center, Geosyntec Consultants, USEPA Region 1, Boston, MA.
- Roseen, R. M., and Ballestero, T. P. (2008). "Porous Asphalt Pavements for Stormwater Management in Cold Climates." HMAT, National Asphalt Pavement Association.
- Roseen, R. M., Ballestero, T. P., and Brannaka, L. K. (2002). "Quantifying groundwater discharge using thermal imagery and conventional groundwater exploration techniques for estimating the nitrogen loading to a meso-scale inland estuary," PhD. Dissertation, University of New Hampshire., Durham, NH.

PROFESSIONAL AFFILIATIONS

- River Management Advisory Council, Member on behalf of New Hampshire Rivers Council and the Appalachian Mountain Club, since 2010
- Massachusetts Stormwater Management Updates Advisory Committee, Member At Large, since 2019.
- New Hampshire Rivers Council, Board of Directors, since 2019.
- Management Committee, Piscataqua Region Estuary Partnership, since 2015
- Expert Panel, Long Creek Watershed Management District, since 2014.
- Wetlands Expert Panel, Chesapeake Bay Program, 2018-2019
- USEPA Headquarters, Urban Retrofit Innovation Roundtable, Next Generation LID/GI Technology and Financing Solutions, The National Experience, Selected participant, April 2012
- Urban Water Resources Research Council, Control Group Member, American Society of Civil Engineers, 2012-2017.
- Water Quality Standards Advisory Committee, Piscataqua Region Estuary Program, since 2010

- Technical Advisory Committee, Piscataqua Region Estuary Partnership, since 2009
- American Academy of Water Resources Engineers, Member since May, 2010
- ASCE EWRI-WERF Task Committee on Guidelines for Certification of Manufactured Stormwater BMPs-Subgroup Chair, Member since 2007
- Science and Technical Advisory Committee, American Rivers, Washington, DC, since 2011
- Board of External Reviewers, Washington State Stormwater Technology Assessment Program, 2010-2014
- Board of Directors, The Low Impact Development Center, Beltsville, Maryland, 2009-2015
- Board of Directors, The NH Coastal Protection Partnership, 2008-2012

HONORS AND AWARDS

- Environmental Merit Award, as porous pavement design expert for Provincetown, MA, awarded by the US Environmental Protection Agency, Region 1, 2019.
- Environmental Merit Award, as project lead for the Water Integration for Squamscott Exeter (WISE) in coastal New Hampshire, awarded by the US Environmental Protection Agency, Region 1, 2016.
- Environmental Merit Award, as participating member in the New Hampshire Climate Adaption Workgroup, awarded by the US Environmental Protection Agency, Region 1, 2015
- In 2010, received the prestigious certification as a Diplomate by the American Academy of Water Resources Engineers (D. WRE), to certify competence in water resources specialization for 1) advanced stormwater management, and 2) design and execution of experiments, data analysis, and interpretation.
- 2010 Outstanding Civil Engineering Achievement Award, New Hampshire ASCE, Project Title: State Street Utilities Replacement and Street Revitalization, Portsmouth, New Hampshire, Design Team Member and Lead for Low Impact Development
- Environmental Merit Award, as participating member in the Long Creek Watershed Management Team, awarded US Environmental Protection Agency, Region 1, 2010
- Letter of Commendation from Commissioner Burack of the New Hampshire Department of Environmental Services for School Street School Stormwater Retrofit Project, September 2010

Appendix B: Pollutant Load Analysis

1. Methods

The PLA method used for this study is distinctly different than the Bay Model, however each approach has merit, and combined can be very useful. In the scientific community the weight of evidence is the idea that multiple approaches and forms of inquiry will result in similar outcomes. The use of different forms of analysis to confirm similar findings is especially valuable in that different methods tend to have different errors and biases. In this instance, the two modeling approaches are 1) the Bay Model, a time-averaged mechanistic simulation watershed model (Phase 6), and 2) PLA Method, a simplistic empirical lumped parameter model. The Bay Model is a physically based calibrated simulation model that establishes loads and loading rates that vary by land use and location. For this reason, a single land use has a wide range of loading rates that represent the unique condition and location in the watershed. The PLA method used here is a simple land use development model that is a variation on the unified stormwater sizing criteria from the 2000 MD Stormwater Manual. The variation includes the modification of the runoff coefficient (R_v) to include the consideration of hydrologic soil group type in the calculation of runoff volume and pollutant loads.

1.1. Land Use Assessment

The Gwynns Falls HUC 8 digit watershed is comprised of three 12 digit watersheds (Table 8).

Table 8: HUC8 and HUC12 Watersheds for Gwynns Falls

	HUC8	HUC12-1	HUC12-2	HUC12-3
Name	Gwynns Falls	Gwynns Falls, Lower	Gwynns Falls, Middle	Gwynns Falls, Upper
Watershed Number	02130905	021309051043	021309051044	021309051045
Acres	41,711	9,901	20,424	11,386
Square Miles	65.17	15.47	31.91	17.79

In order to perform the pollutant load analysis and load allocation amongst urban sources and streambank erosion, detailed land use data from a 2010 Maryland GIS dataset**Error! Bookmark not defined.** was generalized to fit into categories for which EMC values are available.

Table 9 lists the 2010 MDE detailed land uses and resultant categorization into more generalized land uses. Figure 1 shows the relative land use distribution within the watershed and Figure 2 maps the land use for the 65 mi^2 watershed and Table 8 quantifies the land uses. Table 9 details the land use category generalization that was used for the 2010 land use data set to determine pollutant loads.

Table 9 - Land Use Category Generalization

2010 LU_ID	2010 LU_CLASS	Reduced LU_ID	Reduced LU_CLASS
11	Low-density residential	8	Low Density Residential
12	Medium-density residential	9	Medium Density Residential
13	High-density residential	5	High Density Residential
14	Commercial	3	Commercial
15	Industrial	6	Industrial
16	Institutional	7	Institutional
17	Extractive	10	Other Developed Lands
18	Open urban land	10	Other Developed Lands
21	Cropland	1	Agriculture
22	Pasture	1	Agriculture
23	Orchards/vineyards/horticulture	1	Agriculture
24	Feeding operations	1	Agriculture
25	Row and garden crops	1	Agriculture
41	Deciduous forest	4	Forest
42	Evergreen forest	4	Forest
43	Mixed forest	4	Forest
44	Brush	4	Forest
50	Water	13	Water
60	Wetlands	14	Wetlands
70	Barren land 71 Beaches	2	Barren Land
72	Bare exposed rock	2	Barren Land
73	Bare ground	2	Barren Land
80	Transportation	11	Transportation
191	Large lot subdivision (agriculture)	12	Very Low Density Residential
192	Large lot subdivision (forest)	12	Very Low Density Residential
241	Feeding operations	1	Agriculture
242	Agricultural buildings	1	Agriculture

Table 10 - Land Use / Land Cover in the Gwynns Falls Watershed

SR	LAND USE	AREA (MI^2)	% AREA
1	Agriculture	3.8	2.3
2	Barren Land	0.1	0.1
3	Commercial	13.2	7.8
4	Forest	26.2	15.5
5	High Density Residential	34.1	20.2
6	Industrial	10.3	6.1
7	Institutional	12.1	7.2
8	Low Density Residential	7.9	4.7
9	Medium Density Residential	45.5	26.9
10	Other Developed Lands	9.0	5.4
11	Transportation	5.0	3.0
12	Very Low Density Residential	1.0	0.6
13	Water	0.4	0.2
14	Wetlands	0.1	0.1
	Total	168.8	100.0

1.2. Hydrologic Soil Groups and Runoff Coefficients

Hydrologic soil groups were mapped for the watershed using the NRCS SSURGO Soils database for Maryland[19]. Hydrologic soils groups are a necessary component of determining the runoff coefficient for a given land use. Table 11 tabulates the area of the hydrologic soil groups within the watershed. Figure 9 illustrates the hydrologic soil group for the watershed. Soil type largely determines the runoff characteristics of a given land cover. Land use determines largely the pollutant loading characteristics. Table 12 lists runoff coefficients (R_v) by soil type from McCuen (2004)[20]. These runoff coefficients factor in the land use, impervious cover (implicitly), and soil type.

Table 11: Area of Hydrologic Soil Groups

HYDROLOGIC SOIL GROUP	AREA	AREA2
	MI^2	ACRES
HSG A	0.28	176
HSG B	19.31	12,356
HSG B/D	1.67	1,066
HSG C	12.68	8,118
HSG C/D	6.16	3,939
HSG D	22.98	14,710
Water	2.08	1,334

[19] Maryland SSURGO Soils, Maryland GIS Data Catalog https://geodata.md.gov/imap/rest/services/Geoscientific/MD_SSURGOSoils/MapServer/0

[20] Adapted from Table 7.9 from McCuen, R. H. (2004). Hydrologic Analysis and Design. Upper Saddle River, New Jersey, 07458, Prentice Hall.

Total	65.16	41,699

Table 12: Runoff Coefficients (R_v) by Hydrologic Soil Group (McCuen 2004)

LAND USE	**HYDROLOGICAL SOIL GROUP**						
	A	**B**	**C**	**D**	**A/D**	**B/D**	**C/D**
Agriculture	0.08	0.11	0.14	0.18	0.13	0.15	0.16
Barren Land	0.05	0.08	0.12	0.15	0.10	0.12	0.14
Commercial	0.71	0.71	0.72	0.72	0.72	0.72	0.72
Forest	0.05	0.08	0.10	0.12	0.09	0.10	0.11
High Density Residential	0.22	0.24	0.27	0.30	0.26	0.27	0.29
Industrial	0.67	0.68	0.68	0.69	0.68	0.69	0.69
Institutional	0.67	0.68	0.68	0.69	0.68	0.69	0.69
Low Density Residential	0.16	0.19	0.22	0.26	0.21	0.23	0.24
Medium Density Residential	0.19	0.22	0.25	0.28	0.24	0.25	0.27
Other Developed Lands	0.22	0.24	0.27	0.30	0.26	0.27	0.29
Transportation	0.70	0.71	0.72	0.73	0.72	0.72	0.73
Very Low Density Residential	0.14	0.17	0.20	0.24	0.19	0.21	0.22
Water	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wetlands	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: Based on assumption that slopes are <=2%.

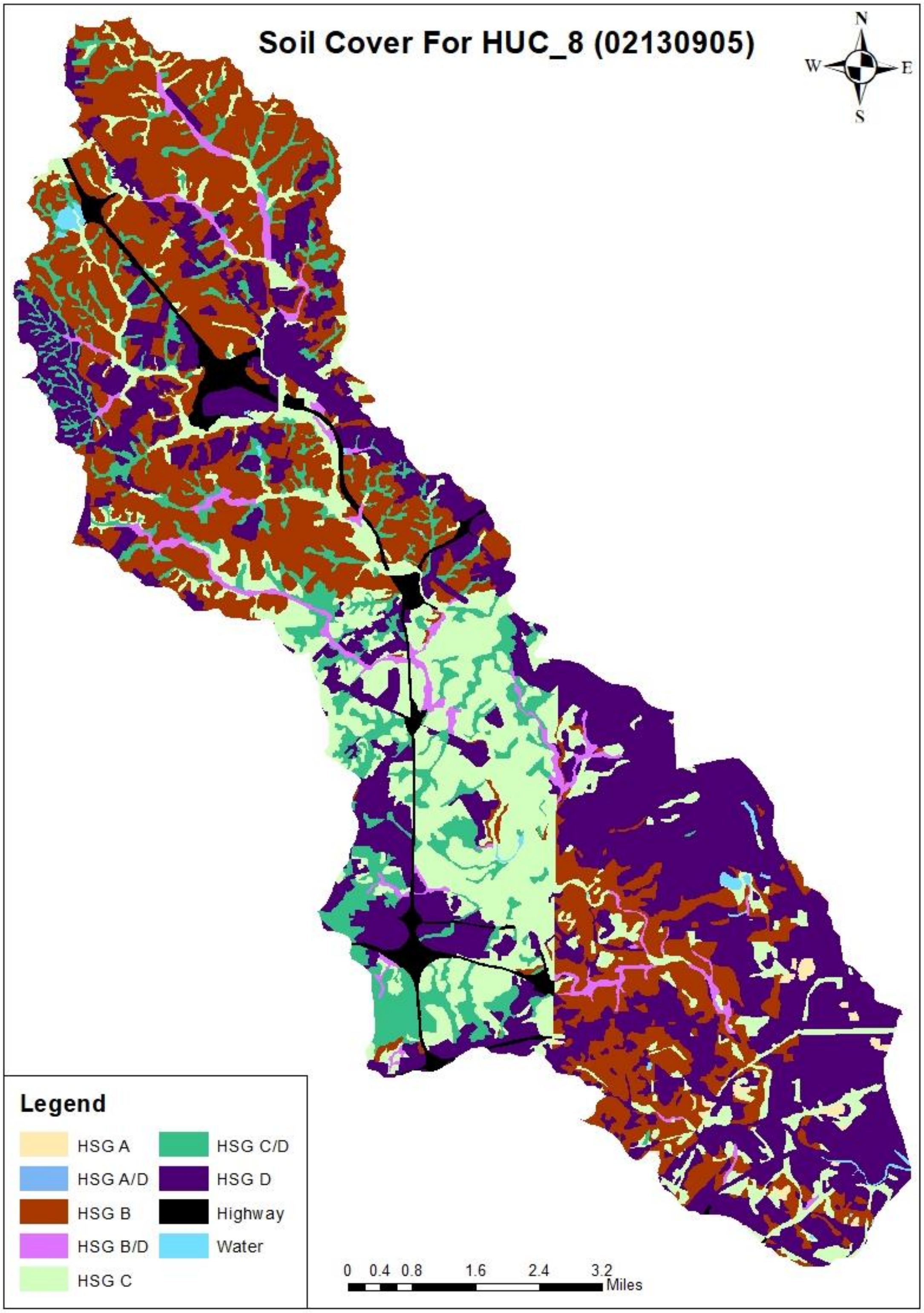

Figure 9 – Soil Cover for the Gwynns Falls Watershed

1.3. Pollutant Load Analysis

The volume and quality of stormwater runoff generated from each major land use within the study watershed was characterized through the use of a PLA method that is a variation on the unified stormwater sizing criteria from the 2000 MD Stormwater Manual as shown in Equation 3 for calculation of the water quality volume. The PLA method, shown in Equation 4, uses a runoff coefficient (R_v)[20] based on hydrologic soil group and land use in the calculation of runoff volume, and the event mean concentration (EMC) of a specific land use to determine pollutant loads. This enables the development of a simple land development model.

Equation 3: Water Quality Volume $WQV = P\ x\ R_v\ x\ A$

P = Average annual runoff (inches)
R_v = Runoff coefficient (unitless)
A = Area

Equation 4: Pollutant Load $L_{LU} = P\ x\ R_{LU}\ x\ A_{LU}\ x\ C_{LU}$

L_{LU}= Land-use specific pollutant load (lbs)
P = Average annual runoff (41.18 inches)
R_{LU} = Land-use specific runoff coefficient (unitless)
A_{LU} = Land-use specific area
C_{LU} = Land-use pollutant concentration or EMC

The average annual rainfall (P) of 41.18 inches was used for Baltimore. Rainfall was determined by data calculated from 1948 to 2008 for the City of Baltimore[21, 22]. Land-use specific EMCs (C_{LU}) for Total Suspended Solids (TSS), Total Phosphorous (TP), and Total Nitrogen (TN) were used to determine the pollutant load source contribution for respective areas. Regional EMCs were calculated by Struck et al (2015) from a subset of the National Stormwater Quality Database (NSQD, 2012) and presented in Table 13. Lastly, pollutant load export rates (PLER)s for TSS, TP, and TN were determined for the subset of 14 land uses excluding agriculture, forest, water, and wetlands. PLERs were developed by combining the EMCs with the computed runoff volume for each specific land use and soil type combination.

Table 14 through Table 16 list the PLER rates in pounds of pollutant per acre per year. Lastly, pollutants loads were calculated and summed by land use. Summary pollutant loads by land use are presented in Table 17 for TSS, TP, and TN.

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[21] Baltimore City, NCDC Station CoopID: 180470, National Climatic Data Center (NCDC)
[22] Struck, S., K. Havens, et al. (2015). Urban Stormwater Runoff Pollutant Loading Analyses for Case Study Watersheds. Lafayette, CO, Geosyntec Consultants, Inc., for American Rivers.

Table 13: Regional Land Use Specific EMCs for Baltimore, Maryland (NSQD, 2012)

LAND USE	TSS (mg/L)	TP (mg/L)	TN (mg/L)
COMMERCIAL	72	0.2	1.65
INDUSTRIAL	87	0.28	3.33
INDUSTRIAL MIX	101	0.33	3.28
INSTITUTIONAL	132	0.24	2.02
TRANSPORTATION	133	0.32	4.21
OPEN SPACES	78	0.34	1.16
RESIDENTIAL	89	0.43	2.44

Table 14: Total Suspended Solids Pollutant Loading Export Rates (TSS/lbs/ac/yr)

MARYLAND LAND USE CLASS	HYDROLOGIC SOIL GROUP						
	A	B	C	D	A/D	B/D	C/D
Agriculture							
Barren Land	36.40	58.23	87.35	109.19	72.79	83.71	98.27
Commercial	477.07	477.07	483.78	483.78	480.42	480.42	483.78
Forest							
High Density Residential	182.73	199.34	224.25	249.17	215.95	224.25	236.71
Industrial	543.98	552.10	552.10	560.22	552.10	556.16	556.16
Institutional	825.35	837.66	837.66	849.98	837.66	843.82	843.82
Low Density Residential	132.89	157.81	182.73	215.95	174.42	186.88	199.34
Medium Density Residential	157.81	182.73	207.64	232.56	195.18	207.64	220.10
Other Developed Lands	182.73	199.34	224.25	249.17	215.95	224.25	236.71
Transportation	868.83	881.25	893.66	906.07	887.45	893.66	899.86
Very Low Density Residential	116.28	141.20	166.11	199.34	157.81	170.27	182.73
Water							
Wetlands							

Table 15: Total Phosphorus Pollutant Loading Export Rates (TP/lbs/ac/yr)

MARYLAND LAND USE CLASS	HYDROLOGIC SOIL GROUP						
	A	B	C	D	A/D	B/D	C/D
Agriculture							
Barren Land	0.16	0.25	0.38	0.48	0.32	0.36	0.43
Commercial	1.33	1.33	1.34	1.34	1.33	1.33	1.34
Forest							
High Density Residential	0.88	0.96	1.08	1.20	1.04	1.08	1.14
Industrial	1.75	1.78	1.78	1.80	1.78	1.79	1.79
Institutional	1.50	1.52	1.52	1.55	1.52	1.53	1.53
Low Density Residential	0.64	0.76	0.88	1.04	0.84	0.90	0.96
Medium Density Residential	0.76	0.88	1.00	1.12	0.94	1.00	1.06
Other Developed Lands	0.88	0.96	1.08	1.20	1.04	1.08	1.14
Transportation	2.09	2.12	2.15	2.18	2.14	2.15	2.17
Very Low Density Residential	0.56	0.68	0.80	0.96	0.76	0.82	0.88
Water							
Wetlands							

Table 16: Total Nitrogen Pollutant Loading Export Rates (TN/lbs/ac/yr)

MARYLAND LAND USE CLASS	HYDROLOGIC SOIL GROUP						
	A	B	C	D	A/D	B/D	C/D
Agriculture							
Barren Land	0.54	0.87	1.30	1.62	1.08	1.24	1.46
Commercial	10.93	10.93	11.09	11.09	11.01	11.01	11.09
Forest							
High Density Residential	5.01	5.46	6.15	6.83	5.92	6.15	6.49
Industrial	20.82	21.13	21.13	21.44	21.13	21.29	21.29
Institutional	12.63	12.82	12.82	13.01	12.82	12.91	12.91
Low Density Residential	3.64	4.33	5.01	5.92	4.78	5.12	5.46
Medium Density Residential	4.33	5.01	5.69	6.38	5.35	5.69	6.03
Other Developed Lands	5.01	5.46	6.15	6.83	5.92	6.15	6.49
Transportation	27.50	27.90	28.29	28.68	28.09	28.29	28.48
Very Low Density Residential	3.19	3.87	4.55	5.46	4.33	4.67	5.01
Water							
Wetlands							

Table 17: Pollutant Loads for Urban Sources for Total Suspended Solids, Phosphorus, and Nitrogen Excluding Contribution from Streambank Erosion

LAND USE	AREA (MI^2)	% AREA	TOTAL SUSPENDED SOLID LOAD (TONS/YR)	TOTAL PHOSPHORUS LOAD (TONS/YR)	TOTAL NITROGEN LOAD (TONS/YR)
Agriculture	1.5	2.3			
Barren Land	0.0	0.1	0.75	0.00	0.01
Commercial	5.1	7.8	767.61	2.13	17.59
Forest	10.1	15.5			
High Density Residential	13.2	20.2	980.45	4.74	26.88
Industrial	4.0	6.1	702.96	2.26	26.91
Institutional	4.7	7.2	1,249.47	2.27	19.12
Low Density Residential	3.0	4.7	164.14	0.79	4.50
Medium Density Residential	17.6	26.9	1,152.10	5.57	31.59
Other Developed Lands	3.5	5.4	205.91	0.99	5.65
Transportation	1.9	3.0	297.89	0.72	9.43
Very Low Density Residential	0.4	0.6	19.40	0.09	0.53
Water	0.2	0.2			
Wetlands	0.1	0.1			
Total	65.2	100.0	5,540.7	19.6	142.2

Note: Agriculture, Forest, Wetlands, and Open Water land uses were not analyzed.

APPENDIX C

Table Comparison of Three MS4 Permits
by Dr. Richard Horner

COMPARISON OF THREE MS4 PERMITS

Program Component	Western Washington Phase I Permit		San Diego Regional Permit		Maryland Permits[a]	
	Title (Notes)	Page Location	**Title** (Notes)	Page Location	**Title** (Notes)	Page Location
Major Components						
Comprehensive stormwater management program incorporating the following components	**Stormwater Management Program** [SWMP] (requires SWMP Plan with detailed minimum performance measures for 11 components)	6-31	**Water Quality Improvement Plans**	21-40	**Stormwater Management**	3-4
Numeric standards	Appendix 12— **Structural Stormwater Controls Project List** (achieve 300 Structural Stormwater Control Program Points over the permit cycle; one minimum performance measure for the Structural Stormwater Controls element)	18; Appendix 12 pp. 1-9	**1. Numeric Goals** ("The Copermittees must develop and incorporate numeric goals into the Water Quality Improvement Plan.") **2. Action Levels** (discharge pollutant concentrations or mass loadings intended to focus runoff management program implementation)	27-28 (elaborated further on 29-40) 41-45	**1 Stormwater Restoration** **2. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (Guidance for National Pollutant Discharge Elimination System Stormwater Permits)**	9-11 1-99
Elements of the Comprehensive Stormwater Management Program						
Legal authority	**Legal Authority**	7	**Legal Authority Establishment and Enforcement**	83-84	**Legal Authority**	2
Mapping and documentation	**MS4 Mapping and Documentation**	8-9	**Optional Watershed Management Area Analysis**	33-34	**Source Identification**	2-3
Coordination	**Coordination** (among jurisdictions and departments within jurisdictions)	9-10	No specific section but inter-jurisdictional coordination covered in six passages	No specific coverage but mentioned in two places in Fact Sheet		
Planning	**Stormwater Planning** (basis for developing water quality management policies and strategies for specific discharge and receiving water conditions)	13-17	**1. Priority Water Quality Conditions** **2. Water Quality Improvement Strategies and Schedules**	23-37	No coverage	

Program Component	Western Washington Phase I Permit		San Diego Regional Permit		Maryland Permits[a]	
	Title (Notes)	Page Location	**Title** (Notes)		**Title** (Notes)	Page Location
Public involvement	**Public Involvement and Participation**	10	**Public Participation**	123	No coverage	
Controlling runoff from new development and redevelopment	**Controlling Runoff from New Development, Redevelopment, and Construction Sites**	10-12; Appendix 1 pp. 1-35	**Development Planning**	92-107	No specific coverage but mentioned in three places in Fact Sheet	
Controlling runoff from construction sites		12-13, 35	**Construction Management**	108-112	**Erosion and Sediment Control**	4-5
Source control for existing development	**Source Control Program for Existing Development**	18-21	**Existing Development Management**	112-120	Represented by Impervious Acre Credit system	
Retrofitting existing development	Accomplished through Structural Stormwater Control Program; see Numeric standards component below)				Represented by Impervious Acre Credit system	
Structural best management practices overall	**Structural Stormwater Controls**	17-18	**1. Priority Development Project Structural BMP Performance Requirements** **2. BMP Design Manual Update** **3. Priority Development Project BMP Implementation and Oversight**	96-107	Represented by Impervious Acre Credit system	
GSI (LID) best management practices specifically	Fact Sheet—**Low Impact Development Code-Related Requirements (**"…local development-related codes … to require LID in order to make it the preferred and commonly used approach.")	14, 17, 29, 30; Fact Sheet 32-33, 42	**Low Impact Development (LID) BMP Requirements**	93-94	Represented by Impervious Acre Credit system	
Illicit discharge detection and elimination	**Illicit Connections and Illicit Discharges Detection and Elimination**	21-24	**Illicit Discharge Detection and Elimination**	84-92	**Illicit Discharge Detection and Elimination**	5-6

Program Component	Western Washington Phase I Permit		San Diego Regional Permit		Maryland Permits[a]	
	Title (Notes)	Page Location	**Title** (Notes)		**Title** (Notes)	Page Location
Operation and maintenance	**Operation and Maintenance Program**	24-28	**BMP Operation and Maintenance**	114-115	**Property Management and Maintenance**	6-8
Public education	**Education and Outreach Program**	28-31	**Public Education**	122-123	**Public Education**	8-9
Monitoring—general requirements	No specific section		**Water Quality Improvement Monitoring and Assessment Program**	37-40	**Assessment of Controls**	13
Receiving water monitoring	**Regional Status and Trends Monitoring**	44-45	**Receiving Water Monitoring Requirements**	47-59	**1. BMP Effectiveness Monitoring** **2. Watershed Assessment Monitoring**	13-16 16
Program effectiveness monitoring	**Stormwater Management Program Effectiveness and Source Identification Studies**	45-46	**Special Studies**	72-81		
Discharge monitoring	**Stormwater Discharge Monitoring**	46-47; Appendix 9 pp. 1-12	**MS4 Outfall Discharge Monitoring Requirements**	59-71	No specific coverage	
TMDL compliance	**Compliance with Total Maximum Daily Load Requirements**	43-44; Appendix 2 pp. 1-44 for specific water body TMDLs	**Attachment E—** **Specific Provisions for Total Maximum Daily Loads**	E-1 to E-58	**1. Countywide TMDL Stormwater Implementation Plan** **2. Appendix A. EPA Approved Total Maximum Daily Loads (TMDLs)** **Montgomery County**	11-13 A-1 to A-4
Climate change	Fact Sheet—**Climate Change**	Fact Sheet 24	No coverage		No coverage but climate resiliency mentioned in three places in Fact Sheet	
Antidegradation	Fact Sheet—**Antidegradation**	Fact Sheet 30-33	**Antidegradation Policy**	F-29 to F-32	No coverage	
Adaptive management	**Adaptive Management Response**	5-6; Appendix 13 pp. 1-7	**Iterative Approach and Adaptive Management Process**	38-40	No coverage	
Enforcement	No specific section but aspects of the subject covered in 16 passages		**1. Legal Authority Establishment and Enforcement** **2. Enforcement Response Plans**	83-84 120-122	**Enforcement and Penalties**	20-23

[a] Anne Arundel County, Baltimore City, Baltimore County, and Montgomery County MS4 permits. Page references are to the Montgomery County permit and may differ slightly in the other two permits.

APPENDIX D

Expert Report of Dr. Richard Horner

ASSESSMENT OF

MARYLAND'S DRAFT MUNICIPAL SEPARATE STORM SEWER SYSTEM DISCHARGE PERMITS

AND

ACCOUNTING FOR STORMWATER WASTELOAD ALLOCATIONS AND IMPERVIOUS ACRES TREATED

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January 21, 2021

INTRODUCTION

I was requested by Chesapeake Legal Alliance to review Maryland's draft Municipal Separate Storm Sewer (MS4) Discharge Permits (the Maryland Permits or the Permits),[1] issued in 2020, and the guidance document Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (the Accounting Guidance), dated June 2020. I was asked to prepare a written report providing my assessment of the adequacy of the Permits and Accounting Guidance with respect to protecting and recovering the Chesapeake Bay ecosystem, which I present herein.

In assessing the documents, I applied the experience of my 43 years of work in the stormwater management field and 11 additional years of engineering practice. During this period, I have performed research, taught, and offered consulting services on all aspects of the subject, including investigating the sources of pollutants and other causes of aquatic ecological damage, impacts on organisms in waters receiving urban stormwater drainage, and the full range of methods of avoiding or reducing these impacts. I am very familiar with the content and implementation of MS4 permits in Washington state and California and have given written and verbal testimony on these matters in both states. Attachment A to this report presents a more complete description of my background and experience, and Attachment B contains my full *curriculum vitae*.

SUMMARY OF OPINIONS

The Maryland Permits place less detailed requirements on permittees than MS4 permits with which I have worked, replacing them with a numeric standard, a specified number of impervious acres to be "restored" in each jurisdiction through implementation of best management practices. The standard serves as a surrogate for direct water quality improvement objectives. In these circumstances the surrogate on which the Permits heavily rely must be very solid to succeed in protecting and recovering the Chesapeake Bay ecosystem. In my opinion, the Accounting Guidance and certain aspects of the Permits should be improved in a number of ways to achieve this goal, specifically:

- Taking more of a watershed approach to programming and implementing impervious acre restoration work;
- Placing emphasis first on capturing and <u>retaining</u> runoff to the extent operationally feasible and only secondarily on capturing and <u>treating</u>;
- Requiring a greater capture quantity for full restoration credit, at or very close to 90 percent of the average annual post-development runoff volume.
- Broadening the focus from pollutant mass loading reduction to encompass quantity control;

[1] Issued for Anne Arundel County, Baltimore City, Baltimore County, and Montgomery County.

- Converting to a hierarchical structure, by which a permittee must first analyze the most broadly effective water quality and quantity control BMPs, implement them if feasible, and substitute lesser practices only when infeasibility is objectively and conclusively documented.

- Requiring permittees to justify credit trading allowances by tying them to specific needs that cannot be better met by other measures.

- Stating clear, detailed monitoring program criteria sufficiently representative of a permittee's circumstances and restoration programs to construct a realistic picture of the effectiveness of those programs with defined levels of certainty.

- Along with the recommended monitoring improvements, building in strong course correction provisions through adaptive management, when monitoring demonstrates their need; and

- Begin addressing the prospects for greater stormwater management challenges created by climate change by selecting or tailoring models to perform the needed analyses.

The remainder of this report elaborates on and justifies these opinions.

THE CONTEXT OF THE MARYLAND PERMITS

Comparison of Distinctive MS4 Permit Types

My initial general impression of the draft Maryland Permits was that they are not as detailed or specific in their requirements as permits with which I have been working over the last 10 years. To examine that perception formally and comprehensively, I selected for comparison two MS4 permits from different states applying to jurisdictions of scales similar to the Maryland cases: (1) the permit for Phase I (largest in population) cities and counties in Western Washington state;[2] and (2) the permit applying regionally to all cities, the county, the port, and the airport in the San Diego, California area.[3] I tabulated the elements making up a comprehensive stormwater management program and noted the presence and extent of the coverage of each in the various permits being compared. Chesapeake Legal Alliance presents this table in its comments prepared for this matter.[4]

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[2] Phase I Municipal Stormwater Permit; National Pollutant Discharge Elimination System and State Waste Discharge General Permit for Discharges from Large and Medium Municipal Separate Storm Sewer Systems; State of Washington, Department of Ecology, Olympia, Washington; Issuance Date July 1, 2019 (Western Washington permit).

[3] National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewers Draining the Watersheds within the San Diego Region; California Regional Water Quality Control Board, San Diego Region; last amended November 18, 2015 (San Diego permit).

[4] Letter to Raymond Bahr, Maryland Department of Environment, Water Science Administration, Baltimore, Maryland, January 21, 2021; from David Reed, Co-Executive Director, Chesapeake Legal Alliance, and others; Appendix B.

My examination of the respective permits confirmed my impression of substantial divergence in detail and specificity of requirements between the Maryland Permits on the one hand and the Western Washington and San Diego permits on the other. I particularly observed that the Maryland Permits rely on the impervious acre restoration credit system, introduced in the Permits and extensively amplified in the Accounting Guidance, to cover key elements of the stormwater management program, including virtually all of the requirements applying to implementation of best management practices (BMPs).

The Maryland Permits represent a substantially different approach than the Western Washington and San Diego documents. The latter two obligate the municipal permittees to take extensive actions in source and problem diagnosis; planning; controlling runoff from various land use categories and how BMPs are to be applied in that regard; and discharge, program effectiveness, and receiving water monitoring. These specifications are missing, indirectly implied, or abbreviated when present in the Maryland Permits. The Maryland Permits, instead, replace detailed stipulations in these areas with a numeric standard, a specified number of impervious acres to be "restored" in each jurisdiction through implementation of BMPs selected by the city or county of variable credit gauged through work done by expert panels.

Actually, the Western Washington and San Diego permits also incorporate numeric standards. The former permit sets a requirement to amass a minimum number of Structural Stormwater Control (SSC) Program Points over the permit cycle. The SSC program bears resemblance to Maryland's impervious acre restoration credit system in that it assigns points for certain source control and structural BMPs based on area. However, it is broader in involving new development, and not just existing impervious area retrofitted with or without land redevelopment, as in Maryland. Also, the obligation to compile SSC points is just one of four minimum performance measures within the Structural Stormwater Controls element of the permit, with the permit as a whole specifying a total of 44 minimum performance measures, often in considerable detail.

The San Diego permit has two numeric standards: (1) Numeric Goals—measurable criteria or indicators that the co-permittees must develop and incorporate into their Water Quality Improvement Plans; and (2) Action Levels—discharge pollutant concentrations or mass loadings intended to focus runoff management program implementation. Just as in the Western Washington permit, these standards are subsumed within segments of the specified overall comprehensive stormwater management program, which has numerous additional requirements delineated at length.

The above discussion implies criticism of the Maryland Permits for lack of detail and specificity of requirements. While I could recommend many improvements, at this point in history, the Permits carry substantial precedent and institutional presence. Advocating wholesale revision is very likely not to be a fruitful position. In these circumstances the impervious area credit system on which the Permits heavily rely must be very solid to succeed in protecting and recovering the Chesapeake Bay ecosystem. Accordingly, the remainder of this report evaluates that system and contributes recommendations aimed at maximizing its effectiveness in achieving its crucial goal.

Basic Description of the Impervious Area Credit Restoration System

In the words of the Accounting Guidance, "The impervious acre credit is the MS4 permit's surrogate parameter for level of implementation required to show progress in total nitrogen (TN), total phosphorus (TP), and total suspended sediment (TSS) load reductions toward meeting Chesapeake Bay and local TMDLs." The impervious acre credit is determined from three variables: drainage area, impervious area, and the rainfall depth treated. Impervious land is considered to receive 100 percent water quality treatment when the runoff from one inch of rainfall over the drainage area is captured and treated with a BMP included in the 2000 Maryland Stormwater Design Manual (the Design Manual). BMP categories covered in the Design Manual are structural practices and environmental site design (ESD) practices. The categories of structural practices are infiltration, ponds, swales, filtering systems, treatment wetlands, and rainwater harvesting. ESD practices involve direction of runoff where it will not flow into the MS4 or a natural receiving water and alternative surfaces such as green roofs and permeable pavements.

Certain alternative BMPs are also eligible for credit. They include street sweeping, storm drain cleaning, floating treatment wetlands, land cover conversion, urban soil restoration, septic practices, shoreline management, stream restoration, and elimination of discovered nutrient discharges from grey infrastructure. Credit for these BMPs is assigned on the basis of an equivalent impervious acre (EIA), which is determined by multiplying the area to which the alternative BMP is applied by an EIA conversion factor (EIA_f). These conversion factors have been derived for different application levels of the various alternative BMPs in relation to the estimated loading reductions of TN, TP, and TSS that they deliver.

The system offers three ways to gain extra credit: (1) capturing and treating runoff from a depth of rainfall greater than one inch; (2) adding extended-detention storage, above that needed to treat runoff from the one-inch event, to reduce downstream flooding and channel erosion; and (3) using green stormwater infrastructure (GSI) principles employing vegetation and soils. The Accounting Guidance specifies the enhanced BMP features necessary to acquire GSI credit. Those that comply receive 35 percent extra credit.

Another means of obtaining credit is through credit trading under the Maryland Water Quality Trading Program (WQTP). In order to use nutrient credits acquired through the WQTP to meet the MS4 Permit impervious acre restoration requirements, the impervious acres must be translated into WQTP credits. This is a two-step process, where the impervious acres are first translated into edge-of-stream (EOS) load reductions and then the load reductions are converted into WQTP credits. The translation of the impervious acres into TN, TP, and TSS load reductions follows the same method used to account for alternative practices through an EIA_f. The translation results in credit for restoring an impervious acre can be met through the WQTP by acquiring 18.08 lbs of TN (EOS), 2.23 lbs of TP (EOS), and 8,046 lbs of TSS (EOS). Because a WQTP credit is defined as a pound of TN, TP, or TSS delivered to Chesapeake Bay, referred to as edge-of-tide (EOT), the EOS load must be converted to an EOT load using jurisdiction-based conversion factors.

MS4 permittees sum the impervious acre credits derived from all of the BMPs they have selected, plus any traded credits, for comparison with the total number of impervious acres to be restored as specified by their Permits. The Permits designate benchmark schedules varying slightly among the four jurisdictions.

ASSESSMENT OF THE ACCOUNTING GUIDANCE

Assessment Scope

This assessment concentrates on the Accounting Guidance. However, evaluating that document cannot be divorced from certain considerations falling within the Permits, for which the Accounting Guidance serves as the principal operational vehicle. It is thus necessary to weigh how the Permits and the accounting system interact to achieve resource protection and recovery benefits. In my assessment I reached opinions that some elements of the Accounting Guidance fall short in supporting the objectives of the Permits and, likewise that certain provisions of the Permits are inadequate to make the best use of the accounting system. In those instances, I offer recommendations for improvement.

In performing the assessment, I was particularly concerned with several key issues, which I take up in the following sections of this report:

- Lack of a strong watershed focus;
- Emphasis on capture and treat (as opposed to other possible bases);
- Rainfall depth to be captured and treated (to receive full credit);
- Heavy focus on pollutant mass loading;
- Heavy focus on three pollutants;
- Lack of differentiation among BMP options (as opposed to emphasis on superior choices);
- Credit trading system;
- Permit monitoring provisions (and their sufficiency for determining the water quality and ecological outcomes of restoring impervious area);
- Adequacy of course corrections (for application if improved outcomes do not result); and
- Implications of climate change.

Other issues arose in my mind but did not enter into the assessment. One is the extent and quality of backing for the impervious area targets set in the Permits. I understand that this issue has a long history, including examination through litigation. I consider it to be beyond my scope to reopen. Furthermore, I did not revisit any products or recommendations of the expert panels, which represent an extensive body of work. This work supplies detail for performing the accounting but does not define its fundamental structure, which I interpret to be my essential scope. I believe that robust monitoring to ascertain water quality and ecological trends and solid means of course correction are the best tools to examine and, if necessary, rectify these central aspects of the functional system comprising the Permits and the Accounting Guidance. I comment extensively on the subjects of monitoring and course correction later.

Lack of a Strong Watershed Focus

The Maryland Permits specify the number of impervious acres to be restored for each permittee as a whole, without any consideration of where in the jurisdiction restoration work should be done. Benefits to be realized for this kind of work are not, in general, equal regardless of where it occurs. Some waters receiving stormwater discharges are already more degraded, or are more vulnerable to further deterioration, than others. Some tributaries to Chesapeake Bay have a greater potential to deliver pollutants to the Bay than others. One factor is proximity to the Bay, with a shorter flow distance and less opportunity for recapture of pollutants in transport. Another is a relatively greater tendency of some tributary stream reaches to erode, owing, for example, to greater slope and/or more erosive bed and bank material. These streams release more sediments and nutrients for transport onward to the Bay than less erosive reaches.

The Accounting Guidance does not recognize these possible issues. A remedy for that deficiency is taking more of a watershed, or even sub-watershed, approach to programming and implementing restoration work. A start would be to require permittees to assess their major watersheds tributary to the Bay for their condition (*e.g.*, stable, deteriorating at some rate, highly degraded) and potential to mobilize the key pollutants. In many cases an assessment would likely indicate differing conditions and pollutant mobilization potential around the watershed. In those situations, the assessment should direct attention to sub-watersheds.

As I comment again in subsequent passages in this report, I believe that the Accounting Guidance pays too little attention to the important negative impacts of elevated stormwater runoff peak flow rates and volumes. These impacts are manifest in the tributary streams. Part of addressing them would be to build more of a watershed focus into the Accounting Guidance, and it should be modified to do so.

Emphasis on Capture and Treat

The phrase "capture and treat" is at the heart of the Accounting Guidance, which states on page 1, "Impervious acres in the drainage area are considered treated 100% for water quality when the runoff from one inch of rainfall over the drainage area is captured and <u>treated</u> [emphasis added]." In my opinion and experience, emphasis should first be placed on capturing and <u>retaining</u> runoff to the extent operationally feasible and should be the basis for the definition of "maximum extent practicable" (MEP).

Runoff retention means preventing stormwater containing pollutants from discharging off-site to surface water, either directly or via the MS4. Full retention is obviously 100 percent effective in preventing the discharge of all pollutants to surface waters and also averting increased runoff volumes and peak flow rates that cause flooding and erode stream channels. The principle is to retain as much runoff as possible, gaining the complete pollutant and flow attenuation benefit for at least a portion of the runoff, and to treat any remnant to reduce pollutants that do discharge. Treatment alone is never 100 percent efficient in pollutant reduction, and a strictly treatment BMP provides no quantity control.

There are three ways to retain runoff to prevent its surface discharge: (1) harvest it for a water supply use, (2) infiltrate it to the ground to percolate down to groundwater, and (3) expose it to the atmosphere until it evaporates. Infiltrative BMPs actually dissipate runoff partially through evaporation, especially when they incorporate relatively large vegetation forms, having the capability to intercept incident precipitation and store water in tissue until it transpires to the atmosphere.

The Accounting Guidance nowhere introduces the general concept of runoff retention. While it does list retentive BMPs as possible selections (*e.g.*, harvesting and various kinds of infiltration and bioretention), it does not place them in a priority position, to be evaluated first and used to the maximum possible extent. It thus misses the opportunity to maximize decrease of pollutant concentrations and loadings and runoff volumes and peak flow rates.

The Accounting Guidance should be modified to create a hierarchy of BMP options with the most effective, specifically the retentive alternatives, designated as the highest priorities and the standard for MEP. They prevent the discharge to surface receiving water of all contaminants, including the difficult-to-capture key nitrogen and phosphorus target pollutants, in the volume of water retained. I examine this subject further below under the topic Lack of Differentiation among BMP Options.

Rainfall Depth to be Captured and Treated

The Accounting Guidance gives full credit for capturing and treating the runoff from one inch of rainfall over the catchment area. I found through an investigation of various alternatives[5] that the one-inch criterion is not the most protective standard that could be reasonably applied, as I now explain.

The investigation examined the ability of low-impact development (LID) BMPs (also known as green stormwater infrastructure, GSI) to meet five potential regulatory standards: (1 and 2) retain the runoff generated by the 85th or 95th percentile, 24-hour precipitation events; (3) retain 90 percent of the post-development runoff; and (4 and 5) retain the difference between the post- and pre-development runoff, both with and without a cap at the 85th percentile, 24-hour event. The study assessed five urban land use types (three residential, one retail commercial, and one infill redevelopment), each placed in four climate regions in the continental United States on two regionally common soil types. Mathematical modeling was employed to estimate runoff

[5] Horner, R.R. and J. Gretz. 2011. Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices Applied to Meet Various Potential Stormwater Runoff Regulatory Standards. Report to U.S. Environmental Protection Agency, Washington, D.C. by Natural Resources Defense Council, Santa Monica, California.

retention and pollutant loading reduction afforded by the LID BMPs and the extent to which they could meet each potential standard.

Standard 3 (retain 90 percent of the average annual post-development runoff volume) proved to be the most environmentally protective standard. Meeting or coming as close as possible to meeting, but not exceeding, this standard was estimated to lead to 66-90 percent of total runoff retention and pollutant loading reduction on relatively more infiltrative Hydrologic Soil Group B and C soils and 37-66 percent runoff retention on more restrictive D soils. Standard 2 (retain the runoff produced by the 95th percentile, 24-hour precipitation event) came very close to standard 3, yielding equivalent protection on D soils and only slightly less protection with B and C soils.

Two of the climate regions investigated bracket Maryland's location. The 95th percentile, 24-hour events at the sites selected to represent the Southeastern and Northeastern United States are 1.79 and 1.72 inch, respectively. It is thus reasonable to assume that approximately 1.75 inch applies to Maryland. Hence, the 1-inch criterion for full credit under the Accounting Guidance is far less protective than the alternative. It is close, but still lower, than the less protective 85th percentile, 24-hour standard, which I estimate to be approximately 1.1 inch for Maryland (between the 1.13 for the Southeast and 1.07 for the Northeast).

As I noted, retaining 90 percent of the average annual post-development runoff volume was found to be very close in performance to the 95th percentile, 24-hour standard. The standard in Western Washington state is essentially equivalent to those options: "Using an approved continuous runoff model, the Water Quality Design Volume shall be the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91% of the entire runoff volume over a multi-decade period of record."[6] This standard has prevailed for many years, signifying its feasibility for use in a regulatory context.

The Accounting Guidance should be modified to require a greater capture quantity for full credit. The standard should be specified to result in capture and retention (or treatment when full retention is operationally infeasible) of a quantity at or very close to 90 percent of the average annual post-development runoff volume.

<u>Heavy Focus on Pollutant Mass Loading</u>

I already commented above that the Accounting Guidance's emphasis on capture and treat ignores the direct impacts of elevated runoff quantities on stream channels. Increased peak flow rates, durations of high flows, and overall volumes raise instantaneous and extended shear stresses on stream banks and beds. The resulting erosion widens and deepens the channel; mobilizes sediments, adding to the TSS and its associated multiple negative physical and biological effects; introduces nutrients transported by the sediments; undermines riparian vegetation; and destroys water column, benthic, and overhanging vegetation habitats.

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[6] Washington Department of Ecology. 2019. Stormwater Management Manual for Western Washington. Washington Department of Ecology, Olympia, Washington (Minimum Requirement 6).

Inattention to these hydrology-based impacts short-changes the tributary creeks and rivers integral to the overall Chesapeake Bay ecosystem. Sediment transport resulting from channel erosion, and the nitrogen and phosphorus carried with it, is not accounted for in the Accounting Guidance but surely is a factor in the loading of these contaminants to the Bay itself. Stream biological integrity has been directly linked to hydrologic "flashiness;" i.e., the frequency and rapidity of short-term changes in stream flow, especially during runoff events. Flashiness can be expressed in a number of ways. One productive measure used in research in which I participated was the ratio of the 2-year frequency peak flow rate to the winter (October 1-April 30) base flow rate (Horner et al. 1997).[7] The highest biological integrity, > 90 percent of maximum possible benthic index of biotic integrity (B-IBI) was possible only if the ratio remained below 10. Ratios above 30 were associated with invertebrate communities exhibiting indices half or less of the maximum B-IBI. The Accounting Guidance should be supplemented with provisions aimed at runoff quantity control to avoid or minimize these demonstrated hydrologic impacts.

As I have already pointed out, changing the emphasis from treatment to retention would partially accomplish quantity control. However, standards governing the application of quantity control BMPs also must be promulgated. Some of the considerations that apply to devising standards are how existing development, new development, and redevelopment are treated; how different stream reaches are treated; the point in time serving as the basis for hydrologic recovery; and the specific hydrologic requirements. These are somewhat complex matters to decide in relation to a region's historic, physiographic, and biological circumstances, an endeavor that is beyond my scope. I will limit my comments to my general point that the Permits and Accounting Guidance should broaden the focus from pollutant mass loading reduction to encompass quantity control and to offer two examples from elsewhere covering specific hydrologic requirements.

Approaches to the considerations listed above have differed substantially among jurisdictions. As one example of hydrologic targets applying to discharges from parcels undergoing development, the Western Washington specification is:[8] "Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. The pre-developed condition to be matched shall be a forested land cover unless …" [certain historic conditions specified in the referenced document apply]. For a second example, the San Diego MS4 permit specifies:[9] "Post-project runoff conditions (flow rates and durations) must not exceed pre-development runoff conditions by more than 10 percent (for the range of flows that result in increased potential for erosion, or degraded instream habitat downstream of Priority Development Projects)."

<u>Heavy Focus on Three Pollutants</u>

The Accounting Guidance is structured around reducing the mass loading discharge of nitrogen, phosphorus, and TSS. I recognize and acknowledge that these are the three pollutants

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[7] Horner, R.R., D.B. Booth, A. Azous, and C.W. May. 1997. Watershed Determinants of Ecosystem Functioning. *In* L.A. Roesner (ed.), *Effects of Watershed Development and Management on Aquatic Ecosystems*, American Society of Civil Engineers, New York, NY, pp. 251-274.

[8] Washington Department of Ecology, *Ibid*. (Minimum Requirement 7).

[9] San Diego permit, section E.3.c(2).

most responsible for the degraded Chesapeake Bay water quality and ecological health. In evaluating this focus, I considered what other problems may exist in the overall ecosystem, incorporating the Bay's tributaries too, and if targeting these three contaminants distorts management strategies such that other pollutants are not mitigated.

While the three pollutants account for the majority of the total maximum daily loads (TMDLs) adopted in the region, there are others, listed in Appendix A of each of the Maryland Permits and summarized in Table 1. The most common other TMDL pollutants are bacterial measures, followed by PCBs.

Table 1. TMDLs Approved in Four Maryland MS4 Permittee Jurisdictions

Pollutant	Anne Arundel County	Baltimore City	Baltimore County	Montgomery County
Escherichia coli	X	X	X	X
Enterococcus	X			X
Fecal coliforms	X			
Polychlorobiphenyls (PCBs)	X	X	X	X
Trash		X	X	X
Biochemical oxygen demand (BOD)				X

Blue Water Baltimore publishes an annual water quality report card. The 2020 edition[10] reported significantly improving trends in bacteria at 34 of 49 monitoring stations. Most of the bacteria improvements were seen in streams during dry weather and were attributed to sewer replacement and relining projects and mitigation of illegal sewer connections and leaking pipes. Only three stations showed significantly improving bacteria trends during wet weather. The latter result indicates that stormwater management efforts are not very effective for bacteria, at least in the Baltimore area and very likely elsewhere too. It strongly suggests that the Permits and Accounting Guidance should add focus on bacteria, at a minimum among the many pollutants transported by stormwater.

The Blue Water Baltimore 2020 report noted some improvement in phosphorus compared to previous years. Nitrogen water quality, however, continued to rate as very poor at the majority of stations.[11]

The treatment mechanisms operating in stormwater BMPs, in general, do not focus on any one individual or class of pollutants. For example, if they remove TSS effectively, they also capture many pollutants that are predominantly in the solid state. PCBs are among those pollutants. However, substantial quantities of nitrogen and phosphorus are typically in the dissolved state and are not as readily removed from the flow. While some bacteria are captured with the solids, as living organisms they have complex behavior, tend to reemerge, and are among the most difficult pollutants to treat with conventional stormwater BMPs. The prominence of nitrogen, phosphorus, and bacteria, along with TSS, as the major target pollutants

[10] https://bluewaterbaltimore.org/blog/2020-water-quality-report-card-is-here (last accessed December 31, 2020).
[11] https://baltimorewaterwatch.org/report-card (last accessed December 30, 2020).

under the Maryland Permits builds the argument for altering the emphasis in the Accounting Guidance from treating runoff to retaining it to the extent operationally feasible. All pollutants in retained runoff, including the most difficult to treat, are mitigated 100 percent.

<u>Lack of Differentiation among BMP Options</u>

The Accounting Guidance does not encourage the selection of any BMP over any other. In this framework, an alternative practice like street sweeping has the same intrinsic value as a Design Manual practice with the best documented effectiveness in water quality and quantity control. While the amount of credit given street sweeping and other alternative practices depends on their degree of application, even with extensive use they have important disadvantages compared to the leading techniques in the stormwater management field. It is possible for a jurisdiction to gain all of its impervious area restoration credit with street sweeping, despite this BMP affording no water quantity control and less well-established water quality benefits than many Design Manual practices.

Likewise, the Accounting Guidance gives no priority to the most beneficial retentive practices that I have already discussed, except for a 35 percent extra credit factor for GSI. This system, for example, allows the same credit for a bioretention cell with an impermeable liner and underdrain to a surface discharge as for open-bottom, fully infiltrating bioretention. The former device only fractionally reduces the runoff quantity and always still discharges pollutants to surface waters, while the latter completely attenuates both.

I believe that the Accounting Guidance should convert to a hierarchical structure, by which a permittee must first analyze the most broadly effective water quality and quantity control BMPs for their practicable operability, implement them if they are found to be feasible, and substitute lesser practices only when infeasibility is objectively and conclusively documented. The Permits should task the jurisdictions with incorporating this documentation process into their development reviews.

Exhibit 1, located following the text of this report, illustrates the concept. I adapted the exhibit from a procedure I use in assessing sites in the Pacific Northwest for practices protective of salmon-bearing waters. It presents as a primary objective implementation of retentive GSI practices, with documentation required when they are judged to be infeasible. In that case it states alternative water quality and quantity control objectives based on utilizing GSI retention techniques to the maximum possible extent and supplementing them with conventional practices to complete compliance obligations. I believe that this procedure offers an environmentally protective and a reasonable and achievable MEP foundation.

<u>Credit Trading System</u>

While the Maryland Water Quality Trading Program does not limit the source of credits, I understand that most credits assimilated into satisfying MS4 permit impervious area restoration requirements have come from municipal wastewater treatment plants (WWTPs). In my opinion, this process does not necessarily target benefits properly. WWTPs, especially relatively large ones, generally discharge to the ultimate receiving water (*i.e.*, an arm of Chesapeake Bay) or a major tributary. This placement does not relate to needs on smaller tributaries, and not at all to quantity control demands. This is another example, of several I have presented, that the Maryland Permits and Accounting Guidance stint on tributary protection and on mitigating hydrologic damage.

It is my opinion that the Accounting Guidance should be modified to put guardrails around the credit trading program as it applies to MS4 permittees. As I commented above, I believe that the Maryland Permits and the Accounting Guidance should take more of watershed approach than they do. That philosophy should be carried into credit trading allowances. They should be tied to specific needs and should not substitute for measures that could serve those needs better. Not all needs are in the waters to which WWTPs discharge. Permittees should have to justify credits for which they have traded in relation to a problem the credits solve. A serious, unaddressed problem should not be allowed to continue while traded credits contribute to the overall impervious area restoration target in the service of a lesser or no particular objective.

In addition to often being out of place spatially, WWTP credits can be misplaced temporally. Credit can be taken for WWTP pollutant reductions achieved some time in the past, whereas further decreases are still needed and should be gained through actions concurrent in time with the needs.

Permit Monitoring Provisions

Summary of the Provisions

As the Accounting Guidance admits, impervious acre restoration credit is a surrogate for a demonstration of pollutant loading reduction. While the proxy has been numerically associated with loading reductions through work of the expert panels, knowing the actual effectiveness of restoration requires well-designed monitoring programs. The Maryland Permits require each permittee to pay into two regional pooled monitoring programs and, within their jurisdiction, to conduct: "Monitoring activities … where the cumulative effects of watershed restoration activities, performed in compliance with this permit, can be assessed." Specifically required within one stream in each jurisdiction is:

- Analysis of 12 storm event samples and four (quarterly) baseflow samples;
- Benthic macroinvertebrate sampling;
- Annual geomorphologic stream assessment;
- A one-time modeling exercise to examine hydrological effects on channel geometry;
- Trend monitoring for biological and habitat variables, bacteria, and chloride; and
- PCB source tracking.

Data are to be used to estimate annual and seasonal pollutant loads and reductions, among other purposes.

This monitoring plan could set a relatively good basis for evaluating surrogate effectiveness, if it actually represents the¸ "… cumulative effects of watershed restoration activities …" However, it is doubtful that the coverage is sufficient, with just one stream per jurisdiction, to demonstrate comprehensively the performance of the impervious area restoration endeavors.

Assessment of an Example Monitoring Program

To examine the conjecture that the limited monitoring prescribed by the Maryland Permits is insufficient, I selected Montgomery County (the County) and consulted its Annual Reports under the MS4 permit for fiscal years 2014-2019. To gauge the performance of its impervious area restoration projects, the County monitors the Breewood tributary, a 1,200-foot first order stream in a 63-acre catchment having 42 percent impervious area (26.5 acres).

Based on the 2019 fiscal year Annual Report, the County has finished 10 right-of-way Environmental Site Design (ESD) practices[12] along residential roads and three RainScapes projects[13] on individual residential properties in the Breewood catchment. County-wide, as of December 28, 2018, impervious acres restored since 2010 totaled 3,778.9. The most that could be in the Breewood subwatershed is 26.5 acres, only 0.7 percent of the total. The types of projects County-wide are Green Streets, Public Property BMPs (including ESD projects), Stormwater Pond Retrofits, Stream Restoration Projects, Community-based Restoration Watershed Grants, RainScapes, and Alternative BMPs (removing impervious surfaces, connecting septic systems to wastewater treatment plants, cleaning catch basins and storm drains, sweeping streets. urban Tree Canopy Expansion and Urban Reforestation projects). I certainly do not regard the Breewood monitoring program, covering only two project types and a tiny fraction of the total restoration program, to be representative of the cumulative effects of watershed restoration activities.

I next examined the results of the Breewood monitoring. Figures 1-4 graph the nutrient and TSS data over the most recent six fiscal years. The plots show that each water quality variable increased for the first three years, then declined for two, followed by large gains in the latest year, when the restoration projects were most advanced. Biologically, Figure III.H.4 in each Annual Report depicts the B-IBI scores returning to the top of the "poor" region in 2017 and 2018 after a one-time ascent to "fair" in 2016, after stream restoration. The fiscal year 2019 Annual Report remarked that change in land use from agricultural to residential has caused instability (erosion) in the stream channel. These results give no encouragement that impervious

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[12] Environmental Site Design (ESD) is a design strategy for maintaining pre-development runoff characteristics and protecting natural resources. ESD stormwater facilities integrate site design, natural hydrology, and smaller controls to capture and treat runoff. These practices include microbioretention, rain gardens, permeable pavement, and green roofs.

[13] The RainScapes program promotes environmentally-friendly landscaping and small-scale stormwater management projects on residential, institutional, and commercial properties and offers technical and financial assistance.

acre restoration projects in Montgomery County are yielding improvements in water quality, biology, or stream habitat conditions and sediment production.

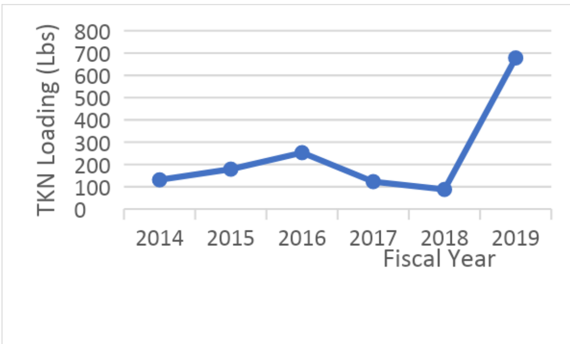

Figure 1. Total Kjeldahl Nitrogen Loading in Breewood Tributary over Six Years

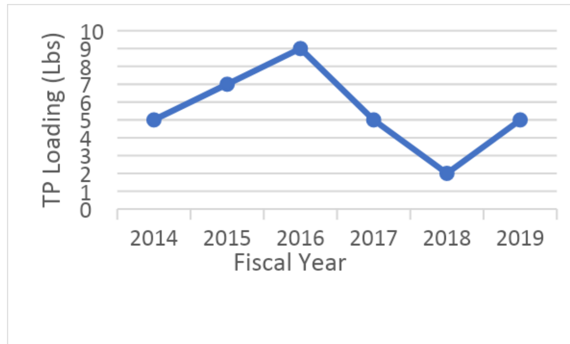

Figure 2. Total Phosphorus Loading in Breewood Tributary over Six Years

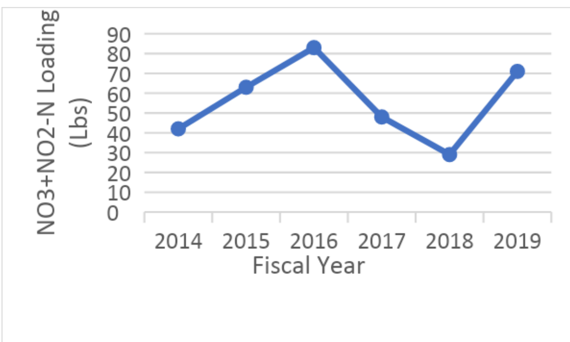

Figure 3. Nitrate+Nitrite-Nitrogen Loading in Breewood Tributary over Six Years

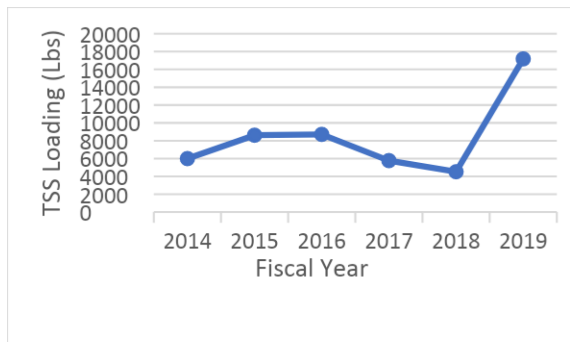

Figure 4. Total Suspended Solids Loading in Breewood Tributary over Six Years

The corrective to this unsatisfactory situation lies within the Maryland Permits. The chief flaw to be rectified is the lack of representativeness. The Permits should state clear, detailed criteria for the attributes of a monitoring program sufficiently representative of the jurisdictions' natural and developed environments and their restoration programs to construct a realistic picture of the effectiveness of those programs with defined levels of certainty. Among those criteria must be adequate coverage of the problems and their sources and the breadth and depth of the BMPs applied to solve them. Inevitably in my opinion, a truly representative monitoring program must involve much more than 0.7 percent of the watershed area of an entire county.

The broader question is, What is the effect of the collective restoration programs among all jurisdictions draining to Chesapeake Bay on water quality and biological resources in the Bay? The answer to that question involves far more than stormwater programs, of course, and presumably is intended to be supplied by the pooled regional monitoring programs. I regard this issue to be beyond my scope from the standpoint of assessing monitoring activities. However, I consider it in my next discussion, in which I examine adapting MS4 programs in relation to progress toward achieving protection and restoration goals.

Adequacy of Course Corrections

The Maryland Permits do not have a well-developed mechanism to respond if outcomes do not result in improvement in water quality and ecological integrity in the Chesapeake Bay ecosystem. The Accounting Guidance does not address the topic at all. The Permits contain only two references to the subject:

> Section D. "… these [management] programs shall be integrated with other permit requirements to promote a comprehensive adaptive [emphasis added] approach toward solving water quality problems."
>
> Section E.2. "Benchmark" as used in this permit is a quantifiable goal or target to be used to assess progress toward the impervious acre restoration requirement or WLAs [waste load allocations], such as a numeric goal for stormwater control measure implementation. If a benchmark is not met, the County should take appropriate corrective action to improve progress toward meeting permit objectives. Benchmarks are intended as an adaptive [emphasis added] management aid …"

In the Maryland system, there is no tie between monitoring and how to react to results. Of course, as I demonstrated in my preceding section, monitoring is inadequate to show whether or not the impervious acre restoration programs are achieving progress. Along with the recommended monitoring improvements, Maryland should build in strong course correction provisions through adaptive management, when monitoring demonstrates their need.

Adaptive management promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. This definition was taken from Adaptive Management, the U.S. Department of the Interior Technical Guide,[14] which lays out a nine-step process to conduct a rigorous adaptive management program involving stakeholders, management objectives, management alternatives, predictive models, monitoring plans, decision making, monitoring responses to management, assessment, and adjustment to management actions. The connection between monitoring and steadily improving management decisions is especially acute. Both the Western Washington and San Diego MS4 permits have adaptive management sections clearly tying monitoring to decision making, and Maryland should follow suit.

The Chesapeake Bay Program's website reports that The Bay Program is moving toward using adaptive management to coordinate the partnership's activities at all organizational levels.[15] There is no evidence in the Maryland Permits and Accounting Guidance that they are integrated into this program, but they should be adjusted immediately to become involved.

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[14] Williams, B.K., R,C. Szaro, and C. D. Shapiro. 2009. Adaptive Management, the U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. https://www.doi.gov/sites/doi.gov/files/migrated/ppa/upload/TechGuide.pdf (last accessed January 4, 2021).

[15] https://www.chesapeakebay.net/what/adaptive_management (last accessed January 4, 2021).

Implications of Climate Change

The Maryland Permits and Accounting Guidance give no attention at all to the implications of climate change for stormwater management. Climate changes, including more frequent and intense storms and more extreme flooding events, would increase stormwater runoff, which could exacerbate existing, or introduce new, pollution problems. While these potential alterations are expected to vary regionally and are not defined with precision for any region, the Northeastern United States, including Maryland, has already experienced more frequent heavy precipitation events in recent decades than any other part of the nation (after Melillo et al., 2014; as reported by the U.S. Environmental Protection Agency, 2016).[16] The Maryland Permits should immediately begin addressing the prospects for greater stormwater management challenges.

The Western Washington permit can provide a model to begin the recommended effort. The state environmental agency is funding a county-led study, working with a university climate impacts group, to downscale global climate models to align with the permittees' scale. The findings will be analyzed and used as the basis for policies and regulations moving forward. The continuous hydrologic modeling that is the foundation of stormwater management regulation in Western Washington already implicitly considers climate change. Continuous modeling is based on the historic rainfall record, which is updated with each permit cycle. Thus, the model adjusts to the extent that the most recent rainfall records reflect the changing climate.

[16] Melillo, J.M., T.C.Richmond, G.W. Yohe; Eds. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. National Climate Assessment, U.S. Global Change Research Program, Washington, DC. Available at http://nca2014.globalchange.gov.
U.S. Environmental Protection Agency. 2016. Stormwater Management in Response to ClimateChange Impacts: Lessons from the ChesapeakeBay and Great Lakes Regions, EPA/600/R-15/087F. Office of Research and Development, National Center for Environmental Assessment, Washington, DC.

EXHIBIT 1: BEST MANAGEMENT PRACTICES HIERARCHY

Objectives

1. Prime Objective—Implement green stormwater infrastructure (GSI) practices, especially runoff retention[17] methods, addressing both water quantity and water quality control to the maximum extent operationally feasible.[18] Provide documentation of how the objective will be achieved. If full achievement of the goal is operationally infeasible, assemble documentation demonstrating why it is not and proceed to consider Alternative Objectives 2A and/or 2B, as appropriate to the site.

2. Alternative Objectives—Assess if achieving the Prime Objective is documented to be operationally infeasible.

   2A. Alternative water quantity control objective when the site discharges to a stream or combined sanitary-storm sewer—Start with the GSI practices identified in the assessment pursuant to Objective 1. To the extent that they cannot prevent the generation of stormwater runoff peak flow rates and volumes greater than in the specified conditions,[19] implement effective alternative measures to diminish and/or slow the release of runoff to the maximum extent operationally feasible, with the minimum objective of complying with the regulatory requirements for water quantity control applying to the location. If the site is exempt from a standard flow control requirement, the minimum objective is to reduce the quantity discharged below the amount released in the immediately preceding condition.[3]

   2B. Alternative water quality control objective when the site discharges to a stream or other water body or a separate storm sewer leading to a water body—Start with the GSI practices identified in the assessment pursuant to Objective 1. To the extent that they cannot prevent the generation of stormwater runoff containing pollutants, implement alternative effective measures to reduce contaminants in stormwater to the maximum extent operationally feasible, with the minimum objective of complying with the regulatory requirements for water quality control applying to the location.

Green Stormwater Infrastructure Practices—GSI practices are systematic methods intended to reduce the quantity of stormwater runoff produced and improve the quality of the remaining runoff by controlling pollutants at their sources, collecting precipitation and putting it to a beneficial use, and utilizing or mimicking the hydrologic functioning of natural vegetation and

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[17] Retention means keeping runoff from flowing off the site on the surface by preventing its generation in the first place, capturing it for a water supply purpose, releasing it via infiltration to the soil or evapotranspiration to the atmosphere, or some combination of these mechanisms.

[18] The Prime Objective addresses all surfaces within the parcel, including those sometimes labeled "non-pollutant generating surfaces" like roofs. Being impervious surfaces in urban areas, roofs collect contaminants, even if only from atmospheric deposition, that add to the site pollutant loadings. If achieving the prime objective is documented to be operationally infeasible and an Alternative Objective is pursued, surfaces with higher pollutant generation potential would take precedence in developing a management strategy.

[19] As determined through hydrologic modeling of the preliminary and modified conditions.

soil in designing drainage systems.

- Harvesting precipitation and putting it to a use such as irrigation, toilet flushing, vehicle or surface washing, industrial water supply, or cooling system make-up water.

- Constructing low-traffic areas with permeable pavements such as porous asphalt, open-graded Portland cement concrete, coarse granular materials, concrete or plastic unit pavers, and plastic grid systems (areas particularly suited for permeable surfaces are low-traffic streets, driveways, walkways and sidewalks, alleys, and overflow or otherwise lightly-used uncovered parking lots not subject to much leaf fall or other deposition).

- Draining runoff from roofs, pavements, other impervious surfaces, and landscaped areas into one or more of the following GSI constructed systems (* signifies with compost-amended soils as needed to maximize soil storage and infiltration):
  - ✔ Infiltration basin;
  - ✔ Bioretention area* (also known as a rain garden);[20]
  - ✔ Planter box*, tree pit* (bioretention areas on a relatively small scale);
  - ✔ Vegetated swale*;
  - ✔ Vegetated filter strip*;
  - ✔ Infiltration trench;
  - ✔ Roof downspout dispersion system;
  - ✔ Green roof.

Alternative Practices—When on-site GSI practices alone cannot achieve Objectives 2A and/or 2B, implement one or more of the following strategies to meet at least the minimum water quantity and quality control objectives stated above:

- <u>For runoff quantity control</u>—Install a pond, vault, or tank[21] to store water for delayed release after storms to help avoid high flows damaging to a stream or contributing to combined sewer overflows.

- <u>For runoff quality control</u>
  - ✔ Treatment pond;
  - ✔ Treatment wetland;
  - ✔ Conventional swale;
  - ✔ Conventional filter strip;
  - ✔ Basic sand filtration;
  - ✔ Advanced treatment system.

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[20] Preferably with an open bottom for the fullest infiltration but with a liner and underdrain if the opportunity for deep infiltration is highly limited or prohibited for some specific reason (*e.g.*, bedrock or seasonal high water table near the surface, very restrictive soil [*e.g.*, clay, silty clay] that cannot be adequately amended to permit effective infiltration, non-remediable contamination below ground in the percolating water pathway).

[21] While useful for runoff quantity control, passive vaults and tanks and ponds not specifically designed for treatment provide very little water quality benefit.

ATTACHMENT A

Background and Experience

RICHARD R. HORNER, PH.D.

I have 54 years of professional experience, 44 teaching and performing research at the college and university level. For the last 43 years I have specialized in research, teaching, and consulting in the area of storm water runoff and surface water management.

I received a Ph.D. in Civil and Environmental Engineering from the University of Washington in 1978, following two Mechanical Engineering degrees from the University of Pennsylvania. Although my degrees are all in engineering, I have had substantial course work and practical experience in aquatic biology and chemistry.

For 12 years beginning in 1981, I was a full-time research professor in the University of Washington's Department of Civil and Environmental Engineering. From 1993 until 2011, I served half time in that position and had adjunct appointments in two additional departments (Landscape Architecture and the College of the Environment's Center for Urban Horticulture). I spent the remainder of my time in private consulting through a sole proprietorship. My appointment became emeritus in late 2011, beyond which I continued university research and teaching at a reduced level while maintaining my consulting practice. My research, teaching, and consulting have embraced all aspects of stormwater management, including determination of pollutant sources; their transport and fate in the environment; physical, chemical, and ecological impacts; and solutions to these problems through better structural and non-structural management practices.

I have conducted numerous research investigations and consulting projects on these subjects. Serving as a principal or co-principal investigator on more than 40 research studies, my work has produced three books, approximately 30 papers in the peer-reviewed literature, and over 20 reviewed papers in conference proceedings. I have also authored or co-authored more than 100 scientific or technical reports.

In addition to graduate and undergraduate teaching, I have taught many continuing education short courses to professionals in practice. My consulting clients include federal, state, and local government agencies; citizens' environmental groups; and private firms that work for these entities, primarily on the West Coast of the United States and Canada but in some instances elsewhere in the nation.

Over a 17-year period beginning in 1986, I spent a major share of my time as the principal investigator on two extended research projects concerning the ecological responses of fresh water resources to urban conditions and the urbanization process. I led an interdisciplinary team for 11 years in studying the effects of human activities on fresh water wetlands of the Puget Sound lowlands. This work led to a comprehensive set of management guidelines to reduce negative effects and a published book detailing the study and its results. The second effort involved an analogous investigation over 10 years of human effects on Puget Sound's salmon spawning and rearing streams. These two research programs have had broad sponsorship, including the U.S. Environmental Protection Agency, the Washington Department of Ecology, and a number of local governments.

I have helped to develop stormwater management programs in Washington State, California, and British Columbia, and studied such programs around the nation. I was one of four principal participants in a U.S. Environmental Protection Agency-sponsored assessment of 32 state, regional, and local programs spread among 14 states in arid, semi-arid, and humid areas of the West and Southwest, as well as the Midwest, Northeast, and Southeast. This evaluation led to the 1997 publication of "Institutional Aspects of Urban Runoff Management: A Guide for Program Development and Implementation" (subtitled "A Comprehensive Review of the Institutional Framework of Successful Urban Runoff Management Programs").

I was a member of the National Academy of Sciences-National Research Council (NAS-NRC) committee on Reducing Stormwater Discharge Contributions to Water Pollution. NAS-NRC committees bring together experts to address broad national issues and give unbiased advice to the federal government. The panel was the first ever to be appointed on the subject of stormwater. Its broad goals were to understand better the links between stormwater discharges and impacts on water resources, to assess the state of the science of stormwater management, and to apply the findings to make policy recommendations to the U.S. Environmental Protection Agency relative to municipal, industrial, and construction stormwater Permitting. The committee issued its final report to the public in October 2008, with a printing date of 2009. My principal but not sole contribution to the report was the chapter presenting the committee's recommendations for broadly revamping the nation's stormwater program.

I have inspected many industrial and other types of facilities to evaluate stormwater management practices and issues related to the environmental impacts of stormwater and to make recommendations on these issues. My work has involved analysis of the sources of stormwater contamination, probable negative effects on receiving waters, stormwater pollution prevention plans intended to manage stormwater to avoid or minimize negative ecological outcomes, existing and potential best management practices, and stormwater monitoring procedures and results. I have substantial familiarity and experience with state Industrial Stormwater Permits regulating all of these aspects of industrial stormwater management.

My experience includes activities concerning industrial stormwater within and outside the litigation framework. I have provided analyses and, in some cases, expert testimony in more than 60 legal cases involving industrial stormwater Permits, over 30 of which have been in Washington. I was appointed as a special master by Judge Christina A. Snyder of the Federal Court for the Central District of California to offer advice on bringing a Los Angeles automobile recycling yard into compliance with the terms of a consent decree entered into with a citizen environmental group. Additionally, I was a member of a panel formed to develop an industry-specific industrial stormwater general Permit (for metal recyclers) under the jurisdiction of the California's Santa Ana Regional Water Quality Control Board. The panel included representation from the industry and its consultants, environmental groups and their consultants, and the Board. The resulting Permit has been in effect for approximately six years and is now in the process of being reissued. Having demonstrated its utility for a full term, it is being considered as a model for stormwater Permits in other California Regional Water Quality Control Boards. I have twice provided analyses and expert testimony in hearings considering appeals of the State of Washington's industrial stormwater Permits.

ATTACHMENT B

Curriculum Vitae

HORNER, Richard Ray

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University of Washington:
Emeritus Research Associate Professor,
Departments of Landscape Architecture and Civil and Environmental Engineering and
Sole Proprietor Consultant

EDUCATION

1976 - 1978 University of Washington, Seattle, Washington; Ph.D. (Civil Engineering)

1965 - 1966 University of Pennsylvania, Philadelphia, Pennsylvania; M.S. (Mechanical Engineering)

1961 - 1965 University of Pennsylvania, Philadelphia, Pennsylvania; B.S. *Cum Laude* (Mechanical Engineering)

HONORS AND AWARDS

Augustus Trask Ashton Scholarship, University of Pennsylvania, 1961 - 65
Annual Academic Honors, University of Pennsylvania, 1961 - 65
Tau Beta Pi National Engineering Honor Society
National Science Foundation Traineeship, University of Pennsylvania, 1965 - 66

EMPLOYMENT

1986 - Present Richard R. Horner, Sole Proprietor (offering services in environmental engineering and science)

2011 - Present University of Washington, Seattle, Washington
Emeritus Research Associate Professor

1981 - 2011 University of Washington, Seattle, Washington
Research Associate Professor

1986 - 1990 King County, Seattle, Washington
Coordinator of Puget Sound Wetland and Stormwater Management Research Program (part-time; continued under contract to University of Washington)

1969 - 1981 Northampton Community College, Bethlehem, Pennsylvania
Engineering Department (Coordinator, 1971 - 73 and 1978 - 79)

	Environmental Studies Department (Co-coordinator, 1973 - 76 and 1978 - 1981) Professor, 1978 - 1981; Associate Professor, 1973 - 78; Assistant Professor, 1969 - 73, Leave of Absence, 1977 - 78; Sabbatical Leave, 1976 - 77
1977 - 1978	University of Washington, Seattle, Washington Department of Civil Engineering Research Engineer, Highway Runoff Water Quality Project
1976 - 1977	University of Washington, Seattle, Washington Department of Civil Engineering and Institute for Environmental Studies Research Assistant and Teaching Assistant
1966 - 1969	Exxon Research and Engineering Company, Florham Park, New Jersey; Project Engineer
1965 - 1966	University of Pennsylvania, Philadelphia Pennsylvania Department of Mechanical Engineering; Research Assistant

NATIONAL COMMITTEES

National Academy of Sciences Panel on Reducing Stormwater Discharge Contributions to Water Pollution, 2007-2008.

Technical Advisory Panel for Water Environment Federation projects on Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow Reduction, 2005-2007.

Co-chair, Engineering Foundation Conference on Effects of Watershed Development and Management on Aquatic Ecosystems, 1996.

National Academy of Sciences Panel on Costs of Damage by Highway Ice Control, 1990-91.

U.S. Environmental Protection Agency National Wetland Research Planning Panel, 1988, 1991.

RESEARCH PROJECTS

* Principal Investigator.
** Co-Principal Investigator. (Where undesignated, I was a member of the faculty investigation team without principal investigator status).

Effects of Waterfront Stormwater Solutions Prototypes on Water Quality Runoff in Puget Sound near Pomeroy Park - Manchester Beach; Washington Sea Grant; $148,838; 2015-17.

Development of a Stormwater Retrofit Plan for Water Resources Inventory Area (WRIA) 9 and Estimation of Costs for Retrofitting all Developed Lands of Puget Sound; U.S. Environmental Protection Agency and King County (WA); $243,619; 2010-13.

Ultra-Urban Stormwater Management; Seattle Public Utilities; $1,130,000; 1999-2008.*

Roadside Vegetation Management Study; Washington State Department of Transportation; $50,000; 2004-05.

The Ecological Response of Small Streams to Stormwater and Stormwater Controls; U. S. Environmental Protection Agency, cooperating with Watershed Management Institute (Crawfordsville, FL); $579,117; 1995-2003.*

Vegetated Stormwater Facility Maintenance; Washington State Department of Transportation; $86,000; 1998-2000.*

Roadside Drainage System Management for Water Quality Improvement; King and Snohomish (WA) Counties; $70,000; 1997-2000.*

Standardization of Wet Weather Protocols for Stream Impact and Treatment Technology Performance Assessments; Water Environment Research Foundation, cooperating with Water Research Center (Huntington Valley, Pennsylvania) and University of Illinois; $125,000; 1996-97.

Road Shoulder Treatments for Water Quality Protection; Washington State Department of Transportation and King County Roads Division; $90,000; 1995-96.**

Control of Nuisance Filamentous Algae in Streams by Invertebrate Grazing; National Science Foundation; $193,691; 1994-96.

Criteria for Protection of Urban Stream Ecosystems; Washington Department of Ecology; $230,000; 1994-96.

Region-Specific Time-Scale Toxicity in Aquatic Ecosystems; Water Environment Research Foundation, cooperating with Water Research Center (Huntington Valley, Pennsylvania) and University of Illinois; $670,000; 1994-96.

Establishing Reference Conditions for Freshwater Wetlands Restoration; U. S. Environmental Protection Agency; $75,000; 1993-97.

Stormwater Management Technical Assistance to Local Governments; Washington Department of Ecology; $115,000; 1992-93.*

Center for Urban Water Resources Management; Washington Department of Ecology; $336,490; plus $157,400 matching support from seven local governments; 1990-93.*

University of Washington Cooperative Unit for Wetlands and Water Quality Research; King County, Washington; amount varied by year; 1987-95.*

Assessment of Portage Bay Combined Sewer Overflows; City of Seattle; $132,676; 1990-91.*

Velocity-Related Critical Phosphorus Concentrations in Flowing Water, Phase 3; National Science Foundation; $108,332; 1988-90.**

Design of Monitoring Programs for Determining Shellfish Bed Bacterial Contamination Problems; Washington Department of Ecology; $12,000; 1988-89.*

Puget Sound Protocols Development; Tetra Tech, Inc. and Puget Sound Estuary Program; $10,144; 1988.*

Improving the Cost Effectiveness of Highway Construction Site Erosion/ Pollution Control, Phase 2; Washington State Department of Transportation; $97,000; 1987-89.*

Wetland Mitigation Project Analysis; Washington State Department of Transportation; $74,985; 1987-89.*

Lake Chelan Water Quality Assessment; Harper-Owes, consultant to Washington State Department of Ecology; $42,977; 1986-88.

Quality of Management of Silver Lake; City of Everett; $67,463; 1986-88.

Effectiveness of WSDOT Wetlands Creation Projects; Washington State Department of Transportation; $42,308; 1986-87.*

Improving the Cost Effectiveness of Highway Construction Site Erosion/Pollution Control; Washington State Department of Transportation; $41,608; 1986-87.*

Management Significance of Bioavailable Phosphorus in Urban Runoff; State of Washington Water Research Center and Municipality of Metropolitan Seattle; $32,738; 1986-87.**

Environmental Monitoring and Evaluation of Calcium Magnesium Acetate (CMA); Transportation Research Board of National Academy of Sciences; $199,943; 1985-87.*

Conceptual Design of Monitoring Programs for Determination of Water Quality and Ecological Change Resulting from Nonpoint Source Discharges; Washington State Department of Ecology; $49,994; 1985-86.**

Development of an Integrated Land Treatment Approach for Improving the Quality of Metalliferous Mining Wastewaters; Washington Mining and Mineral Resources Research Institute; $4,000; 1985-86.*

Preliminary Investigation of Sewage Sludge Utilization on Roadsides; Washington State Department of Transportation; $6,664; 1984-85.*

Source Control of Transit Base Runoff Pollutants; Municipality of Metropolitan Seattle; $26,867; 1984-85.**

Lake Sammamish Future Water Quality; Municipality of Metropolitan Seattle; $28,500; 1984-85.

Implementation of Highway Runoff Water Quality Research Results; Washington State Department of Transportation; $13,998; 1984-85.*

Performance Evaluation of a Detention Basin and Coalescing Plate Oil Separator for Treating Urban stormwater Runoff; Washington State Water Research Center; 1984-85; $11,724.**

Velocity-Related Critical Phosphorus Concentrations in Flowing Water, Phase 2; National Science Foundation; $99,088; 1983-85.**

Development of a Biological Overland Flow System for Treating Mining Wastewaters; Washington Mining and Mineral Resources Research Institute; $6,030; 1983-84.*

Nutrient Contributions of Agricultural Sites to the Moses Lake System; Moses Lake Conservation District; $15,039; 1982-84.*

Planning Implementation of Runoff Water Quality Research Findings; Washington State Department of Transportation; $12,735; 1982-83.**

Transport of Agricultural Nutrients to Moses Lake; Brown and Caldwell Engineers; $22,725; 1982-83.**

Investigation of Toxicant Concentration and Loading Effects on Aquatic Macroinvertebrates; University of Washington Graduate School Research Fund; $3,788; 1982.*

Sampling Design for Aquatic Ecological Monitoring; Electric Power Research Institute; $542,008; 1981-86.

Velocity-Related Critical Phosphorus Concentrations in Flowing Water; National Science Foundation; $70,310; 1980-82.

Highway Runoff Water Quality; Washington State Department of Transportation; $461,176; 1977-82.

BOOKS

Shaver, E., R. Horner, J. Skupien, C. May, and G. Ridley. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*, 2nd Edition. U.S. Environmental Protection Agency, Washington, D.C., 2007.

Azous, A. L. and R. R. Horner. *Wetlands and Urbanization: Implications for the Future*. Lewis Publishers, Boca Raton, FL, 2000.

Horner, R. R., J. J. Skupien, E. H. Livingston, and H. E. Shaver. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*. Terrene Institute, Washington, D. C., 1994.

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Welch, E.B., R.R. Horner, and C.R. Patmont. Phosphorus Levels That Cause Nuisance Periphyton: A Management Approach. *Water Research* 23(4):401-405, 1989.

Butkus, S.R., E.B. Welch, R.R. Horner, and D.E. Spyridakis. Lake Response Modeling Using Biologically Available Phosphorus. *Journal of the Water Pollution Control Federation* 60(9):1663-1669, 1988.

Reinelt, L.E., R.R. Horner, and B.W. Mar. Nonpoint Source Pollution Monitoring Program Design. *Journal of Water Resources Planning and Management* 114(3):335-352, 1988.

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Reinelt, L.E., R. Castensson, and R.R. Horner. Modification of an Existing Monitoring Program to Address Nonpoint Source Pollution, A Case Study of the Svarta River Basin, Sweden. *Vatten* 43:199-208, 1987.

Mar, B.W., R.R. Horner, J.S. Richey, D.P. Lettenmaier, and R.N. Palmer. Data Acquisition, Cost-Effective Methods for Obtaining Data on Water Quality. *Environmental Science and Technology* 20(6):545-551, 1986.

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May, C.W. and R.R. Horner. 2002. The Limitations of Mitigation-Based Stormwater Management in the Pacific Northwest and the Potential of a Conservation Strategy Based on Low-Impact Development Principles. Proc. 2002 ASCE Stormwater Conference, Portland, OR.

Horner, R. R. and C. R. Horner. Performance of a Perimeter ("Delaware") Sand Filter in Treating Stormwater Runoff from a Barge Loading Terminal. Proc. Comprehensive Stormwater and Aquatic Ecosystem Management Conf.; Auckland, New Zealand; February 1999, pp. 183-192, 1999.

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Horner, R. R. Training for Construction Site Erosion Control and Stormwater Facility Inspection. Proc. National Conf. on Urban Runoff Management; Chicago, Illinois; March 1993, pp. 426-450, 1995.

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Taylor, B. K. Ludwa, and R. R. Horner. Urbanization Effects on Wetland Hydrology and Water Quality. Proc. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1995, pp. 146-154, 1995.

Reinelt, L.E. and R.R. Horner. Urban Stormwater Impacts on the Hydrology and Water Quality of Palustrine Wetlands in the Puget Sound Region. Proc. Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; January 1991; pp. 33-42.

Horner, R.R. Environmental Effects of Calcium Magnesium Acetate, Emphasizing Aquatic Ecosystem Effects. Proc. Conf. on Environmental Impacts of Highway Deicing, Institute of Ecology Publication No. 33, University of California, Davis; 1990; pp. 97-119.

Stockdale, E.C. and R.R. Horner. Using Freshwater Wetlands for Stormwater Management: A Progress Report. Proc. Wetlands 1988: Urban Wetlands and Riparian Habitat Symposium; Oakland, California, June 1988.

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PRESENTATIONS AND DISCUSSIONS

*Presented by a co-author. In all other cases, I presented the paper.

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Structural and Non-Structural Best Management Practices (BMPs) for Protecting Streams. Invited presentation at the Engineering Foundation Conference on Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation; Snowmass, Colorado; August 2001.

Performance of a Perimeter ("Delaware") Sand Filter in Treating Stormwater Runoff from a Barge Loading Terminal. Invited presentation at the Comprehensive Stormwater and Aquatic Ecosystem Management Conf.; Auckland, New Zealand; February 1999.

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Toward Ecologically Based Urban Runoff Management. Invited presentation at The Engineering Foundation Conference on Urban Runoff and Receiving Systems; Crested Butte, Colorado; August 1991.

How Stormwater Harms Shellfish. Invited presentation at the Pacific Rim Shellfish Sanitation Conference; Seattle, Washington; May 1991.

Environmental Evaluation of Calcium Magnesium Acetate for Highway Deicing Applications. Invited presentation at Conference on Calcium Magnesium Acetate, An Emerging Chemical for Environmental Applications; Boston, Massachusetts; May 1991.

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The Impact of Nonpoint Source Pollution on River Ecosystems. Invited presentation at the Northwest Rivers Conference; Seattle, Washington; November 1990.

Research Program Overview and Discussion of Hydrologic and Water Quality Studies. Presented at the Puget Sound Wetlands and Stormwater Management Research Program Workshop; Seattle, Washington; October 1990.

Control of Urban Runoff Water Quality. Invited presentations at American Society of Civil Engineers Urban Stormwater Short Courses; Bellevue, Washington; April, 1990; Portland, Oregon; July 1990.

Various Aspects of Erosion Prevention and Control. Invited presentations at University of Wisconsin Erosion Control Short Course; Seattle, Washington; July 1990.

Examination of the Hydrology and Water Quality of Wetlands Affected by Urban Stormwater. Presented at the Society of Wetland Scientists Annual Meeting; Breckenridge, Colorado, June 1990 (prepared with L.E. Reinelt).*

Analysis of Plant Communities of Wetlands Affected by Urban Stormwater. Presented at the Society of Wetland Scientists Annual Meeting; Breckenridge, Colorado; June 1990 (prepared with S.S. Cooke).*

Environmental Evaluation of Calcium Magnesium Acetate. Invited presentation at the Symposium on the Environmental Impact of Highway Deicing; Davis, California; October 1989.

Application of Wetland Science Principles in the Classroom and Community. Invited presentation at the Annual Meeting of the Association of Collegiate Schools of Planning; Portland, Oregon; October 1989.

Structural Controls for Urban Storm Runoff Water Quality. Invited presentation at the Northwest Regional Meeting of the North American Lake Management Society; Seattle, Washington; September 1989.

The Puget Sound Wetlands and Stormwater Management Research Program. Invited presentation at the U.S. Environmental Protection Agency Workshop on Wetlands and Stormwater; Seattle, Washington; September 1989.

An Overview of Storm Runoff Water Quality Control. Invited presentation at the American Water Resources Association Workshop on Forest Conversion; LaGrande, Washington; November 1988.

Progress in Wetlands Research. Invited presentation at the Pacific Northwest Pollution Control Association Annual Meeting; Coeur d'Alene, Idaho; October 1988.

Long-Term Effects of Urban Stormwater on Wetlands. Invited presentation at the Engineering Foundation Conference on Urban Stormwater; Potosi, Missouri; July 1988.

Highway Construction Site Erosion and Pollution Control: Recent Research Results. Invited presentation at the 39th Annual Road Builders' Clinic; Moscow, Idaho; March 1988.

Urban Stormwater and Puget Trough Wetlands. Presented at the 1st Annual Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; March 1988 (prepared with F.B. Gutermuth, L.L. Conquest, and A.W. Johnson).

Preliminary Comparative Risk Assessment for Hanford Waste Sites. Presented at Waste Management 88; Tucson, Arizona; February 1988 (prepared with R.F. Weiner and J. Kettman).*

What Goes on at the Hanford Nuclear Reservation? Invited presentation at the Northwest Association for Environmental Studies Annual Meeting; Western Washington University, Bellingham, WA; November 1987.

The Puget Sound Wetlands and Stormwater Management Research Program. Invited presentation at the Pacific Northwest Pollution Control Association Annual Meeting; Spokane, Washington; October 1987.

Design of Cost-Effective Monitoring Programs for Nonpoint Source Water Pollution Problems. Invited presentation at the American Water Resources Association, Puget Sound Chapter, Annual Meeting; Bellevue, Washington; November 1986.

A Review of Wetland Water Quality Functions. Invited plenary presentation at the Conference on Wetland Functions, Rehabilitation, and Creation in the Pacific Northwest: The State of Our Understanding; Port Townsend, Washington; May 1986.

Nonpoint Discharge and Runoff session leader. American Society of Civil Engineers Spring Convention; Seattle, Washington; April 1986.

Prevention of Lake Sammamish Degradation from Future Development. Invited presentation at the American Society of Civil Engineers Spring Convention; Seattle, Washington; April 1986.

Design of Monitoring Programs for Nonpoint Source Water Pollution Problems. Invited presentation at the American Society of Civil Engineers Spring Convention; Seattle, Washington, April 1986 (prepared with L.E. Reinelt, B.W. Mar, and J.S. Richey).*

Nonpoint Pollution Control Strategies for Moses Lake, Washington. Presented at the Fifth Annual Meeting of the North American Lake Management Society; Lake Geneva, Wisconsin; November 1985 (prepared with R.C. Bain, Jr., and L. Nelson).

Response of Lake Sammamish to Urban Runoff Control. Presented at the Fifth Annual Meeting of the North American Lake Management Society; Lake Geneva, Wisconsin; November 1985 (prepared with J.I. Shuster, E.B. Welch, and D.E. Spyridakis).*

A General Approach to Designing Environmental Monitoring Programs. Invited presentation at the Pacific Section AAAS Symposium on Biomonitors, Bioindicators, and Bioassays of Environmental Quality; Missoula, Montana; June 1985 (prepared with J.S. Richey and B.W. Mar).

Panel Discussion on the Planning Process for Non-point Pollution Abatement Programs. Non-point Pollution Abatement Symposium; Milwaukee, Wisconsin; April 1985.

Nutrient Transport Processes in an Agricultural Watershed. Presented at the Fourth Annual Meeting of the North American Lake Management Society; McAfee, New Jersey; October 1984 (prepared with E.B. Welch, M.M. Wineman, M.J. Adolfson, and R.C. Bain Jr.).*

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A Guide for Assessing the Water Quality Impacts of Highway Operations and Maintenance. Presented at the Transportation Research Board Annual Meeting; Washington, D.C.; January 1983 (prepared with B.W. Mar).

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Stream Periphyton Development in Relation to Current Velocity and Nutrients. Presented at American Society of Limnology and Oceanography Winter Meeting; Corpus Christi, Texas; January 1979 (prepared with E.B. Welch).

A Comparison of Discrete Versus Composite Sampling of Storm Runoff. Presented at the Northwest Pollution Control Association Annual Meeting; Victoria, British Columbia; October 1978 (prepared with B.W. Mar and J.F. Ferguson).*

A Method of Defining Urban Ecosystem Relationships Through Consideration of Water Resources. Presented at UNESCO International Man and the Biosphere Project 11 Conference; Poznan, Poland; September 1977.

GRADUATE AND UNDERGRADUATE COURSES TAUGHT (University of Washington)

Civil and Environmental Engineering 552, Environmental Regulations; 8 quarters.

Landscape Architecture 590, Urban Water Resources Seminar; 3 quarters.

Landscape Architecture 522/523, Watershed Analysis and Design; 15 quarters.

Engineering 260, Thermodynamics; 1 quarter.

Engineering 210, Engineering Statics; 2 quarters.

Civil Engineering/Water and Air Resources 453, Water and Wastewater Treatment; 1 quarter.

Civil Engineering/Water and Air Resources 599, Analyzing Urbanizing Watersheds; 1 quarter.

CONTINUING EDUCATION SHORT COURSES TAUGHT (University of Washington; multiple offerings)

Infiltration Facilities for Stormwater Quality Control

Wetlands Ecology, Protection, and Restoration

Storm and Surface Water Monitoring

Fundamentals of Urban Surface Water Management

Applied Stormwater Pollution Prevention Planning Techniques

Construction Site Erosion and Pollution Control Problems and Planning

Construction Site Erosion and Pollution Control Practices

Construction Site Erosion and Sediment Control Inspector Training

Inspection and Maintenance of Permanent Stormwater Management Facilities

Biofiltration for Stormwater Runoff Quality Control

Constructed Wetlands for Stormwater Runoff Quality Control

LOCAL COMMITTEES

Stormwater Panel advising Puget Sound Partnership, 2007.

Technical Advisory Committee, City of Seattle Environmental Priorities Project, 1990-91.

Environmental Toxicology Graduate Program Planning Committee, University of Washington, 1990.

Habitat Modification Technical Work Group, Puget Sound Water Quality Authority, 1987.

Underground Injection Control of Stormwater Work Group, Washington State Department of Ecology, 1987.

Nonpoint Source Pollution Conference Advisory Committee, 1986-87.

Puget Sound Wetlands and Stormwater Management Research Committee, 1986-90.

Accreditation Review, University of Washington Department of Landscape Architecture, 1986.

Planning Committee for University of Washington Institute for Environmental Studies Forum on Perspectives on Cumulative Environmental Effects, 1983.

<u>CONSULTING</u>

Chesapeake Legal Alliance; Annapolis, Maryland; Assessment of and comment on Maryland's draft Municipal Separate Storm Sewer Discharge Permits and Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated; 2020-2021.

Gonzaga University Legal Assistance; Spokane, Washington; Review of technical documents supporting a proposal for a PCB water quality variance for the Spokane River; 2020.

City of Monrovia, California; Recommendations for improving a watershed management plan; 2020.

Columbia Riverkeeper; Portland Oregon; Assessment of a port industrial development; 2020.

Columbia Riverkeeper and Northwest Environmental Defense Center; Portland Oregon; Assessment of Oregon Department of Environmental Quality's actions regarding setting Water Quality-Based Effluent Limits; 2020.

Coast Law Group, Encinitas, California; Technical assistance in a Clean Water Act legal cases and expert testimony; 2019-2020.

Monterey County District Attorney, Monterey, California; Assessment of pollution issues at two construction company yards; 2019-2020.

Seneca Lake Guardian, Seneca Falls, New York; Assessment of potential water quality problems associated with an industrial plant; 2019.

Endangered Habitats League, Los Angeles, California; Assessment of stormwater management systems proposed for a large residential development; 2018-2019.

Ziontz Chestnut Law Firm, Seattle, Washington; Assistance with implementation of a court order on a settled case.

U.S. Department of Justice; Technical assistance in a Clean Water Act legal case; 2017-2018.

Kampmeier & Knutsen PLLC, Portland, Oregon; Technical assistance in a Clean Water Act legal case; 2017.

Black Warrior Riverkeeper, Birmingham, Alabama; Review and comment on a total maximum daily load assessment for the Black Warrior River; 2017.

DeLano and DeLano, Escondido, California; Assessment of stormwater management systems proposed for residential and commercial developments; 2012-present.

Salmon-Safe, Inc.; assessment of sites for possible certification representing practices that protect salmon; 2004-present.

Puget Soundkeeper Alliance and Smith and Lowney, PLC, Seattle, Washington; Technical assistance in Clean Water Act legal cases and expert testimony; 1996, 2002-present.

Natural Resources Defense Council, Los Angeles, California; Technical and program analysis and expert testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance and assistance in reacting to California municipal stormwater permits; 1993-present.

Santa Monica Baykeeper (now Los Angeles Waterkeeper); Technical and program analysis and expert testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance; 1993-present.

Orange County Coastkeeper; Assistance with legal cases involving industrial and construction site pollution control and monitoring and expert testimony; 2001-present.

Lawyers for Clean Water; Assistance with legal cases involving stormwater discharges and expert testimony; 2004-2018.

Earthjustice; Report and testimony regarding Washington state municipal stormwater permit before Pollution Control Hearing Board; 2008, 2013; assessment of Washington, DC combined sewer overflow control plan; 2015.

Tulane Environmental Law Clinic; Assessment and declaration on a legal case involving discharge under an industrial stormwater permit and expert testimony; 2015.

San Diego Coastkeeper, San Diego, California; Technical and program analysis and expert testimony on potential legal cases involving municipal and industrial stormwater NPDES permit compliance; liaison with City of San Diego; 1996-2011 and 2019.

Stillwater Science and Washington Department of Ecology; Water quality modeling for Puget Sound Characterization, Phase 2; 2010-2011.

City of Seattle Public Utilities; Analysis of technical aspects of stormwater management program; 2000-2008.

Ventura Coastkeeper; Technical and program analysis and expert testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance; 2010-2015.

San Diego Airport Authority; Peer review of consultant products, training; 2004-2006.

U. S. Federal Court, Central District of California; Special master in Clean Water Act case; 2001-2002.

Storm Water Pollution Prevention Program, City of San Diego; Advising on response to municipal stormwater NPDES program; 2001-2002.

Kerr Wood Leidel, North Vancouver, B.C.; subconsultant for Stanley Park (Vancouver, B.C.) Stormwater Constructed Wetland Design; 1997-1998.

Clean South Bay, Palo Alto, California; Technical and program analysis and expert testimony on potential legal cases involving municipal and industrial stormwater NPDES permit compliance; 1996.

Resource Planning Associates, Seattle, Washington; Assistance with various aspects of monitoring under Seattle-Tacoma International Airport's stormwater NPDES permit; 1995-1997.

Watershed Management Institute, Crawfordsville, Florida; Writing certain chapters of guides for stormwater program development and implementation and maintenance of stormwater facilities; 1995-2003.

King County Roads Division, Seattle, Washington; Teaching two courses on construction erosion and sediment control; 1995.

Snohomish County Roads Division, Seattle, Washington; Teaching a course on construction erosion and sediment control; 1995.

Alaska Marine Lines, Seattle, Washington; Performance test of a sand filter stormwater treatment system; 1994-95.

Economic and Engineering Services, Inc., Bellevue, Washington; Assessment of the potential for water quality benefits through modifying existing stormwater ponds; technical advice on remedying operating problems at infiltration ponds; 1994-96.

Washington State Department of Transportation, Olympia, Washington; Teaching courses on construction erosion and sediment control; 1994.

City of Bellevue, Washington; Peer review of documents on potential erosion associated with a road project; analysis of stormwater quality data; 1993-95.

City of Kelowna, B. C., Canada; Teaching short courses on constructed wetlands and erosion and sediment control; 1993.

Oregon Department of Environmental Quality, Portland, Oregon; Technical review of Willamette River Basin Water Quality Study reports; 1992-93.

Whatcom County, Bellingham, Washington; Mediation on lakeshore development moratorium among county, water district, and local community representatives; 1993.

Boeing Commercial Airplane Company, Renton, Washington and Sverdrup Corporation, Kirkland, Washington (at request of City of Renton); Review of stormwater control system design; design of performance monitoring study for system; 1992-94.

Golder Associates, Redmond, Washington; Technical advisor for study of stormwater infiltration; 1992.

Smith, Smart, Hancock, Tabler, and Schwensen Attorneys, Seattle, Washington; Technical advice on a legal case involving a stormwater detention pond; 1992.

PIPE, Inc., Tacoma, Washington; Teaching a course on the stormwater NPDES permit; 1992.

CH2M-Hill, Inc., Bellevue, Washington and Portland, Oregon; Technical seminar on constructing wetlands for wastewater treatment; literature review on toxicant cycling in arid-region wetlands constructed for waterwater treatment; literature and data review on lake nutrient input reduction; expert panel on TMDL analysis for Chehalis River; 1989-1995.

Kramer, Chin and Mayo, Inc., Seattle, Washington; Watershed analysis in Washington County and Lake Oswego, Oregon; literature review in preparation for stormwater infiltration system design; literature review and contribution to design of constructed wetland for municipal wastewater treatment; 1989-1995.

Woodward-Clyde Consultants, Portland, Oregon and Oakland, California; Analysis of wetland capabilities for receiving urban stormwater; design of a constructed wetland for urban stormwater treatment; technical advisor on Washington Department of Ecology and City of Portland stormwater manual updates; 1989-1995.

R.W. Beck and Associates, Seattle, Washington; Assessment of pollutant loadings and their reduction for one master drainage planning and two watershed planning efforts; 1989-92.

Boeing Computer Services Corporation, Bellevue, Washington; mediation among Boeing, citizens' group, and City of Bellevue on stormwater control system design; 1990.

Parametrix, Inc., Bellevue, Washington; Review of Kitsap County Drainage Ordinance; 1990.

U.S. Environmental Protection Agency, Duluth Laboratory; Review of certain provisions of WET 2.0 wetland functional assessment model; 1989.

King County Council, Seattle, Washington; Review of King County Surface Water Design Manual; 1989.

Port of Tacoma, Washington; Assessment of stormwater control strategies; 1989.

Municipality of Metropolitan Seattle, Seattle, Washington; Assessment of land treatment systems for controlling urban storm runoff water quality; 1988-1992.

Impact Assessment, Inc., La Jolla, California (contractor to Washington State Department of Ecology); Socioeconomic impact assessment of the proposed high-level nuclear waste repository at Hanford, Washington; 1987.

Technical Resources, Inc., Rockville, Maryland (contractor to U. S. Environmental Protection Agency); assessment of water treatment waste disposal at pulp and paper plants; 1987-88.

Dames and Moore, Seattle, Washington; analysis of the consequences of a development to Martha Lake; 1987.

Harper-Owes, Seattle, Washington; project oversight, data analysis, and review of limnological aspects for Lake Chelan Water Quality Assessment Study; 1986-88.

URS Corporation, Seattle, Washington and Columbus, Ohio; presentation of a workshop on nonpoint source water pollution monitoring program design; analysis of innovative and alternative wastewater treatment for Columbus; development of a stormwater utility for Puyallup, Washington; watershed analysis for Edmonds, Washington; 1986-88.

Entranco Engineers, Bellevue, Washington; environmental impact assessment of proposed highway construction; technical review of Lake Sammamish watershed management project; technical review of Capital Lake wetland development; 1981-82; 1987-88; 1990.

Washington State Department of Ecology, Olympia, Washington; review of literature on wetland water quality, preparation of conference plenary paper, and leading discussion group at conference; analysis in preparation for a Shoreline Hearing Board case; 1986-87.

Richard C. Bain, Jr., Engineering Consultant, Vashon Island, Washington; analysis of watershed data and development of a policy for septic tank usage near Moses Lake, Washington; 1984-87.

University of Washington Friday Harbor Laboratory; analysis of adjacent port development and preparation of testimony for Shoreline Hearing Board; 1986.

Washington State Department of Transportation and Morrison-Knudsen Company, Inc./H.W. Lochner, Inc., Joint Venture, Mercer Island, Washington; environmental assessment of disposal of excavated material by capping a marine dredge spoil dumping site; 1984.

Foster, Pepper, and Riviera Attorneys, Seattle, Washington; analysis and testimony on provisions to reduce pollutants in stormwater runoff from a site proposed for development; 1983.

Williams, Lanza, Kastner, and Gibbs Attorneys, Seattle, Washington; collection and analysis of water quality data to support a legal case and preparation of testimony; 1982.

Herrera Environmental Consultants, Seattle, Washington; lake data analysis and report preparation; 1982-83.

Brown and Caldwell Engineers, Seattle, Washington; data collection and analysis for watershed study; 1982-83.

City of Marysville, Washington; environmental impact assessment of proposed bridge construction; 1982-83.

F.X. Browne Associates, Inc., Lansdale, Pennsylvania; contributions to manual on lake restoration for U.S. Environmental Protection Agency; preparation of funding proposals and permits for lake restoration; lake data analysis; literature reviews and analysis of septic tank contributions to lake nutrient loading and availability of different forms of nutrients; 1980-83.

Reston Division of Prentice-Hall, Inc., Reston, Virginia; review of and contributions to texts on environmental technology; 1978-79.

Butterfield, Joachim, Brodt, and Hemphill Attorneys, Bethlehem, Pennsylvania; analysis of environmental impact statements; expert witness; 1973.

APPENDIX E

EIP Report: Pollution Trading in the Chesapeake Bay

AN EIP POLICY PAPER

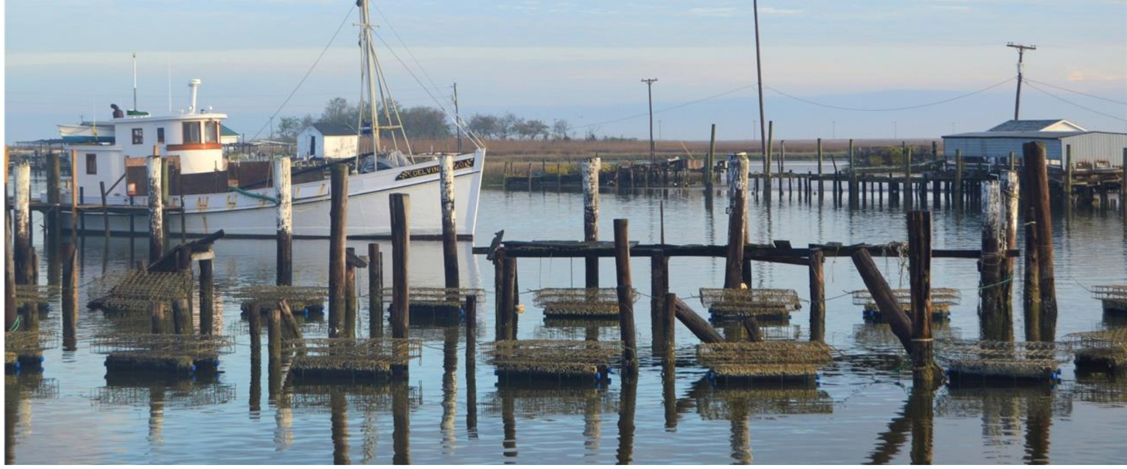
AUGUST 19, 2019

Pollution Trading in the Chesapeake Bay:

Threat to Bay Cleanup Progress

ENVIRONMENTAL INTEGRITY PROJECT

BY ABEL RUSS, EIP SENIOR ATTORNEY



Pollution Trading in the Chesapeake Bay:

Threat to Bay Cleanup Progress

Executive Summary

The Chesapeake Bay cleanup effort – guided by the EPA's Bay Total Maximum Daily Load, or TMDL – is slowly making progress. Pollution loads are starting to decline, and indicators of Bay health are starting to improve. However, the low-hanging fruit has been picked, and the next wave of pollution reductions will be harder to achieve. The Bay states are trying to make this process easier by encouraging polluters to trade with each other. In the abstract, this might be a plausible strategy. Polluters who cannot easily reduce their pollution loads can buy "credits," or pollution reduction equivalents, from other polluters who have ways of making relatively cheap pollution reductions. In the real world, though, pollution trading is complicated, and there are many pitfalls. A poorly executed trading program can be counterproductive, slowing progress toward overall cleanup targets and even causing net increases in pollution. This white paper explores pollution trading in Maryland, Pennsylvania and Virginia and makes the following observations:

1. So far, the volume of pollution trading has been limited to less than 1% of total nitrogen and phosphorus loads reaching the Bay each year.

2. The Bay states are hoping to encourage more trading by, among other things, allowing urban stormwater permittees to purchase credits instead of reducing stormwater loads.

3. The Bay states sometimes suggest that pollution trading will reduce pollution loads. It will not. Even in a best-case scenario, pollution trading will have no net effect on pollution loads.

4. A good trading program should be transparent. If you cannot trace each pollution credit from a specific generator to a specific buyer, then you cannot protect local water quality, enforce pollution permits, or even keep an accurate pollution balance sheet. Unfortunately, none of the Bay states has a perfectly transparent trading platform. Each one is missing some key information. For example, many trading programs have

intermediary brokers who buy and sell credits. Listing a broker as the credit seller for a particular trade obscures the original generator associated with that credit.

5. The trading programs are encouraging the sale of credits based on pollution controls implemented several years ago. As a policy matter, this means that polluters can literally “take credit” for past reductions, rather than generating new, additional pollution reductions. This will hamper progress.

6. If credits based on past reductions are sold as offsets for new loads, then the net result will be an increase in overall pollution. Pollution trading might therefore cause states to backslide on the progress achieved to date.

7. The trading programs are not adequately accounting for the fact that credit-generating practices on farms and other “nonpoint” sources tend to underperform – a problem exacerbated by climate change. The buyers of these credits are generally not getting what they pay for, and these trades will further hamper progress toward TMDL goals.

Contents

Pollution Trading in the Chesapeake Bay: Threat to TMDL Progress

1. Background

The Chesapeake Bay is slowly getting better. The Bay states have made some progress since the current cleanup plan was launched in 2009, though not as much as they had hoped. Now the Bay states are trying to figure out how to complete the process by 2025, working to complete their third "Watershed Implementation Plans" based on a new set of targets for nitrogen and phosphorus load. Meeting the 2025 targets will require the states to redouble their effort and accelerate pollution reductions. The states will also try to make the process more efficient – reducing pollution loads at a lower per-pound cost – by allowing various sources of pollution to trade. For example, it might be cheaper for a farmer to reduce 100 pounds of phosphorus runoff by planting cover crops than it is for a county to reduce 100 pounds of phosphorus runoff by ripping up pavement and replacing it with something more permeable. Instead of restoring the pavement, the county might elect to purchase pollution reductions from the farmer. The trade would not change the overall balance – the net phosphorus load would still be 100 pounds less with or without the trade – but the trade would make the pollution reduction more affordable. That is the idealized version of "nutrient trading." The reality is much more complicated. In the real world, many things can go wrong, and a poorly designed and implemented nutrient trading program can undermine incentives for pollution reduction, or even cause a net increase in pollution loads. This white paper evaluates a few key elements of the Bay states' nutrient trading programs to answer three basic questions. First, how much will each state lean on nutrient trading as a strategy? Second, how transparent are the trading programs? Is it possible for the public to follow pollution reductions from a seller of a pollution credit to a buyer? Finally, will the trading programs help, or hinder, TMDL progress?

This white paper will focus on just three states – Maryland, Pennsylvania and Virginia – because these three states account for roughly 90 percent of annual nitrogen and phosphorus loads to the Chesapeake Bay.[1]

We found that trading is a relatively minor feature of the overall TMDL implementation landscape so far, generally amounting to less than one percent of each state's annual nitrogen and phosphorus loads. However, the states are hoping to increase the volume of nutrient trading, particularly as a replacement for urban stormwater controls. Although each of the states maintains a public website with a substantial amount of information about nutrient trades, there are gaps in each state that make it difficult to track pollution credits from a permitted credit purchaser back to a credit-generating practice at a particular source. Finally, for reasons unrelated to transparency, including the use of questionable credit generation baselines and failure to correctly apply trading ratios for uncertainty, the three states' trading programs are more of an obstacle than an asset: They are not incentivizing additional pollution controls and they are not reducing pollution. In fact, the opposite is true. Nutrient trading programs are undermining incentives for pollution reduction, and in some case causing net increases in pollution load.

2. How much is each state leaning on nutrient trading?

So far, the volume of trading in each state (in terms of nitrogen or phosphorus pounds traded) has amounted to less than one percent of statewide nutrient loads. Maryland is hoping to see a significant volume of trading in the future, but its trading program is new, and only a handful of trades have occurred so far. Pennsylvania and Virginia have older trading programs, but trading in these two states has been somewhat limited.

The Bay states and the U.S. EPA are currently in the process of refining their strategies for meeting 2025 pollution targets. The strategic plans are known as "Watershed Implementation Plans" or "WIPs." We looked at each WIP to see what the states had to say about nutrient trading. Among other things, we wanted to know whether the states were trying to assign pollution reductions to nutrient trading. This would be improper, and it would be bad accounting. After all, a trade is not a reduction. An idealized trading situation works like this: Suppose I, as a polluter, am supposed to reduce my annual nitrogen load by 10 pounds. Either I can make that reduction myself, or I can pay someone else to make that reduction. Either way, there will be a 10-pound reduction. Similarly, if a state is supposed to reduce the loads of phosphorus from urban runoff by 100,000 pounds, it can restore its impervious surfaces (pavement) to prevent the equivalent volume of runoff, or perhaps it can purchase 100,000 pounds of phosphorus credits

[1] Based the "2017 progress" outputs of the Chesapeake Bay program's Phase 6 watershed model, Maryland, Pennsylvania and Virginia are responsible for 88 percent of the nitrogen reaching the Bay each year, and 92 percent of the phosphorus.

from farmers. Either way, there will be a 100,000-pound reduction in phosphorus load. Nutrient trading may change where the reductions come from, and how much they cost, but nutrient trading does not reduce pollution.

a. Maryland

Maryland has a very new trading program. The state's point source trading registry, maintained by the Maryland Department of the Environment, lists a single transaction: 30 nitrogen credits, 8 phosphorus credits, and 3,400 sediment credits, all sold by the Elkton Wastewater Treatment Plant to the Terumo Medical Corporation on March 19, 2019. Maryland's point source registry lists a larger number of *certified* (but not necessarily purchased) credits, most of which have not been purchased: 10,741 nitrogen credits, 1,742 phosphorus credits, and 217,391 sediment credits. These certified point source credit totals represent less than 0.1 percent of Maryland's total annual load of each pollutant.

Agriculture is a "nonpoint" source, meaning that agricultural loads are not discharged through discreet point source outfalls. Instead, agricultural loads enter rivers and streams as runoff or baseflow (groundwater that discharges into surface waterways). Agricultural credits in Maryland are certified by the Maryland Department of Agriculture (MDA). MDA is developing its own online trading platform, but it appears that MDA has not yet certified any agricultural credits.

Looking to the future, Maryland's WIP discusses nutrient trading with respect to municipal storm water ("MS4s"), which are likely to be nutrient credit purchasers, and septic systems and sewage treatment plants, which are likely to be credit generators. Maryland's WIP is inconsistent about whether these trades should be thought of sources of additional pollution reductions (which would be inappropriate). Maryland's trading program is new, and the WIP does not put a quantitative estimate on future trading capacity (e.g., in pounds traded per year). Maryland probably does not know how popular its trading program will be, and the WIP generally does not try to guess how important nutrient trading will be to total TMDL progress.

> **Stormwater.** Developed, paved land generates large quantities of runoff when it rains. Until now, Maryland had been planning to reduce these stormwater loads by requiring cities and counties with Municipal Separate Storm Sewer Systems ("MS4s") to make a 20 percent reduction in impervious acres through "restoration," or replacing impervious surfaces with materials that allow rainwater infiltration. Now, through Maryland's Water Quality Trading Program, MS4s can purchase reductions from other sources, including neighboring, non-MS4 counties that install stormwater Best Management Practices (BMPs).[2] Pages 7 and 21 of the draft WIP state that "miscellaneous implementation on non-MS4 counties (i.e., trading, trust fund)" will reduce nitrogen and phosphorus loads by 5,000 and 500 pounds, respectively, at a cost of $5 million. This is problematic. It is not clear how much of these reductions are being attributed to trading, but it appears that some of them are.

[2] Maryland draft WIP at B-34.

Again, nutrient trading does not reduce pollution. If an MS4 meets part of its restoration requirement by purchasing credits from a neighboring non-MS4 county, then the 'reduction' in the non-MS4 county is really an offset. The non-MS4 county will reduce its stormwater load, and this will offset the fact that the MS4 failed to reduce stormwater by as much as it was supposed to.

This can be further illustrated with another example from Maryland's WIP. One source of nitrogen credits in Maryland's nutrient trading scheme is "non-required septic upgrades."[3] Maryland believes that "this will act as an additional driver of septic implementation."[4] Maybe so. But every trade involving septic implementation represents two things – nitrogen reductions at the septic system, and a failure to reduce nitrogen somewhere else. In other words, the septic upgrade will be used to offset nitrogen reductions that another source was supposed to make. The other source – the nitrogen credit purchaser – will continue to discharge more nitrogen than it should. On balance, Maryland will not be any closer to its overall nitrogen goals. At one point in its WIP Maryland seems to acknowledge this fact:

> Maryland will promote using septic upgrades as a mechanism for generating credit to meet NPDES permit requirements. We acknowledge that there will be a reduction; however, that reduction will be used to meet NPDES permit requirements so no estimate figure is provided here. MD WIP at B-21.

In other words, the septic upgrades generate reductions, but since those are used as an offset (to meet someone else's NPDES permit requirements), they are not counted on the balance sheet as new reductions. This is the proper way to account for and discuss nutrient trading. Unfortunately, Maryland's WIP is inconsistent. Where trading incentivizes septic upgrades, Maryland acknowledges that there is no net improvement. Yet where trading incentivizes stormwater BMPs in non-MS4 counties, Maryland falsely claims that there is an additional pollution reduction.

There is an additional problem with MS4s in Maryland's trading scheme, and that has to do with how trades account for uncertainty around the pollution reductions generated by non-point sources like farms. This is discussed in greater detail in Section 3 of this white paper, but in short, MS4s are exempted from the general requirement (and EPA expectation) that all trades involving nonpoint credits should use a 2:1 "uncertainty ratio." To illustrate, consider a farmer planting cover crops, a form of agricultural Best Management Practice or BMP. The cover crops are assigned a certain pollution reduction using a Chesapeake Bay Program-approved effectiveness estimate. However, BMPs tend to under-perform, and this will become increasingly true as a result of climate change. So the EPA expects credit purchasers, when buying credits from a farm or other nonpoint source, to purchase 2 pounds of credits for every pound that it wants to offset. This creates a margin of safety to account for any underperformance on the part of the credit

[3] Id. at B-20.
[4] Id. at B-21.

generator. Under Maryland's trading scheme, MS4s are exempt from the required 2:1 uncertainty ratio. As a result, when an MS4 purchases credits from a nonpoint source, and the nonpoint source fails to reduce nutrient loads by the predicted amount, then the reduction that appears on paper will be greater than the reduction that actually occurs.

Wastewater. Pages 7 and 21 of the WIP state that trading will incentivize additional treatment of sewage, beyond the level of treatment necessary to meet wastewater nitrogen concentrations of 3 mg/L. The WIP does not quantify the associated load reduction ("no estimate"). It is not clear whether Maryland sees this incentive as a source of additional reductions. Regardless, there are other problems with this strategy. Among other things, it seems clear that Maryland's trading program will not incentivize additional sewage treatment, because sewage treatment plants will be flooding the market with credits based on past reductions, for which no additional pollution control investments are required (see Section 3 below).

b. Pennsylvania

Pennsylvania has had an active nutrient trading program since 2013. Over that time, the number of credits traded each year has declined, as shown in the following table:

Table 1: Summary of nutrient trades in Pennsylvania, 2013-2018

	Nitrogen credits traded (% of annual nitrogen load)	Phosphorus credits traded (% of annual phosphorus load)
2013	1,155,705 (1.0%)	106,336 (2.6%)
2014	817,822 (0.7%)	72,686 (1.8%)
2015	611,696 (0.6%)	55,196 (1.4%)
2016	602,487 (0.6%)	45,487 (1.2%)
2017	272,399 (0.3%)	35,143 (0.9%)
2018	628,891 (0.6%)	31,529 (0.8%)

Over the 2013-2018 time period, most credits appear to have come from wastewater treatment plants. Pennsylvania's trading regulations allow point sources to sell credits for the difference between what they actually discharge and what their permits allow. In addition, starting with the 2016 compliance year, wastewater treatment plants can only sell credits to the extent that their annual discharge concentrations are less than 6 mg/L (nitrogen) and 0.8 mg/L (phosphorus).

Since 2016, wastewater treatment plants have been the source of roughly 60 percent of the nitrogen and phosphorus credits traded in Pennsylvania.[5]

The role of agriculture in nutrient trading has declined, perhaps in part because Pennsylvania adopted a 3:1 trading ratio for agricultural sources in 2016, meaning that credit purchasers must obtain three agricultural credits for every pound of their own discharge that they want to offset. In 2013, agriculture was the source of 23 percent of the nitrogen credits and 26 percent of the phosphorus credits traded in Pennsylvania. Over the 2016-2018 time period, farms were the source of 17 percent of the nitrogen credits and 15 percent of the phosphorus credits.

Going forward, Pennsylvania's Phase III WIP describes the nutrient trading program under the heading "Accounting for State Actions Not Currently Credited to Pennsylvania: Agriculture."[6] The WIP does not appear to attribute any specific reductions to trading, which suggests that Pennsylvania correctly views trading as a potential way to increase the efficiency and affordability of meeting TMDL goals, rather than as a unique source of reductions.

c. Virginia

So far, Virginia's nutrient trading program has been limited to a small number of permanent offsets and a larger number of annual point source trades. 55,597 permanent nitrogen credits have been generated by nonpoint sources. Of these, 94 percent were generated by land conversion (e.g., allowing farmland to re-forest). For phosphorus, 8,306 credits have been generated, again coming mainly from land conversion (87 percent). Just over of half of these credits have been used/purchased – 32,110 nitrogen credits and 4,903 phosphorus credits. Virginia's nonpoint source nutrient credit registry does not say where the credits were used, instead providing the name of the bank and broker that obtained each set of credits. Our understanding from conversations with Virginia DEQ staff is that these credits have been used to offset relatively permanent new loads (e.g., new development). The total number of nonpoint credits is very low. The 32,110 nonpoint nitrogen credits that have been used amount to 0.06% of Virginia's annual nitrogen load (as of 2017). The 4,903 nonpoint phosphorus credits represent 0.08% of Virginia's annual phosphorus load.

Virginia's point source credit trades are summarized in annual "nutrient trades reports." The state's website currently includes annual reports for 2015-2018. Each report lists the buyer of a set of credits, the watershed in which the buyer is located, the buyer's waste load allocation, the buyer's actual discharge the year in question, and the number of credits purchased (generally equal to the extent to which actual load exceeded the waste load allocation). The reports also show the source of the credits, though the source is almost always the Virginia Nutrient Credit Exchange Association (VNCEA). The VNCEA, in turn, publishes its own annual reports, which are also available on the Virginia DEQ website, with prospective details of nutrient trades

[5] The total is probably higher. We sorted credit generators into three categories based on their names. Many generators have "wwtp" or "stp" in their name, and we put these in the "wastewater treatment plant" category. Other generators have "farm generator IDs" and we put these in the "agricultural" category. The remaining sources we described as "unknown," but many of these (e.g., "Wellsboro Mun Auth") are likely to be wastewater treatment plants.
[6] Draft Pennsylvania WIP at 67.

arranged by watershed. The number of credits for a given year (e.g., roughly 2,000,000 nitrogen credits were available and tentatively claimed for the 2017 year) is much greater than the number of credits actually traded (306,174 nitrogen credits were actually traded in 2017).

The credits traded in 2015-2018 are shown below. The number of credits traded is equal to less than 1 percent of Virginia's total load each year, for both nitrogen and phosphorus. However, if all of the credits lined up by VNCEA were to be purchased, then traded credits would amount to roughly 3% of Virginia's nitrogen and phosphorus load.

Table 2: Summary of point source nutrient trades in Virginia, 2015-2018

	2015	2016	2017	2018
Nitrogen				
Credits traded	508,516	508,190	306,174	324,333
Statewide nitrogen load	60,673,504	59,757,370	58,155,064	58,161,130
Trading/total load	0.8%	0.9%	0.5%	0.6%
Phosphorus				
Credits traded	30,124	43,757	28,962	47,084
Statewide phosphorus load	6,203,643	6,278,241	6,122,161	6,156,269
Trading/total load	0.5%	0.7%	0.5%	0.8%

Virginia, like Maryland, is predicting an increase in the number of MS4s seeking to purchase nutrient credits:

> Financing of urban reductions has been partially achieved through the Virginia Stormwater Local Assistance Fund (SLAF). Under § 62.1-44.19:21.A of the Code of Virginia, MS4s are also able to take advantage of point source and nonpoint source trading programs to achieve their nutrient and sediment reduction goals. Trading activity to date has been very limited as MS4s have achieved required reductions through the implementation of onsite BMPs. Trading activity is expected to increase in the future as incremental reductions in urban sector nutrient and sediment loads become more challenging to achieve and urban retrofits are phased in over time.[7]

3. How transparent are the trading programs?

From the perspective of environmental protection and accountability, a transparent trading program would allow the public to trace each credit back from a buyer to a generator. There are several reasons for this. First, credit buyers, who are using credits to meet legally enforceable

[7] Draft Virginia Phase III WIP at 9.

permit limits, are liable for any credit failure. For example, if a wastewater point source buys credits from a farmer who claims to have planted a forest buffer, but it later turns out that the buffer was never planted, then the point source will have violated its permit limit. A second reason for 'cradle-to-grave' accountability has to do with local water quality. Trading can have adverse impacts on local water quality if, for example, a polluter defers pollution upgrades and instead buys credits from a different watershed. If the polluter (credit purchaser) had made the pollution control upgrades, then the environmental benefit would have occurred in the polluter's watershed. With the trade, however, the environmental benefit is transferred to the credit generator's watershed, and the polluter's watershed is arguably worse off (or no better). Finally, accountability is important for evaluating overall TMDL implementation. As we discuss in more detail below, trading may create the appearance of pollution reductions where in fact there are none. And to the extent that trades are actually offsets – where credits are purchased to offset a new load – they are very likely to create net increases in pollution load. All of this can only be proven or disproven with complete data.

So, how transparent are the states' programs? The short answer, based on what the states make available online[8], is that they are all 'translucent.' Each state provides some information, and some states more than others, but no state provides everything we might want to see.

Maryland's trading program is the newest, and also the most transparent, at least for point source credits. The state maintains an online credit registry[9] that provides the following information for each point source credit:

- A credit ID number for each credit/pound. For example, when the Easton Wastewater Treatment Facility registered 6,648 nitrogen credits for sale, they were given credit IDs of 2018_CHOOH_N_00001 through 2018_CHOOH_N_06648. These IDs show the year in which the credits were generated (2018), the subwatershed where they were generated ("CHOOH" is the oligohaline portion of the Choptank River), the nutrient (N, for nitrogen), and a unique number for each pound.
- Information about the generator, including the name and address of the facility and the name of someone to contact.
- Details about the credits. These include the watershed, the year generated, and the credit type (nitrogen or phosphorus), all of which can also be gleaned from the credit ID numbers. Other details include the date certified and the "credit status," either available for purchase ("active") or sold ("traded").
- Details about the purchaser of each credit, including name, date of trade, whether the credit has been applied to the purchaser's permit, and the associated permit number.

This is a good start. It allows the public to trace the fate of each credit, from generator to purchaser.

What's missing from Maryland's trading registry is a link to the certification for each credit. We do not know *how* each generator generated its credits, and that is important information. There is

[8] Although more information may be available through public records requests, we consider that to be an additional obstacle to true transparency, and

[9] https://mde.maryland.gov/programs/Water/WQT/Pages/MDE_WQT_Register.aspx

a big difference between claiming credit for pollution reductions that a facility made in 2008 using taxpayer money, and claiming credit for reductions generated by a facility's investments in new pollution controls.

Pennsylvania's nutrient trading website also provides a great deal of information, including a list of trades for every year between 2013 and 2018. These annual trading reports include the name of both the credit generator and the credit purchaser, though the shorthand is not always clear. Pennsylvania's websites also includes more extensive details on credit generators, including the mechanism by which each credit was generated "pollutant reduction activity," but only for the most recent credit year (2018). The permit numbers associated with each buyer and seller are not available in the annual trading reports. Credit buyers' permit numbers are available for credit years 2014-2018 in separate documents. Credit generators' permit numbers are available for credit years 2017-2018.

Virginia's nutrient trading website provides links to several different types of document:

- Annual "nutrient trades reports" for 2015-2017. These show the name, permit number, and basin (watershed) of each credit purchaser, each purchaser's delivered load, the number of credits purchased, and the source of the credits. However, the source of the credits is almost always listed as "VNCEA," the Virginia Nutrient Credit Exchange Association." The VNCEA serves as a kind of broker between credit generators and credit buyers. The annual nutrient trades reports do not allow the public to see where the credits for each buyer were generated, or how they were generated.
- Annual "nutrient loads" reports for 2015-2018. These reports, organized by basin, show each permittee's wasteload allocation and actual load.
- Annual "exchange compliance plans" from the Virginia Nutrient Credit Exchange Association for 2017-2019. These plans are largely prospective, showing the trading potential for the upcoming year and future years, including details about credit purchase agreements. Of the large number of credits lined up for potential trades year (e.g., roughly 2,000,000 nitrogen credits for 2017), only a small subset are actually traded (roughly 300,000 nitrogen credits in 2017).
- A nonpoint source credit registry. As discussed above, the nonpoint registry provides a list of "permanent" credits, including information about the credit generators (certification number, nutrient bank, bank sponsor, broker, and broker contact) and about the Best Management Practices used to generate credits (almost always "ag land conversion"). The nonpoint source credit registry does not provide information about credit buyers.
- Nonpoint source credit applications. This spreadsheet provides the same information as the nonpoint source credit registry, but for nonpoint sources that have pending applications.

The following table summarizes what each state does and does not provide on its public website. It can be seen that each state provides some, but not all, of the information that can support complete accountability.

Table 3: Transparency of online nutrient trading registries

	Maryland	Pennsylvania	Virginia
Point source credit purchasers			
Name	Yes	Yes	Yes
Permit number	Yes	Yes	Yes
Credit ID	Yes	No	No
Associated credit generator	Yes	Yes	Generally not[10]
Point source credit generators			
Name	Yes	Yes	Prospective estimates only[11]
Permit number	No	Yes	
Credit ID	Yes	No	
Pollutant reduction activity	No	Yes	Each point source generates credits by discharging less than its wasteload allocation
Associated credit purchaser	Yes	Yes	No
Nonpoint source credit purchasers			
Name	No nonpoint sources have purchased credits in Maryland	It appears that only point sources purchase credits in PA[12]	No
Credit ID			No
Associated credit generator			No
Nonpoint source credit generators			
Name	The Maryland Department of Agriculture has not yet launched its credit registry, perhaps because it has not yet certified any nonpoint credits	Yes	Yes
ID number		Yes (certification ID)	Yes (certification number)
Credit ID		No	No
Pollutant reduction activity		Yes	Yes
Associated credit purchaser		Yes	No

[10] The source is almost always listed as "VNCEA" (Virginia Nutrient Credit Exchange Association).
[11] Annual VCNEA plans provide prospective estimates of credit generation for each point source
[12] There are also a small number of credits purchased by credit brokers from time to time. For example, 12% of the nitrogen credits purchased in 2018 went to the broker Red Barn, while the rest (and all phosphorus credits) went to point sources. All of the nitrogen and phosphorus credits in 2017 were purchased by point sources. In 2016, 97% of the nitrogen credits and all of the phosphorus credits went to point sources.

4. Is trading going to help, or hinder, TMDL progress?

Transparency and accountability are critical elements of any adequate trading program, but they are not the only critical elements. Each state's nutrient trading program has additional weaknesses, some of which are inherent in the form of nutrient trading sanctioned by the U.S. EPA, that will inevitably lead to an unfortunate conclusion: Nutrient trading will almost certainly slow each state's progress toward meeting its TMDL targets.

a. Baselines and additionality

One of the key elements of a nutrient trading program is the baseline for credit generation. Credits are supposed to represent pollution reductions. When someone buys nutrient credits, it is because they have a legal obligation to reduce their pollution load. They decide that it's cheaper to pay someone else to do it. In the case of offsets, someone is generating a new pollution load, and under the terms of the TMDL, that new load has to be offset by a pollution reduction somewhere else.

But how do we quantify that credit generator's pollution reduction? Theoretically, the pollution reduction behind each credit should be the difference between the credit generator's load *now*, and what that load used to be. What that load used to be can be described as the 'baseline,' the point of comparison from which we calculate credits. This is simple enough in theory, but much more complicated in practice. The following list of questions illustrate that complexity:

- When was the baseline? Was it last year? Was it five years ago? Is it a multi-year average?
- If the credit generator is a nonpoint source like a farm, for which we have no monitoring data, the baseline has to be estimated. How do we do that?
- What if a permitted point source has permit limits that reflect that source's wasteload allocation under the TMDL. Could that be a baseline? In other words, if a source discharges less pollution than it is legally allowed to discharge, can it claim (and sell) credit for the difference?

The U.S. EPA has answered these questions in the TMDL document itself and in a series of "technical memoranda" that lay out the Agency's expectations for trading programs in the Bay region. In its simplest form, EPA's expectation is that baselines are whatever the TMDL required in the form of waste load allocations (for significant point sources) and load allocations (for other sources).[13] As described in more detail below, the Bay states are generally meeting this expectation.

However, the EPA also requires "additionality," explained as follows:

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[13] See, e.g., TMDL at 10-1 ("[O]ffsets are to be in addition to reductions already needed to meet the allocations in the TMDL…"); TMDL at S-2 (defining "Offsets Baseline" as "the amount of pollutant loading allowed by wasteload allocation (WLA) or load allocation (LA) that applies to individual credit generators in the absence of offsets"); U.S. EPA, Establishing Offset and Trading Baselines in the Chesapeake Bay Watershed: EPA Technical Memorandum at 4 (Feb. 2, 2016) ("The baseline used for credit generation is the same regardless of whether those credits will be used as offsets for new or increased loads or trades for compliance purposes.").

> During the initial stage of a trading or offset regime, a credit generating practice is: (1) to have been implemented no earlier than January 1, 2006, which was the cutoff date for calibrating the CBP Partnership Watershed Model that was used in setting the Bat TMDL; and (2) in addition to pollutant reductions committed to in the generating sector's level of implementation contained in a Bay jurisdiction's final Phase II Watershed Implementation Plan.[14]

Finally, the TMDL also states that "EPA does not support any trading activity that would delay or weaken implementation of the Bay TMDL."[15]

At the state level, baselines are defined as follows:

In Maryland, the general baseline for a point source is that source's wasteload allocation.[16] Sewage treatment plants are subject to the additional requirement that they can only obtain credit to the extent that their average annual discharge concentrations are less than 3 mg/L (nitrogen) or 0.3 mg/L (phosphorus).[17] This is roughly what sewage treatment plants upgraded to "enhanced nutrient removal" are expected to achieve. For agricultural nonpoint sources, the baseline is a farm's share of the applicable load allocation, as calculated using a modeling tool provided by the Maryland Department of Agriculture.[18]

In Pennsylvania, the baseline is generally the applicable TMDL wasteload allocation or load allocation.[19] Sewage treatment plants can only obtain credit to the extent that their average annual discharge concentrations are less than 6 mg/L (nitrogen) or 0.8 mg/L (phosphorus).[20] Agricultural sources can only generate credits after they comply with a set of performance requirements, including, for example, erosion and sediment control planning and manure application setbacks.[21]

In Virginia, the general baseline for point sources is each point source's wasteload allocation.[22] The baseline for agricultural credits is "those actions necessary to achieve a level of reduction assigned in the Virginia Chesapeake Bay TMDL Watershed Implementation Plan or approved TMDLs as implemented on the tract, field, or other land area under consideration."[23]

In short, and aside from more restrictive baselines applied to sewage treatment plants in Maryland and Pennsylvania, the baseline for generating credits is the applicable TMDL allocation. This is problematic. Consider a hypothetical point source polluter subject to, but currently exceeding, a certain wasteload allocation and associated permit limit on its nitrogen

[14] U.S. EPA, Components of Credit Calculation: EPA Technical Memorandum at 9 (May 14, 2014).
[15] TMDL at 10-3.
[16] Where a source is subject to a local TMDL in addition to the Bay TMDL, then the stricter TMDL controls for purposes of calculating the baseline. COMAR 26.08.11.05.C.
[17] COMAR 26.08.11.06, 26.08.11.03(35).
[18] COMAR 15.20.12.04.
[19] Where a local TMDL applies in addition to the Bay TMDL, the baseline would be based on the stricter of the two. 25 Pa. Code § 96.8(a), 98.6(d)(2)(ii).
[20] Pennsylvania DEP, Phase 2 Watershed Implementation Plan Nutrient Trading Supplement, Revised (Oct. 14, 2016).
[21] 25 Pa Code § 96.8(d).
[22] 9VAC25-820-10 (definitions of "point source nitrogen credit" and "point source phosphorus credit").
[23] Va. Code Ann. § 62.1-44.19:20.

load. In the absence of nutrient trading, the polluter would have to reduce its pollution load. With trading, however, the polluter could instead purchase credits. And those credits would probably not represent new reductions. Instead, the credits might represent pollution reductions that occurred 5 or 6 years ago, and may have been paid for by taxpayers. In the absence of trading, nitrogen loads would have declined. With trading, nitrogen loads stay the same.

Another specific, actual example can be found in Maryland's first nutrient trade: On March 19, 2019, the Terumo Medical Corporation bought 30 nitrogen credits, 8 phosphorus credits, and 3,400 sediment credits from the Elkton Wastewater Treatment Plant. This was the first, and as of June 2019, the only trade on Maryland's trading registry. It was a small trade, but it illustrates the problem with wastewater treatment plants selling credits.

The Elkton Wastewater Treatment Plant upgraded to "enhanced nutrient removal" in 2008. The project was partly paid for by taxpayers, through the Bay Restoration Fund. Enhanced nutrient removal is a technique that is designed to achieve nitrogen concentrations of 3 mg/L and phosphorus concentrations of 0.3 mg/L. The Elkton plant upgrades worked, and the plant's nitrogen discharges are almost always less than 3 mg/L. Since the upgrades were completed in 2008, the Elkton plant has discharged an average of roughly 12,000 pounds of nitrogen each year, compared to annual discharges of over 100,000 pounds before the upgrade. Figure 1 shows the trend since 2008.

Figure 1: Total nitrogen discharges from the Elkton Wastewater Treatment Plant (lb/year)

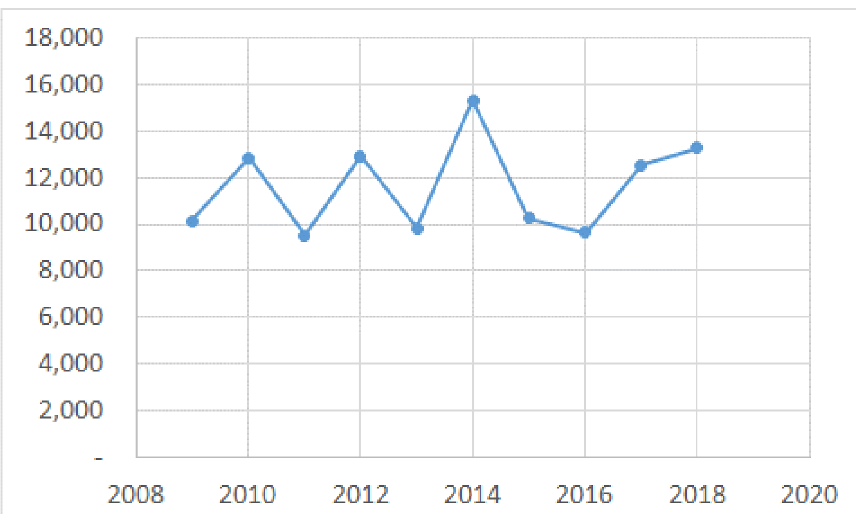

Figure 1 shows that the Elkton plant's discharges have fluctuated since 2008, but with no clear upward or downward trend. In other words, after making a significant improvement in wastewater quality in 2008, things have stayed about the same. In 2018, the Elkton plant had an annual nitrogen load of just over 13,000 pounds. This was above average for the plant, and in fact the second-highest nitrogen load since the 2008 upgrade.

In short, there was no reduction in nitrogen load in 2018. If anything, there was an increase. Yet the Maryland Department of the Environment (MDE) certified over 4,000 pounds of nitrogen credits that the Elkton plant can now sell. That's because Maryland's trading regulations allow any wastewater treatment plant discharging less than 3 mg/L of nitrogen to sell credits for the difference between what they actually discharge and what they would be discharging if the nitrogen concentration were 3 mg/L. The Elkton plant had an average nitrogen concentration of 2.2 mg/L in 2018. If that concentration had been 3 mg/L, Elkton's nitrogen load would have been roughly 18,000 pounds. The difference is now being sold as nitrogen credits.

The Elkton plant example shows that these credits are not backed up by real reductions in nitrogen load. Nitrogen loads from the Elkton plant increased in 2018, yet the plant was able to sell over 4,000 pounds of credits. These are "paper credits." The purchaser of these credits will not make pollution reductions that they would otherwise have made. In terms of real nitrogen load, nothing will change.

MDE also certified a number of phosphorus and sediment credits for the Elkton plant, and again, these are not backed up by real reductions. The plant's phosphorus load has been increasing since 2008 (see **Attachment** A, Figure A1), and although its sediment load dropped between 2010 and 2011, it has been steady since then (Figure A2). This is unfortunately not a unique case, and is in fact typical. Point sources can generally sell credits whenever they discharge less than they are allowed to discharge, regardless of whether they have made actual reductions in the past few years.

Without nutrient trading, each polluter has an incentive – in the form of legally enforceable permit limits – to make pollution reductions. With nutrient trading, that incentive is undermined. The polluter can instead take credit (literally) for another polluter's less-than-allowable discharge. And while proponents of nutrient trading often claim that trading creates a financial incentive for polluters to generate credits by reducing pollution, we can see that this is simply not happening, because the market is already flooded with credits from polluters who did not have to invest in any new pollution controls. In this scenario, relative to last year, or even relative to 2009, neither the credit purchaser nor the credit generator is making any additional pollution reductions. Nutrient trading has undermined TMDL progress by allowing pollution loads to be re-allocated rather than reduced.

In the case of offsets, the problem is even worse. Consider a new source of pollution purchasing offset credits from a sewage treatment plant that made upgrades in 2008 and currently discharges less than 3 mg/L of nitrogen. The combined result will be (a) an increase in pollution from the new source, plus (b) no change on the part of the credit generator, resulting in a net increase in pollution load overall.

It is worth repeating that "EPA does not support any trading activity that would delay or weaken implementation of the Bay TMDL."[24] The trading programs in all three states will delay and weaken implementation of the Bay TMDL by undermining incentives for pollution reduction. A proper trading program would require <u>new</u> reductions, generated by <u>new</u> pollution control upgrades, for the sale of credits. What we have instead is a shell game that simply moves pollution around.

The problem with sewage treatment plants selling nutrient credits is explored in much greater detail in **Attachment B**, a report written by EIP and the Center for Progressive Reform in 2017,

[24] TMDL at 10-3.

and **Attachment C**, comments on Maryland's nutrient trading program produced by EIP and others.

b. Uncertainty Ratios

Attachments B and C also explore the issue of uncertainty ratios. The EPA expects trading programs to apply 2:1 trading ratios whenever credits come from nonpoint sources, meaning that a credit purchaser would have to buy two credits for every pound it wishes to offset. The 2:1 uncertainty ratio is there to account for the fact that reductions in nonpoint source pollution are uncertain. Each nonpoint reduction is generated by a Best Management Practice, or BMP. BMPs include things like cover crops, forest buffers, stream restoration, the restoration of impervious surfaces, and so on. The Chesapeake Bay Program generates estimates of how well each BMP works, but acknowledges that these estimates are optimistic. The estimates are optimistic because, among other things, they are based on carefully controlled experimental studies. In the real world, things are less predictable. Everyone familiar with this area of study, including the Chesapeake Bay Program and the National Research Council, acknowledges that BMPs generally don't work as well as they are expected to work (see Attachment B at page 17). This problem is amplified by climate change, which is creating more erratic and intense precipitation patterns.[25]

Unfortunately, Maryland and Virginia appear to be heading down a path where they will allow sources of urban stormwater (municipal separate storm sewer systems, or MS4s) to purchase credits from nonpoint sources without a 2:1 uncertainty ratio.[26] The logic behind this policy choice is deeply flawed, but goes something like this: 'Since agricultural nonpoint pollution and urban stormwater pollution are both 'runoff,' trading between them is apples-to-apples. There may be uncertainty in agricultural BMP effectiveness, but there is also uncertainty in urban runoff estimates. The uncertainty cancels out.' This is wrong. The uncertainty does not cancel out, as we explained in comments on Maryland's nutrient trading program.[27] When a state fails to require a 2:1 uncertainty ratio, it allows a credit buyer to forego pollution controls in exchange for an overestimate of pollution reductions somewhere else. Instead of reducing its nitrogen load by 10,000 pounds, for example, a point source might buy 10,000 nonpoint credits, which represent an actual load reduction of something much less than 10,000 pounds. In the absence of trading, the point source would have reduced its load by 10,000 pounds. With trading, the net result is a pollution reduction of maybe 7,500 pounds. In this scenario, trading has impeded TMDL progress.

Pennsylvania, on the other hand, has been requiring a trading ratio of 3:1 for all trades involving agricultural credits, in response to intervention from EPA.[28]

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[25] See, e.g., Maryland's draft Phase III WIP at 53 ("The BMPs used to control water pollution will likely become less effective at controlling extreme storm events and be subject to damaging stresses of climate change").
[26] See, e.g., COMAR 26.08.11.08.C(1)(a).
[27] Attachment B at 19 and Appendix A.
[28] Pennsylvania DEP, Phase 2 Watershed Implementation Plan Nutrient Trading Supplement, Revised, at 7 (Oct. 14, 2016). EPA had expressed concern that "DEP had not made a quantitative demonstration that [baseline] requirements achieve the load allocations for agricultural sources in the [TMDL]"). *Id* at 1.

4. Conclusions and recommendations

So far, nutrient trading is not a major component of the Bay states' efforts to meet TMDL targets, but that may be changing. The current trading programs have a number of critical flaws. They are not adequately transparent, they do not require "additionality" of pollution reductions, and they do not adequately account for the underperformance of pollution reduction practices. If these trading programs grow, they will undermine TMDL progress. The wisdom of nutrient trading is debatable, but if the Bay states hope to encourage more nutrient trading, they should make several changes in their programs.

First, the Bay states should require each trading platform to include "cradle to grave" credit tracking, where each pollution credit gets an ID number that can be matched to both a generator and a purchaser. Maryland's point source trading platform provides a good example of how this should look. Intermediary credit brokers are not a problem so long as assign each credit to a specific buyer and publicly share the necessary credit tracking information.

Second, the Bay states should require additionality. All pollution credits should be derived from new, additional pollution reductions. Although this could be implemented in a variety of ways, one option would be to establish a credit calculation baseline year of 2017, which was the midpoint of the TMDL process and the benchmark from which the Bay states are planning to reach their 2025 targets.

Finally, the Bay states must apply a 2:1 uncertainty ratio to all trades involving nonpoint credit generators, regardless of whether the credit purchaser is a point source or a nonpoint source. This is the only way to ensure that nutrient credits do not overestimate pollution reductions.

Attachment A

Figure A1: Phosphorus discharges from the Elkton Wastewater Treatment Plant (pounds per year)

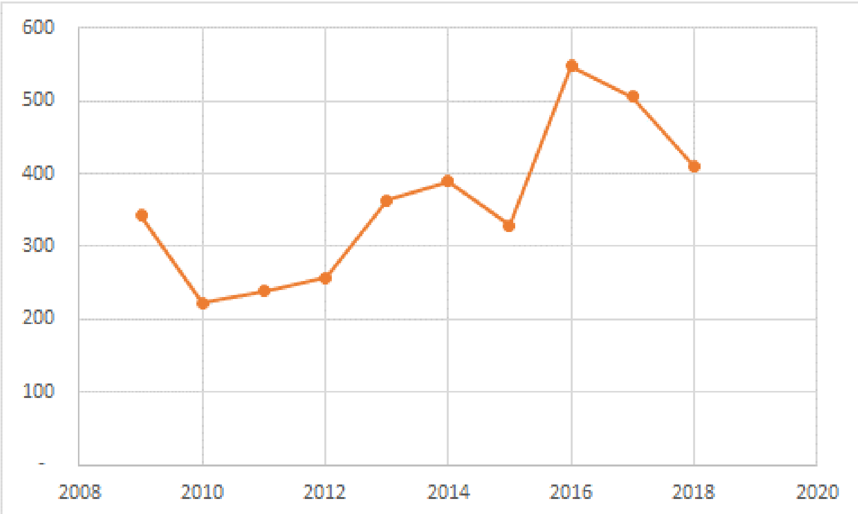
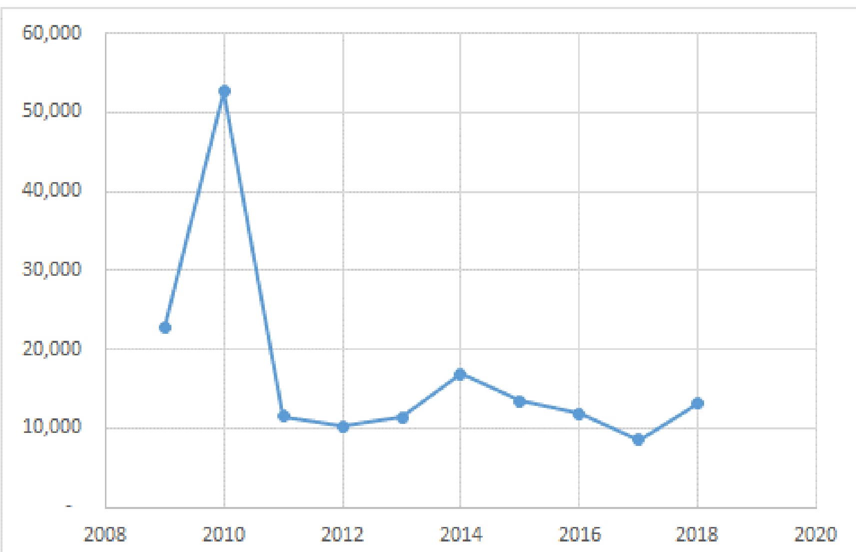


Figure A2: Sediment discharges from the Elkton Wastewater Treatment Plant (pounds per year)



Attachment B

Trading Away Clean Water Progress in Maryland

Center for Progressive Reform CPR

EIP ENVIRONMENTAL INTEGRITY PROJECT

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Executive Summary

The Chesapeake Bay watershed covers parts of eight states and the District of Columbia. It is home to an aquatic ecosystem so diverse and historically productive that it is studied by scientists from around the world. But years of pollution have left the Bay in poor health, prompting the Environmental Protection Agency (EPA) to establish a landmark watershed cleanup plan in coordination with the six watershed states and the District of Columbia. Begun in 2010, the ambitious goal of this plan was to have practices in place by 2025 that would eventually reduce the quantity of nitrogen, phosphorus, and sediment pollution entering the Bay by 25 percent, 24 percent, and 20 percent, respectively. To be sure the effort stayed on track, the plan called for more than half of the progress to be in place by the plan's midpoint in 2017.

We are now at that midpoint of the restoration plan, and it is clear that the states collectively have not met their interim 2017 goal, and indeed look to be nowhere close to reaching the final 2025 goal. Progress has lagged in large part because restoring the Chesapeake Bay requires substantial energy, commitment, and, of course, resources. But with most of the "low-hanging" pollution reductions already banked, regulators and government officials across the watershed are desperately scrambling for additional reductions. Sometimes, these efforts result in truly innovative approaches, but sometimes they rely on corner-cutting.

The current push for a trading market for nutrient pollution is seen by some as an innovative market-based solution to jump-start the flagging restoration effort at a low cost. A trading market would allow people, companies, and governments required by law to reduce the amount of pollution they discharge to purchase "credits" for pollution reduction efforts undertaken by someone else. In theory, water pollution trading ensures overall discharges are capped over time and encourages reductions to happen where they can be achieved at the lowest cost. If done right, a trading program may provide an incentive for some to reduce pollution beyond what is required of them by law.

But water pollution trading is untested on a large scale in the real world, and success or failure in the context of the Bay depends entirely on how the market is structured. The main problem with trading generally is the risk that program designers will prioritize rules that promote trading activity over ones that would demonstrably help to meet pollution-reduction goals. In their efforts to develop a functioning market, they can lose sight of the true purpose: cleaning up the Bay.

The first principle of trading should be to do no harm. Trading programs are only a means to an end. The end is clean water, not establishing a high-volume trading market. The Chesapeake Bay will not be restored by shuffling pollution credits around or by concocting questionable accounting rules. If the rules governing a trading market are drawn poorly, then the market could actually facilitate an increase in pollution with each pollution credit traded.

The following report is based on a close evaluation and analysis of more than two years' effort by the Maryland Department of the Environment to create a water pollution trading program. Over the past two years, the department has worked with a stakeholder advisory group to develop a new, comprehensive nutrient trading program. The department released a draft trading manual and a number of early discussion drafts before submitting its finished product to the General Assembly in October 2017. After immediate criticism, the department pulled the regulations back to make some changes and on December 8, 2017, published a final proposal of the regulations for public comment. Unless the department again pulls the regulations back, the new trading program will be up and running in early 2018.

From day one, environmentalists and others have raised concerns about program design choices that threaten to undermine the broad goal of reducing pollution in an equitable, measureable, and transparent way. True to those expectations, the final proposed trading regulations suffer from three major problems:

- **Uncertain Reductions**: The regulations fail to account for uncertainty about the degree to which certain pollution-reduction activities are actually reducing pollution;

- **Pollution Hot Spots**. The regulations will allow trading in a way that leads to pollution hot spots and other concerns for local communities and water quality; and

- **Paper Credits**. The regulations will allow trading of credits that exist only on paper and are not backed by real pollution reductions — "paper credits."

If Maryland's trading program is to succeed in creating a market that reduces pollution with every trade, we should expect to see dozens or hundreds of new water pollution control projects created throughout the state over the next few years. Instead, what the newly proposed regulations are likely to generate is what the nonpartisan federal analysts at the Government Accountability Office (GAO) recently found in their review of about two dozen smaller water pollution trading programs around the United States: that "trading is not responsible for reducing nutrient pollution, according to EPA, state, and other stakeholders" but instead "was useful because it allowed point sources to manage risk" and "reduce the cost of compliance." If Maryland expects a different result here, one that actually reduces nutrient pollution, it will need to significantly revise the proposed trading regulations.

Maryland has traditionally been seen as a leader in Bay restoration efforts, but the new nutrient trading policy proposed by the state's Department of the Environment has several major flaws. If adopted, the policy would threaten not only Maryland's leadership role, but also the potential for meeting the state's pollution reduction goals under the Bay cleanup.

An Introduction to Pollution Trading

Pollution trading is a market-based regulatory tool that has primarily been used in the United States over the last several decades to facilitate the reduction of air pollution or mitigate human impact on our climate. Familiar examples include the national acid-rain reduction effort based on trading credits for reducing nitrogen oxide and sulfur dioxide emissions from stationary sources of air pollution. The common theme is that trading can be used to allocate pollution reduction responsibilities across a large geographic area, where pollutants are widely dispersed and the total pollution load from all sources may be capped and reduced.

The premise behind pollution trading is that some entities can reduce their pollution loads more easily than others. If the required reductions are converted to 'credits,' which can be bought and sold, then those who cannot easily reduce their pollution can instead offset their excess by purchasing credits from others who are able to go beyond their individual limits at a lower cost. In the abstract, trading can incentivize pollution reductions from the easiest, most affordable sources, leading to a lower total cost of meeting a pollution cap.

A nutrient trading program, if implemented correctly, will include carefully considered rules and safeguards. A trading program implemented without such safeguards, can easily lead to an overall increase in pollution.

In theory, then, pollution trading might be a reasonable regulatory mechanism for the Chesapeake Bay Total Maximum Daily Load (Bay TMDL) because Bay pollutants originate at a variety of geographically dispersed sources and because decades of careful scientific study have established a strong understanding of the pollution levels that the receiving waters can accommodate.

Real-world nutrient trading programs are complex. A nutrient trading program, if implemented correctly, will include carefully considered rules and safeguards. These safeguards include things like rigorous reporting requirements, transparency, mechanisms for enforcement and evaluation of program effectiveness, and quantitative adjustments to account for uncertainty.

If a trading program is implemented without such safeguards, it can easily lead to an overall increase in pollution. In other words, efforts to promote a nutrient trading program by making it easier or cheaper for participants can be counterproductive. If policymakers lose sight of the ultimate goal — clean water — and instead become fixated on maximizing trading market activity, they may omit important safeguards. This will inevitably lead to a policy failure – marketplace activity will go up, but so will pollution.

Another risk inherent in trading relates to geography – if a nutrient trading program is designed around a cap covering a large area (*e.g.*, the Bay watershed, or a state in its entirety), it can create local "hot spots" where pollution can remain at previous levels or even increase. Such a failure to eliminate hot spots might not prevent the region from meeting the overall cap but could create unhealthy conditions for specific waterways and communities. A successful nutrient trading program will, therefore, include safeguards to protect local water quality.

The U.S. Environmental Protection Agency (EPA) expects all state-level nutrient trading programs to contain multiple, specific safeguards. The agency's expectations are laid out in a series of "Technical Memoranda" on topics such as "establishing offset and trading baselines" and "accounting for uncertainty."[1] The Technical Memoranda reflect EPA expectations about what is necessary to ensure the attainment of water quality standards in the Chesapeake Bay watershed. EPA is supposed to object to Clean Water Act permits, and reject pollution load reduction credits claimed by states that are part of the Bay TMDL, if they are based on an inadequate trading program.

To briefly summarize, a few of the essential elements of a successful trading program include:

- Nutrient credits that account for uncertainty and the risk of a net increase in pollution loads;

- Nutrient credits that meet the principle of "additionality," meaning that each credit must be backed by a real and additional reduction beyond what the credit generator is already obligated to produce; and

- Protections for local water quality.

These issues are not the only fundamental components of a legitimate and well-designed trading policy, but they stand out because they have the greatest potential to derail progress in restoring the Chesapeake Bay. If the final trading program regulations address these three issues properly, the program may ultimately be successful at providing minor additional nutrient and sediment pollution reduction benefits while mitigating the side effects of pollution trading. But if the current trading regulations become law, Maryland's program will almost surely deliver a clear and unambiguous setback for the Bay and may significantly worsen local water quality and environmental conditions for many communities.

Pollution Hot Spots Are Inevitable and Must Be Mitigated

Pollution trading programs can create local "hot spots," where a large number of pollution credits are bought in a small geographic area. By definition, each credit represents pollution reduced somewhere other than where credits are purchased. A well-designed pollution trading program, however, can mitigate local impacts. Unfortunately, Maryland's recently proposed trading regulations do not resolve these concerns, raising the possibility that they cross the line in the Clean Water Act that prohibits anything that "causes or contributes" to local water quality impairments.

Hot spots present two primary concerns: first, that discharges of the target pollutant remain unacceptably high in local areas; and second, that discharges of co-pollutants are ignored.

Hot spots present two primary concerns: first, that discharges of the target pollutant remain unacceptably high in local areas; and second, that discharges of co-pollutants are ignored.

In a properly designed trading program, pollution is reduced in the locations where credits are generated and never surpasses pre-trading levels where the credits are purchased. In essence, credit purchasers in a trading program with a pollution cap are importing the right to continue to discharge pollution in their area. This will necessarily cause disparate outcomes for communities and ecosystems surrounding the credit purchasers, compared with the area surrounding the credit sellers.

All trading programs focus on only one or a few specific pollutants. The pollutant of concern for climate trading programs is generally carbon dioxide; with air programs, it might be nitrogen oxides or sulfur dioxide; and with water pollution trading programs, the pollutants of concern are often nutrients. Invariably, any type of trading program ignores many other pollutants that are discharged alongside the pollutant of concern. This is a challenge for nearly every trading program. Thus, program designers and policymakers should ask important questions before proceeding, such as:

- How many other pollutants are present in the discharges that we are seeking to address?
- Are these other co-pollutants more or less harmful to public health or the environment?
- Would existing pollution reduction efforts better protect communities than a trading program?
- Would a trading program lead to significant disinvestment in environmentally and economically beneficial pollution reduction programs?

Maryland's proposed trading regulations have fundamental flaws that fail to protect local waters from both stubbornly high levels of nutrients and unacceptable discharges of co-pollutants.

Maryland's Proposed Trading Regions Are Not Based on the Real World

One of the first questions confronting pollution trading program designers – and one of the first opportunities to establish policies that protect against hot spots – is how to draw trading region boundaries. Put simply, large boundaries maximize the number of potential trades, while smaller boundaries limit the possibility for adverse consequences on local communities. Since the main purpose of a nutrient trading program is clean water, not maximizing trading volumes, Maryland's nutrient trading program needs geographic restrictions based on reasonably small and actual watershed boundaries, reflecting local water quality conditions and guarding against downstream trades that fail to benefit local areas.

Figure 1. Comparison of the Proposed Trading Regions and Four-Digit Watersheds

Note: The map on the left shows the five different four-digit watersheds in Maryland's portion of the Chesapeake Bay watershed, including the merger of three different four-digit watersheds (Western Shore, Eastern Shore, and Susquehanna) into one new trading region, as proposed in the trading regulations. The map on the right shows the 153 eight-digit watersheds in Maryland, including the 142 watersheds in the Chesapeake Bay watershed.

The commonly used classification system for watersheds is the U.S. Geological Survey's Hydrologic Unit Code.[2] This code spans from very large "two-digit" regions (like the entire Mid-Atlantic, coded HUC 02) all the way down to a small "twelve-digit" subwatershed (like Lower Rock Creek or Upper Bull Run, both of which have HUC identifiers that are 12 numbers long). From the outset, Maryland's trading rules have centered on only three excessively large trading regions: the Potomac River Basin, the Patuxent River Basin, and everything else in Maryland's portion of the Chesapeake Bay watershed (which creates a single trading region out of three different four-digit watersheds).

Despite consistent opposition and feedback from concerned stakeholders, Maryland's recently proposed regulations maintain these three trading regions, which are both overly expansive and not based on real watershed boundaries. Figure 1 above illustrates the difference between large four digit watersheds in Maryland and smaller eight-digit watersheds.

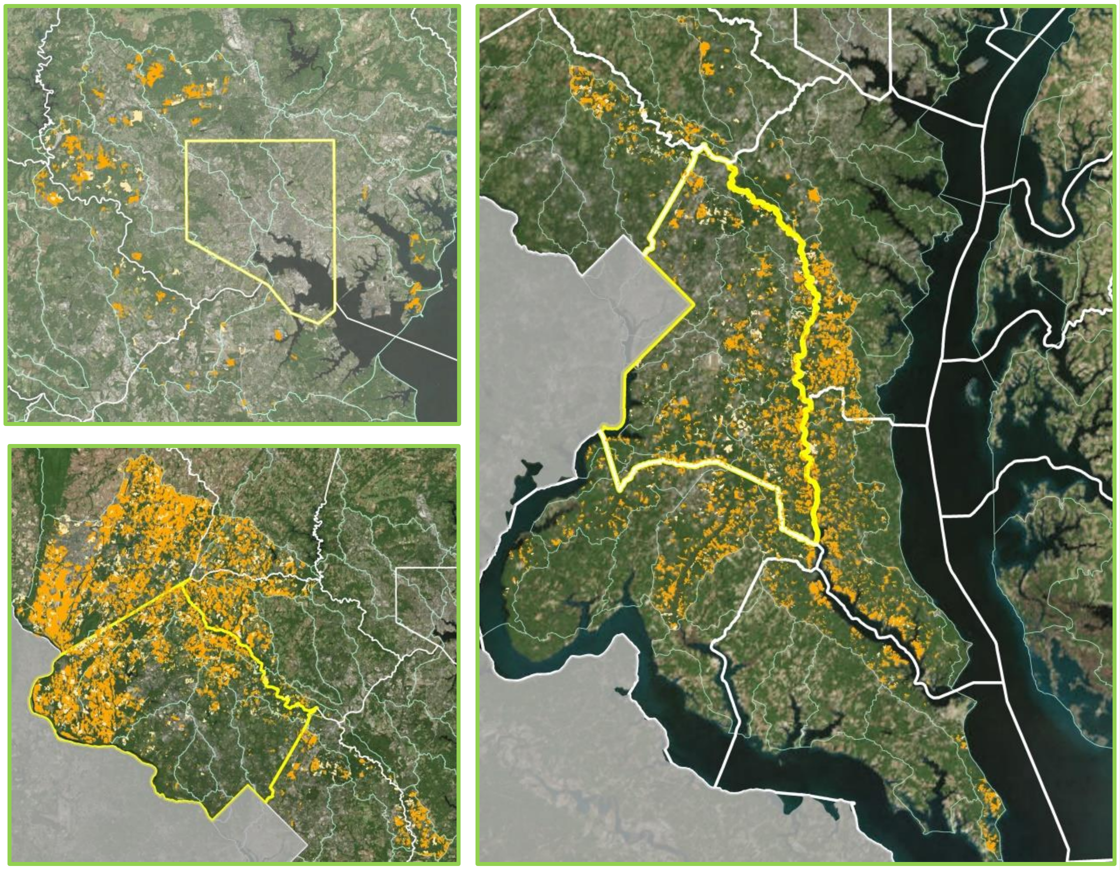
Drawing only three excessively large "four-digit" trading regions means that urban Prince George's County, east of Washington, D.C., could buy pollution reduction credits from someone in Garrett County in the far western part of the state, or that Baltimore City could buy credits from somewhere in Worcester County near the Atlantic Ocean. The justification for such expansive trading geographies is that it is all the same as far as pollution to the main stem of the Chesapeake Bay is concerned. But what about local water quality?

Recognizing that the largest demand for nutrient credits will likely be cities and counties needing to comply with their relatively expensive stormwater permits, Maryland's early draft trading manual laid out specific rules governing where those credits could come from. For example, one of the drafts of the trading manual proposed a sensible trading scale in which a county stormwater permit holder could purchase credits from any eight-digit watershed that overlapped with the county boundary, giving most counties somewhere between five and ten watersheds from which to purchase credits and creating a trading region twice the size of the county.

Using moderately sized eight-digit watersheds as the trading boundaries would have been a reasonable compromise among stakeholders. Unfortunately, the recently proposed final version of the regulations submitted in December 2017 uses the excessively large four-digit regions. Without suitably small trading boundaries, the regulations will fail to protect local water quality and will distort the market by limiting the demand for local credits. Figure 2 below shows that a trading system based on eight-digit watersheds would provide plenty of capacity to purchase credits generated on crop or pasture land in and around each urban county. With so much agricultural and other land available for the generation of credits in local watershed boundaries, there is no justification for maintaining just three oversized trading regions.

The early draft trading manual declared as a "guiding principle" that the program must "protect local water quality." But without more stringent rules, this guiding principle will be a hollow promise, inconsistent with EPA's recent guidance[3] providing explicit directions to Chesapeake Bay states regarding how to create a proper trading program that protects local water quality. Protecting local water quality is neither optional nor subordinate to efforts to protect the Chesapeake Bay. The Clean Water Act prohibits anything that causes or contributes to local water quality impairments. If the trading regulations are designed in a way that leads to an increase in pollution of local waters, it will be hard to defend the regulations as lawful.

Figure 2: Crop and Pasture Lands in Urban Watersheds



Note: The maps above show crop and pasture lands in watersheds that are within or intersect the boundaries of Montgomery and Prince George's counties and Baltimore City. This demonstrates the potential for the purchase of credits generated from the agriculture sector even in the most urban counties and where trading regions are restricted to only eight-digit watersheds.

Sending Money Downstream

Another basic principle that Maryland has recognized in early drafts of the trading rules but failed to fully achieve in its recently proposed regulations is the need to ensure that pollution credit buyers are downstream of the sellers or generators of those credits. To understand why this principle is essential to creating a trading program that protects local water quality, consider the following example.

If the Town of Springfield wanted to purchase pollution reduction credits from a farmer who can reduce water pollution at a much lower cost than the town can, should it turn to Farmer Joe two miles upstream or Farmer Bob two miles downstream? The town would be foolish if it sent taxpayer dollars down to Farmer Bob, whose pollution reductions would only benefit downstream communities and never reach the town. In addition, the entire stretch of land and water between the upstream town and farmer Bob would suffer. The town would obviously want to contract with Farmer Joe, upstream, to benefit water quality for the town (and the stretch between Farmer Joe and the town).

But what if Farmer Joe is charging twice as much, or cannot and will not reduce pollution at all? Then Springfield might have an incentive to work with Farmer Bob downstream anyway, even though the trade threatens local water quality.

Maryland's new regulations include some restrictions on these sorts of trades involving downstream purchases that are improved somewhat from earlier drafts of the regulations, but not enough to prevent local water quality from being sacrificed with inappropriate downstream purchases of credits.

Last-Minute Changes Are Still Not Enough to Protect Local Waters

Precise and carefully crafted geographic trading rules are essential for creating a trading market that is protective of the local environment. But smart geographic rules are also economically beneficial.

Maryland first announced the release of its trading regulations in October 2017, but after stakeholders expressed serious concerns about the lack of rules protecting impaired local waters, among other things, the department pulled the regulations back to make changes. Unfortunately, those changes still do not address a few important issues.

For example, the department changed the regulations by requiring that a credit from a local impaired waterway be generated within the same watershed "*or* upstream" [emphasis added]. It is unclear whether this is a drafting error or intentional, but instead of requiring the credit to be bought in the same local watershed *and* upstream, the regulations still allow for downstream purchases. Moreover, the regulations do not provide a definition of "upstream." This is no small or inconsequential oversight. Because the trading regulations contain only three excessively large trading regions, it is possible that a credit buyer in a locally impaired watershed could still be allowed to buy a credit from dozens, or even hundreds, of miles "upstream" in that same trading region.

Precise and carefully crafted geographic trading rules are essential for creating a trading market that is protective of the local environment. But smart geographic rules are also economically beneficial. MDE declared that a nutrient trading system supports "an emerging environmental restoration economy." But if a town sends its taxpayer dollars downstream, or to far-flung areas of the state, not only will less money go to improve local water quality, it could stymie the actual restoration economies that have already been emerging around the state thanks to major investments in clean water projects funded by county stormwater remediation fees and other sources.

Each year, state and local governments invest hundreds of millions of dollars in stormwater remediation, stream restoration, and other projects to reduce the impact of polluted runoff and improve local streams. These restoration projects improve water quality and the health of local communities and ecosystems. A growing body of economic research shows that they also provide a substantial return on the investment of local taxpayer dollars.[4] These projects are both labor- and capital-intensive, providing local jobs that cannot be exported and boosting demand for local contractors and engineering firms. Such investments benefit the local economy, the local environment, and local quality of life – a triple bottom line.

But if trading regions are drawn broadly and municipalities are allowed to purchase cheap credits from faraway places, the state's trading program will create a strong disincentive to make these investments, trading away all of the benefits and undercutting the local restoration economy.

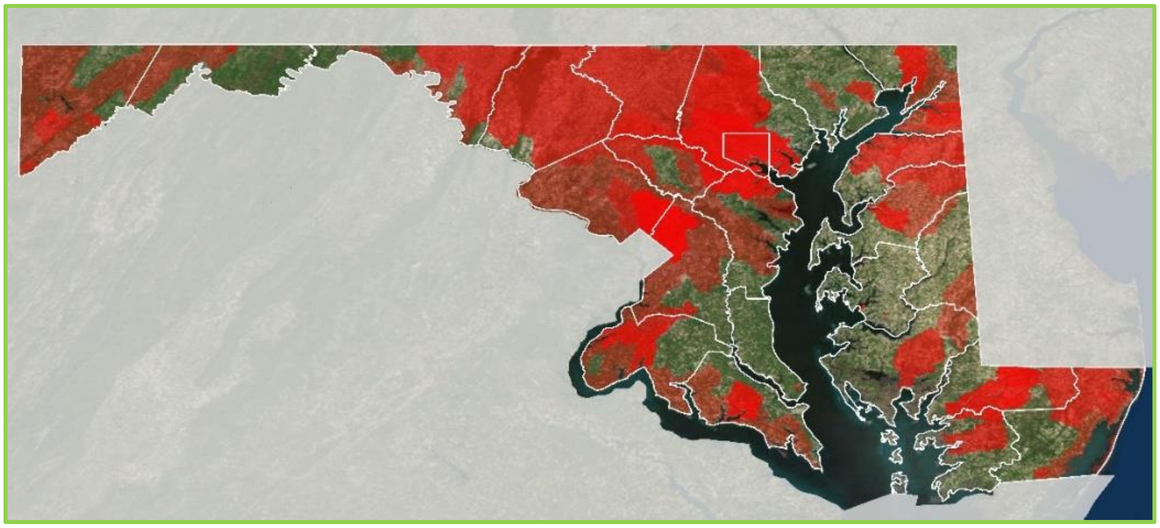
Making Sure Hot Spots Do Not Become Dangerously Polluted Clusters

Creating reasonably small trading regions and prohibiting the purchase of downstream credits are two relatively straightforward recommendations for mitigating hot spots and addressing local water quality concerns. But a much thornier issue is how to make sure a *nutrient* trading program does not delay or destroy efforts to reduce *other* forms of pollution, including some that are far more toxic and hazardous to local communities.

The main focus of Maryland's nutrient trading program is reducing nitrogen pollution in the Chesapeake Bay. The program's developers are certainly cognizant of the problems that arise when local water quality conditions are ignored. In fact, the very first paragraph of the trading regulations refer to the need to "enhance Maryland's effort to protect and restore not only the water resources of the Chesapeake Bay and its tributaries, *but also local waters*" [emphasis added], and allow trades "as long as the trade does not cause or contribute to a violation of State water quality standards." However, the new regulations are designed in such a way that they will almost certainly result in disinvestment from pollution control projects, particularly in urban areas that are most afflicted by pollution.

Most local waterways in Maryland are recognized as impaired by at least one pollutant, and as a result, many watersheds are subject to one or more TMDLs (see Figure 3 below). If the state's trading program were to fully respect local water quality concerns, virtually all trades would be subject to restrictive geographic trading rules that force trades to be upstream *and* within the local (eight-digit or smaller) watershed. Unfortunately, even if such protective rules that respect the territorial boundaries of TMDLs or impaired watersheds were developed, they would not, by themselves, be sufficient to protect local water quality. To illustrate why, consider the most common type of trade initially envisioned by trading program advocates and developers.

Figure 3. Watersheds Subject to a Local TMDL



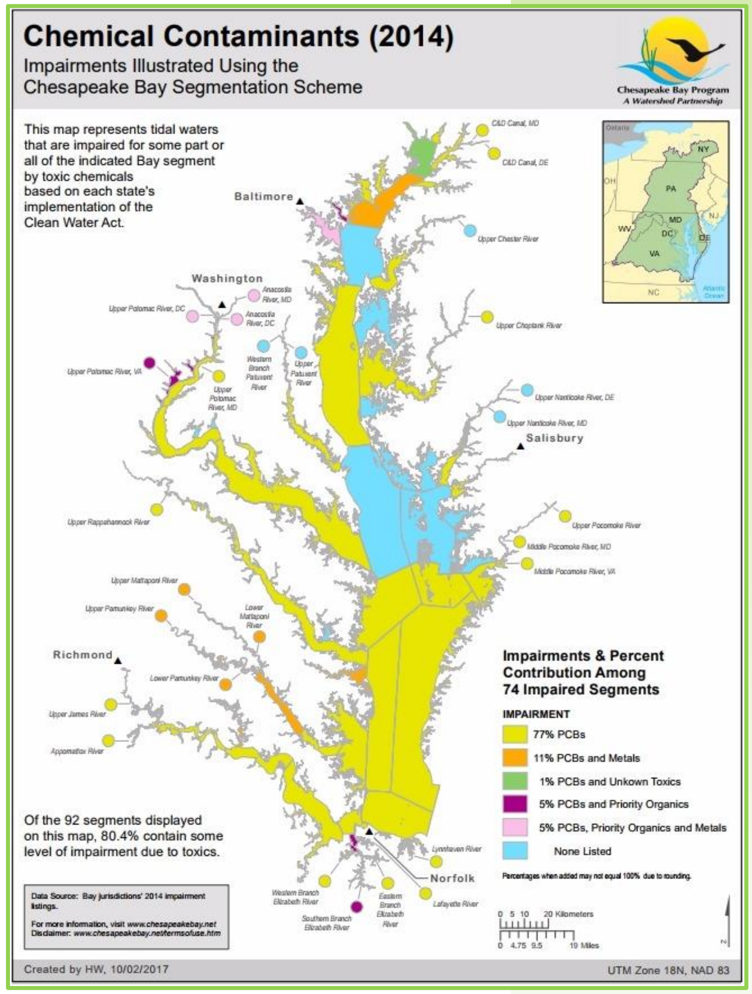
Note: Areas in red reflect watersheds subject to a local TMDL. Darker shades of red reflect areas subject to multiple TMDLs. The map does not show areas subject to the Chesapeake Bay TMDL, which covers nearly all of the state, or areas that are known to be impaired but do not yet have a TMDL.

Most trading volume in a future trading market in Maryland will likely occur between a municipality holding a stormwater permit and a farmer, because this is where the greatest opportunity for arbitrage, or difference in the ability to reduce pollution, exists. Reducing a pound of nitrogen pollution by removing pavement or installing polluted runoff control projects is expensive on a dollar-per-pound basis. It is much cheaper to reduce a pound of nitrogen on a farm field by planting or installing agricultural best management practices and projects. Given this price differential, most nitrogen credits should theoretically be purchased by a stormwater permit holder and sold by a farmer.

In this theoretical world, the trading program would involve millions of *nitrogen* credits flowing from agricultural sellers to eager urban buyers, and total *nitrogen* pollution would theoretically decline (further assuming the trading program rules were designed appropriately). But if a municipality decides to forgo the installation of stormwater management projects, it is not only missing the opportunity to reduce *nitrogen* pollution, but also to address the problem of hundreds of chemicals and other pollutants coating the pavement and washing untreated through the local communities and directly into the nearest waterways.

In this way, where the pollution profiles of buyers and sellers are vastly different, a one-for-one trade of nitrogen will not necessarily improve the environment or protect community health. In fact, such a trade could make matters much worse for communities if the buyer is purchasing only a reduction of nitrogen in exchange for the permission not to control dozens, if not hundreds, of other toxic pollutants that would otherwise be captured. (And, as noted, the community gets no benefit at all if the credit is not purchased from upstream in the same watershed.)

This sort of disinvestment in local environmental restoration projects limits local investments in green jobs and fails to deliver needed improvements to public health in local communities. It may reduce short-term costs for the local government, but it shifts costs onto members of the local community and prevents the economic, health, and environmental benefits that come from such investments.



The Chesapeake Bay suffers from nitrogen, phosphorus, and sediment pollution, but it also receives all sorts of other toxic contaminants, such as lead, mercury, and thousands of chemical compounds. This is why the 2014 Chesapeake Bay Watershed Agreement speaks of the need for achieving the Bay TMDL reductions of nutrient and sediment pollution, as well as "reducing the impact of toxic contaminants" including "mercury, PCBs, and other contaminants of emerging and widespread concern." [5] The Chesapeake Bay Program has established an entire work group focused on how to address these many dangerous pollutants.[6]

A trading program that does not recognize the hazardous potential from the many toxic substances polluting urban waterways can end up ignoring our most vulnerable communities by allowing local jurisdictions to merely pursue the cheapest possible manner to reduce nutrients or comply with their environmental permit obligations. As shown in a map produced by the Toxic Contaminant Workgroup,[7] at right, most tidal segments of the Chesapeake Bay watershed are impaired by at least one class of toxic chemicals, and urban waters near Baltimore City and Washington, D.C., are impaired by several classes of toxic contaminants.

To address this problem, trading regulations should include provisions that require credit purchasers to disclose publicly all pollutants they discharge and require the department to prohibit any purchase without a demonstration that the credit buyer is adequately controlling each pollutant. Where a proposed purchaser of nutrient or sediment credits discharges a different type of pollution into a waterway that has been deemed impaired for that same pollutant, the trade should be prohibited without a clear demonstration that the purchase will not interfere with efforts to control that pollutant.

Real Pollution Reductions Can Only Be Achieved if Maryland Accounts for Uncertainty

If a farmer plants a forested buffer between her crop fields and a river, she will reduce the amount of nitrogen and phosphorus migrating from the crop fields to the river. The farmer will reduce her pollution load. If the farmer lives in a state with a nutrient trading program, she may be able to sell credits for that reduction. The number of credits that the farmer can sell will be calculated using a model based on studies that estimate the extent to which buffers are generally able to reduce nutrient loads.

But will this particular farmer's forest buffer perform as well as the model assumes? Probably not. The scientific literature on this topic suggests that forest buffers and other agricultural Best Management Practices (BMPs) do not perform as well in the real world as they do in experimental studies. There is a lot of uncertainty in BMP performance. If we do not account for that uncertainty, we run the risk of giving credit for load reductions that have not actually occurred.

Substantial Trading Ratios Are a Fundamental Component of Good Trading Programs

Simple pound-for-pound water pollution trading schemes are rare. Most trading programs apply one or more *trading ratios* or *retirement provisions* to alter the balance of credits on either side of a sale. A 2:1 trading ratio, for example, requires a credit buyer to purchase two pounds worth of credits for every pound of pollution the buyer plans to discharge. Whatever the precise numbers, trading ratios or retirement provisions are critical to good trading programs because they enable the programs to achieve a range of policy goals including water quality improvement, creation of an insurance or reserve pool of credits that are used to mitigate failed credit generation, and adjustment for pollution attenuation between an upstream location and a downstream location.[8]

One of the most important policy goals served by trading ratios is accounting for the uncertainty inherent in a trade. A credit theoretically represents a pound of pollution reduction, but the actual amount of pollution reduced by a BMP is rarely, if ever, known. The net load after a trade should be zero – with the credit generator offsetting the load of the credit purchaser – but in practice it will almost always be something other than zero. This uncertainty is typically addressed with an explicit "uncertainty ratio." Uncertainty ratios provide a margin of safety against overestimates of load reduction, and they help to account for variability in the performance of credited practices. An uncertainty ratio is especially important for trades or offsets involving so-called "nonpoint" sources, such as farm fields, because the pollution loads from nonpoint sources cannot be measured in the same way that discrete point source discharges (e.g., at the end of a pipe) can be measured.

In the context of the Bay TMDL, uncertainty ratios help environmental agencies provide the required "reasonable assurance" that water quality standards will be attained:

> When the [EPA] establishes or approves a [TMDL] that allocates pollutant loads to both point and nonpoint sources, it determines whether there is reasonable assurance that load allocations will be achieved and water quality standards will be attained. EPA does that to ensure that the wasteload allocations and load allocations established in the TMDL are not based on overly generous assumptions regarding the amount of nonpoint source pollutant reductions that will occur. This is necessary because the wasteload allocations for point sources are determined, in part, on the basis of the expected contributions to be made by nonpoint sources to the total pollutant reductions necessary to achieve water quality standards. If the reductions embodied in load allocations are not fully achieved because of a failure to fully implement needed point source pollution controls, or the reduction potential of the proposed BMPs was overestimated, the collective reductions from all sources will not result in attainment of water quality standards. As a result, EPA evaluates whether a TMDL provides reasonable assurance that nonpoint source controls will achieve expected load reductions.[9]

Research indicates that regulators routinely overestimate best management practices efficiencies; because of the present degree of uncertainty, an uncertainty ratio of at least 2:1 should be established.

Uncertainty ratios also help agencies provide a margin of safety, another requirement of the Clean Water Act.[10]

As explained below, research indicates that regulators routinely overestimate BMP efficiencies; because of the present degree of uncertainty, an uncertainty ratio of at least 2:1 should be established. This is in line with the uncertainty ratios applied in other nonpoint-point nutrient trading programs, which are almost universally 2:1 or higher.

Regulators Routinely Overestimate BMP Effectiveness

Unlike discharges through monitored point source outfalls, the nutrient load reductions from agricultural BMPs are difficult to measure. Instead, pollution reduction assumptions, sometimes called "BMP efficiencies," are generated from carefully controlled research studies.

For a number of reasons, BMP efficiencies derived from research experiments tend to overestimate real-world pollution reductions. A study of BMP implementation at a small farm in Michigan presents one example.[11] Researchers first estimated and then measured the phosphorus removal efficiencies of various BMPs, including the exclusion of livestock from a stream area, the planting of grass filter strips, and manure management. The projected BMP efficiency (87 percent phosphorus removal) overestimated the actual efficiency (23.4 percent) by a factor greater than 3.

That was not an isolated case. The National Research Council (NRC) observed that

> BMP efficiencies are often derived from limited research or small-scale, intensive, field-monitoring studies in which they may perform better than they would in aggregate in larger applications . . . Thus, estimates of load reduction efficiencies are subject to a high degree of uncertainty.[12]

The NRC suggests that the uncertainty is largely in one direction – BMP efficiencies are likely to overestimate actual nutrient removals. Indeed, the report goes on to say that "[p]ast experience . . . has shown that credited BMP efficiencies have more commonly been decreased rather than increased in the light of new field information."[13]

The EPA echoes the NRC conclusion, stating that "few, if any, data suggest actual watershed-wide implementation efficiencies as high as those in the research literature."[14] This is in part because real-world validation of nonpoint pollution load estimates is so difficult that it is rarely attempted. However, to the extent that we can compare BMP pollution reduction assumptions to actual pollution reductions, the BMP efficiencies appear to be overly optimistic.[15]

Such findings are persuasive, and they make clear that the gaps between projected and actual pollution savings from BMP are not simply a matter of uncertainty or unpredictability, but rather of systematic bias in the projections. In some cases, the Chesapeake Bay Model BMP efficiencies reflect adjustments made to account for this bias. Research estimates for cover crop effectiveness, for example, were reduced by 25 percent in an attempt to approximate realistic estimates for average conditions.[16] It is important to note that these adjustments, when they were made, only accounted for a perceived bias. Even after such adjustments are made, the effectiveness of a BMP continues to be uncertain due to factors such as how well a BMP is maintained or how long a living BMP (e.g., a forest buffer) takes to reach maturity.

BMP Efficiencies Are Not 'Conservative'

Some people familiar with the development and implementation of nutrient trading programs have mischaracterized BMP efficiencies as "conservative," meaning that they are intentionally lower than actual effectiveness.[17] This is a critical error. As discussed above, it is more likely that the opposite is true, and that BMP efficiencies are overly optimistic. In the case of the Bay Model's treatment of agricultural BMPs, for example, even after adjustments were made to adjust for known biases, the results were not conservative. According to EPA, "The process used to develop the CBP partnership BMP effectiveness values is designed to arrive at unbiased and realistic values…. [Adjustments to remove bias] generate BMP effectiveness values that are *unbiased and realistic but not necessarily conservative* [emphasis added]."[18] In the best case, BMP efficiencies are realistic. In other cases, they suffer from such a bias, and they are too high. They are, in fact, the opposite of conservative.

Research to date suggests that an uncertainty ratio of at least 2:1 is needed to account for the high degree of uncertainty associated with agricultural and other nonpoint BMPs.

Trading Ratios Less Than 2:1 Are Outside the Norm

Research to date suggests that an uncertainty ratio of at least 2:1 is needed to account for the high degree of uncertainty associated with agricultural and other nonpoint BMPs. In general, reviews of pollutant trading programs have confirmed that uncertainty ratios are usually 2:1. A 2005 EPA review, for example, stated that:

> Trading ratios often are used as a mechanism to manage uncertainty associated with the effectiveness of non-point source controls. All programs use trading ratios, but these ratios vary considerably from program to program. . . [T]he most common trading ratio for programs that are trading nutrients between point and non-point sources is 2 to 1.[19]

Trading programs have been reviewed many times, and this conclusion about uncertainty ratios is consistent.[20]

Several reviews of trading ratios have blurred the distinction between ratios used to address uncertainty and ratios used for other purposes (*e.g.*, net reduction in load), and have also considered various ratios used in point-to-point, nonpoint-to-point, or cross-pollutant trading. We have read several reviews and looked into individual trading programs in order to make a rough inventory of uncertainty ratios used specifically in nonpoint-to-point trading of nutrients. As shown in Table 1, uncertainty ratios are almost uniformly 2:1.

Uncertainty Ratios Account for Uncertainty in Credit Generation

The EPA has identified several overlapping sources of uncertainty in nutrient trading, including the BMP efficiency estimate, variability in weather conditions, the time it takes for a BMP to become fully functional, and others. All of these sources of uncertainty relate to characteristics of the credit generator.[21] The uncertainty ratio is a tool to mitigate against underperformance of credit-generating BMPs. Some have suggested that trades between nonpoint credit generators and nonpoint credit purchasers – nonpoint-nonpoint trades – should not require uncertainty ratios, with a vague justification that the uncertainties on either side of the trade will mysteriously "cancel each other out." This argument is both glib and unsupported by experience.

The uncertainty ratio exists to account for uncertainty in *credit generation*; the characteristics of the credit purchaser are irrelevant. Mathematically, there is no reason to expect that the uncertainties on either side of the trade will cancel each other out. In fact, in some scenarios they will amplify each other, leading to an even greater net increase in loads. Appendix A breaks this down graphically and shows that the net result of a trade is the same regardless of whether the credit purchaser is a point source or a nonpoint source. With both types of trade, there is a significant risk that there will be a net increase in pollution unless an uncertainty ratio is used.

EPA Expects All Trades Involving Nonpoint Credit Generators to Use 2:1 Uncertainty Ratios

The EPA set out its expectations for addressing uncertainty in nutrient trading programs in a 2014 technical memorandum.[22] Again, this memorandum's expectations are not merely aspirational or in any way optional. The memo provides instructions to the states regarding the policies that the EPA will require before approving permits and accepting nutrient reduction data for use in the Bay Model.

The technical memorandum on uncertainty states that, with a couple of narrow exceptions, "EPA expects the Bay jurisdictions to apply an uncertainty ratio of at least 2:1 to transactions involving credits generated by nonpoint sources."[23] This statement is clearly focused on credit generators, says nothing about credit purchasers, and does not create an exception for nonpoint credit purchasers (nonpoint-nonpoint trades). States must apply the 2:1 ratio to all trades involving nonpoint credit generators, even if the purchaser is also a nonpoint source. Failure to do so would violate the TMDL and increase the risk of an overall increase in pollution loads.

Maryland's Proposed Nutrient Trading Regulation Fails to Adequately Implement the 2:1 Uncertainty Ratio

The Maryland Department of the Environment's (MDE) recently proposed nutrient trading regulation includes a 2:1 uncertainty ratio but does not apply it broadly enough. Specifically, it requires a 2:1 ratio for trades "involving credits generated by nonpoint sources and acquired by wastewater point sources."[24] However, the next sentence of the proposed rule creates a giant loophole, allowing MDE to use a lower ratio (or no ratio) if "the generator, seller or buyer of the credit is able to demonstrate to the Department that a lower ratio is justified and protective of water quality standards." MDE therefore has virtually unlimited discretion to ignore EPA's 2:1 ratio requirement.

Just as troubling, the regulation explicitly exempts certain nonpoint-to-point trades from the 2:1 requirement. For trades "involving credits generated by nonpoint sources and acquired by stormwater point sources," the uncertainty ratio is 1:1, which is to say no uncertainty ratio at all.[25] This plainly fails to meet EPA expectations.

In addition, the regulation creates yet another carve-out for trades between nonpoint credit generators and "other non-regulated sources," which are generally going to be other nonpoint sources. As described above, there is no rational policy reason to exempt trades between two nonpoint sources, and again MDE has failed to meet EPA expectations.

The result of all of these loopholes is that many trades, perhaps even most trades, will be exempted from the 2:1 uncertainty ratio requirement. If the BMPs used to generate these credits fail to perform as expected, overall pollution loads will increase. As discussed earlier, there is a high likelihood of this happening. MDE's nutrient trading regulation is therefore likely to seriously undermine Maryland's ability to meet its TMDL targets.

Table 1: Uncertainty ratios used in point-nonpoint nutrient trading programs.

Trading Program	Pollutant	Trading Ratio	Basis for Ratio	Reference
Colorado; Bear Creek Total Phosphorus Trade Program	Phosphorus	2:1	Unknown	Bear Creek Watershed Association[26]
Colorado; Chatfield Reservoir	Phosphorus	2:1[27]	Uncertainty (implied by basis for possible exemption[27])	Chatfield Water Authority[28]
Colorado; Cherry Creek Basin Trading Program	Phosphorus	2:1 to 3:1	Uncertainty	U.S. EPA [29]
Colorado; Lake Dillon	Phosphorus	2:1	Unknown	U.S. EPA[30]
Delaware; Pinnacle (Vlassic Foods)	Nutrients	2:1	Margin of safety and location	UVA[31]
Delaware; Inland Bays	Nutrients	2:1	Unknown	UVA[32]
Florida; Lower St. Johns River	Nutrients	2:1 and 3:1, depending on source of credits	Uncertainty	Florida DEP[33]
Massachusetts; Wayland Business Center Treatment Plant Permit	Phosphorus	3:1	Unknown	Environomics[34]
Michigan; Kalamazoo River Water Quality Trading Demonstration Project	Phosphorus	2:1 or 4:1, depending on the nature of baseline practices	Uncertainty	Environomics[35]; U.S. EPA [36]
Michigan; Water Quality Trading	Nutrients and other pollutants	2:1[37]	Uncertainty and environmental benefit	Michigan Administrative Code[37 above]
Minnesota; Southern Minnesota Beet Sugar Cooperative Trading Program	Phosphorus	1.6:1[38]	Uncertainty	Environomics and EcoAgriculture Partners[38]
Minnesota; Draft Statewide Water Quality Trading Rules	Phosphorus	2.5:1	Uncertainty, risk, and location	UVA[39]

Trading Program	Pollutant	Trading Ratio	Basis for Ratio	Reference
New York; New York City Watershed Phosphorus Offset Pilot Program	Phosphorus	3:1	Unknown	Environomics; U.S. EPA [40]
New York; Croton Watershed	Phosphorus	2:1 to 3:1	Unknown	UVA[41]
North Carolina; Neuse River Nutrient Sensitive Water Management Strategy	Nutrients	2:1 (implied by payment price)[42]	Unknown	Environomics[42]; U.S. EPA [43]
North Carolina; Tar-Pamlico Nutrient Reduction Trading Program	Nutrients	2:1 or 3:1, depending on source of credits	Uncertainty	UVA[44]
Ohio; sugar Creek Watershed—Alpine Cheese Co.	Phosphorus	3:1	Uncertainty and Margin of Safety	UVA[45]
Ontario South Nation River Total Phosphorus Management Program	Phosphorus	4:1	Uncertainty	OECD[46]
Virginia trading policy	Nutrients	2:1	Uncertainty	U.S. EPA[47]
Wisconsin Red Cedar River Pilot Trading Program	Phosphorus	2:1	Unknown	Environomics[48]

Paper Credits and the Principle of Additionality

In 2004, Maryland's General Assembly made a bold decision that would significantly reduce water pollution flowing into the Chesapeake but would also alter the nature of any future nutrient trading program in Maryland. The Bay Restoration Fund law created a small user fee to pay for upgrades at the state's 67 major sewage treatment plants, among other pollution control projects. Once fully completed, these 67 large projects will reduce annual nitrogen pollution discharged into the Bay by more than 9 million pounds.

Years later, when Maryland officials began discussing the creation of a comprehensive nutrient trading program, the simplest path forward would have been to simply ignore sewage treatment plants as a potential source of pollution reduction credits, or at least ignore any facilities that had received Bay Restoration Fund money. After all, the state long ago made the decision to subsidize the installation of pollution reduction equipment representing the limits of technology, taking off the table 9 million potential pollution credits – a significant majority of credit generating potential from the municipal wastewater pollution source sector.

Instead, Maryland's trading program will allow already upgraded sewage treatment plants to generate pollution reduction credits. The problem with that approach, of course, is that if pollution reductions have already occurred, then there cannot be any *additional* pollution reductions behind each pollution reduction credit traded. Moreover, if facilities upgraded with public funds are allowed to generate credits without affirmatively acting or investing in a way that further reduces pollution, then the public has effectively subsidized the pollution of waters near both the credit buyer and seller.

It is in fact technologically possible for any of Maryland's upgraded sewage plants to further reduce pollution. But the danger in allowing these plants to become a source of new credits is that, if the trading program does not include just the right mix of carefully crafted rules, the entire program could be jeopardized and the market overwhelmed by "paper credits" backed by no new and actual pollution reductions. This situation would represent a major setback for water quality in Maryland, a dubious use of taxpayer dollars, an unfair advantage for these facilities in the nutrient trading market, and a substantial distortion in the market that the state is working to foster.

This section describes the fundamentally important trading principle of "additionality," analyzes Maryland's development of trading rules for upgraded sewage treatment plants, and offers a few straightforward recommendations to prevent the market from becoming overwhelmed with paper credits that can seriously impair water quality.

Additionality Means Not Getting Something for Nothing

The principle of "additionality" is as simple as it is essential in a pollution trading program. Basically, it means that behind each pollution reduction credit is an *additional* reduction in pollution. By contrast, we use the term "paper credit" here to refer to a credit that exists only on paper and is not backed by any new reduction in pollution. For example, a discharger might try to sell credits for reductions that were made in the past, or for reductions that are to occur in the future. If there are a large number of paper credits in a trading marketplace, the ultimate amount of pollution will fail to meet reduction targets, and may even increase, as buyers attempt to offset real pollution with fictional reductions.

In some pollution trading markets, selling a paper credit might be considered fraud or grounds for serious sanction. And in any trading market, a significant number of paper credits not only harms the environment but can cripple the market by establishing artificially low prices that prevent the participation of legitimate credit producers. After all, it does cost money, time, and resources to reduce pollution. If there is no market signal setting a price, no incentive will exist to invest in the work needed to create pollution-reducing projects to generate new credits. Without significant changes, Maryland's regulations will fail to establish a legitimate market to promote new pollution control projects.

Over the last several years, each of the drafts of the Maryland's nutrient trading manual or regulations has contained provisions that would allow the market to be flooded with innumerable paper credits from sewage treatment plants.

Over the last several years, each of the drafts of the Maryland's nutrient trading manual or regulations has contained provisions that would allow the market to be flooded with innumerable paper credits from sewage treatment plants. This happens when an upgraded facility that had previously used state Bay Restoration Fund subsidies to upgrade to "enhanced nutrient removal" (ENR) technology is allowed to count these past reductions from already upgraded plants as creditable projects.

Specifically, a few provisions in these drafts allowed for the creation of paper credits. First, the rules attempted to redefine ENR pollution levels as 4 milligrams per liter (mg/L) of nitrogen pollution, rather than the lower and more protective 3 mg/L standard already set out in state statute. The Bay Restoration Fund law and all written materials generated by both the General Assembly and MDE during and after the enactment of the statute set 3 mg/L for nitrogen as a key threshold level for the program. To establish a baseline of 4 mg/L would set an inappropriately weak standard for becoming eligible to trade and would, as noted above, subsidize additional pollution.

Second, the draft rules failed to specify that credits must be based on a level of pollution lower than the one at which sewage plants were already operating. In other words, even if a sewage plant was operating at clean levels below the appropriate baseline of 3 mg/L, they could still sell credits for doing nothing more than operating at the levels they were supposed to after receiving state funds to upgrade their technology. Third, these early draft rules did not specify that credits must be generated by *new* projects or activities, such as ones established after a certain date or specified in a credit application. Here again, it appears that the drafters of the rule lost sight of the purpose of the credit-trading market: to reduce pollution.

Despite Improvements, the Regulations Fail To Ensure Real Reductions

After receiving significant feedback about the need to ensure conformance with the principle of additionality, MDE made some changes before releasing the first version of its proposed regulations in October 2017. These new rules appeared to address some of the additionality problems but still contained a number of inconsistent provisions that would create uncertainty and potential loopholes.

These pre-release revisions included three improvements on earlier proposals related to the principle of additionality. One allowed upgraded sewage plants to only “generate credits for performance below 3 mg/L of nitrogen.” The second properly defined a “pollution reduction” behind each credit as “a practice, or combination of practices that is determined by the Chesapeake Bay Program to be an effective and practicable method of preventing or reducing pollutants.” The third is a prohibition on the generation of credits prior to the effective date of the regulations.

After strong and immediate opposition from stakeholders, MDE pulled the October 2017 regulations back for revisions and released an improved set of regulations in December 2017.

Each of these changes made before the regulations were first proposed in October 2017 took steps toward resolving the additionality problem, but each was seemingly negated by conflicting or ambiguous language elsewhere in the regulations. For instance, while the October 2017 regulations appropriately stated that credits generated by sewage plants must be below 3 mg/L of nitrogen, they nevertheless redefined ENR to be 4 mg/L of nitrogen, which is inconsistent with statute. The regulations also repeated this higher 4 mg/L threshold in the rule governing how to calculate credits. It is unclear what the purpose of these provisions would have been if plants are truly not allowed to generate credits without at least meeting the 3 mg/L limit currently defined by state law.

After strong and immediate opposition from stakeholders, MDE pulled the October 2017 regulations back for revisions and released an improved set of regulations in December 2017. The December regulations take additional steps toward resolving the problem by requiring wastewater treatment plants to discharge at rates consistent with statute (the definition of ENR was not corrected and still includes a reference to nitrogen levels of 4 mg/L, but the operative rules were fixed). But, once again, the December regulations simply do not go far enough to close the loopholes and ensure suitably protective trades.

Although the final regulations submitted in December contain a more restrictive standard (at 3 mg/L) and also a rule requiring that credit generating practices be new as of the effective date of the regulations, this language rings hollow if sewage plants that have already been upgraded over the last decade are still allowed to generate credits without doing anything additional.

Paper credits from sewage treatment facilities are still virtually certain to be sold on the market. Under the final December regulations, a municipal wastewater treatment plant that was upgraded years ago and is operating under ENR levels of 3 mg/L can generate credits. The regulations do not require a facility to apply for credits prospectively and describe what new actions they will take or investments they will make to reduce pollution. Instead, the credit calculation provisions merely state that “at the end of each calendar year,” credits will be awarded based simply on a subtraction between ENR levels and actual levels. Not only does it not matter if the facility did nothing new at all to earn those credits, nothing in the rules even prevent the facility from earning credits if pollution increased over the prior year. Such credits exist entirely on paper and do nothing to curb pollution. To the contrary, they support increased pollution.

Another failing of the December draft is that while the regulations sensibly claim to prohibit the use of public funds for the generation of credits, the rule is rendered meaningless because sewage plants previously upgraded using state funds are expressly permitted to generate credits for doing nothing. The vast majority of the taxpayer-funded cost associated with restoring the Chesapeake Bay over the last decade occurred at the time that each of the ENR upgrade projects was installed. These pollution reductions were already purchased by taxpayers and should not be allowed for purchase now.

MDE officials understand the need for these simple and common-sense rules. In fact, better provisions have already been drafted by the department and are included in another regulatory proposal to implement the new Clean Water Commerce Act, a state law designed to spur innovative new pollution reduction projects using the state Bay Restoration Fund. If sensible protections against paper credits are appropriate for those regulations, surely they are similarly appropriate for the state’s larger and more comprehensive pollution trading regulations.

If the final nutrient trading regulations are revised to include a few corrective provisions, water quality advocates can be assured that each credit generated by an ENR facility is new and represents actual reductions, and other credit generators can participate in the market knowing they compete on a level playing field as part of a fair market for buying and selling credits.

Conclusions and Recommendations

Maryland's new nutrient trading regulations suffer from three main shortcomings. If they are not addressed, Maryland's efforts to restore the Chesapeake Bay and protect local water quality will suffer, and the state's attempt to establish a nutrient trading program that can serve as a model for other states will likely fail.

The following is a set of recommendations designed to remedy the problems with the trading rules.

- **Maryland's trading regions must be suitably small and firmly drawn.** An eight-digit boundary could represent a reasonable compromise for all trades, and the rules should incentivize the creation of local pollution reduction practices by clearly prohibiting trades outside of the bounds of these trading regions.

- **Maryland's trading rules should clearly prohibit the purchase of credits from downstream sellers.** Even if trading regions are maintained within the boundaries of eight-digit watersheds or smaller, local water quality problems will arise if buyers purchase credits from sellers located downstream.

- **Maryland's trading program must recognize pollutants beyond nutrients or other pollutants of concern.** The program must require the prospective buyer of credits to demonstrate that trades will not jeopardize other existing efforts to invest in local projects that control polluted and toxic runoff and mitigate public and community health hazards.

- **All trades involving nonpoint credits must use a 2:1 uncertainty ratio.** Nonpoint pollution credits are inherently uncertain. In many cases, the default assumption about how well a nonpoint pollution control works will be overly optimistic. Since the uncertainty derives from the credit generator, the characteristics of the credit purchaser are irrelevant, and there is no rational basis for exempting "nonpoint-nonpoint" trades from this requirement.

- **The regulations should take a firm and unambiguous stance that no credits may be generated without an additional and verifiable pollution reduction.** These provisions should require a facility to submit an application to the department describing what new and additional capital investments or operational improvements it will make to reduce pollution. Any resulting pollution reduction credits awarded should be based only on the difference in actual pollution loads between the subsequent year and the prior year. And in no circumstance should credits be allowed for a plant that is not meeting the statutorily defined ENR threshold of 3 mg/L.

Appendix A: Net Change in Pollution Load with Point or Nonpoint Source Credit Purchasers

The following tables demonstrate that the characteristics of the credit purchaser are irrelevant to the need for an uncertainty ratio. These tables assume that pollution loads from credit generators or purchasers are greater than or less than expectations by a fixed amount – in other words, that errors in opposite directions will "cancel each other out." The tables also assume that there are no trading ratios used. Table A1 presents scenarios in which the credit generator is a nonpoint source, with uncertain loads, and the credit purchaser is a point source, with certain loads. Table A2 presents scenarios in which both sources are nonpoint sources with uncertain loads.

These tables show that whether the credit purchaser is a point source or a nonpoint source, the likelihood of a net increase in pollution loads is the same. If the credit purchaser is a nonpoint source, there is the additional risk of a large net increase in pollution.

Table A1: Nonpoint source credit generator and point source credit purchaser.

Credit generator: Is load reduction greater than, less than, or equal to expectation?	Credit purchaser: Is load to be offset greater than, less than, or equal to expectation?	Net result
Reductions > expectation	Load = expectation	Net decrease in pollution
Reductions = expectation	Load = expectation	No net change
Reductions < expectation	Load = expectation	Net increase in pollution
Net increase in pollution:		**1 out of 3 scenarios**

Table A2: Nonpoint source credit generator and nonpoint source credit purchaser.

Credit generator: Is load reduction greater than, less than, or equal to expectation?	Credit purchaser: Is load to be offset greater than, less than, or equal to expectation?	Net result
Reductions > expectation	Load > expectation	No net change
Reductions > expectation	Load = expectation	Net decrease in pollution
Reductions > expectation	Load < expectation	Large net decrease in pollution
Reductions = expectation	Load > expectation	Net increase in pollution
Reductions = expectation	Load = expectation	No net change
Reductions = expectation	Load < expectation	Net decrease in pollution
Reductions < expectation	Load > expectation	Large net increase in pollution
Reductions < expectation	Load = expectation	Net increase in pollution
Reductions < expectation	Load < expectation	No net change
Net increase in pollution:		**1 out of 3 scenarios**

About the Center for Progressive Reform

Founded in 2002, the nonprofit Center for Progressive Reform is a 501(c)(3) nonprofit research and educational organization comprising a network of scholars across the nation dedicated to protecting health, safety, and the environment through analysis and commentary. CPR believes sensible safeguards in these areas serve important shared values, including doing the best we can to prevent harm to people and the environment, distributing environmental harms and benefits fairly, and protecting the earth for future generations. CPR rejects the view that the economic efficiency of private markets should be the only value used to guide government action. Rather, CPR supports thoughtful government action and reform to advance the well-being of human life and the environment. Additionally, CPR believes people play a crucial role in ensuring both private and public sector decisions that result in improved protection of consumers, public health and safety, and the environment. Accordingly, CPR supports ready public access to the courts, enhanced public participation, and improved public access to information.

About the Environmental Integrity Project

The Environmental Integrity Project is a nonpartisan, nonprofit watchdog organization that advocates for effective enforcement of environmental laws. Comprised of former EPA enforcement attorneys, public interest lawyers, analysts, investigators, and community organizers, EIP has three goals:

1. To illustrate through objective facts and figures how the failure to enforce or implement environmental laws increases pollution and harms public health;
2. To hold federal and state agencies, as well as individual corporations, accountable for failing to enforce or comply with environmental laws; and
3. To help local communities obtain the protections of environmental laws.

We act as a watchdog because we have to. State and federal agencies charged with protecting the environment often are squeezed by limited resources and political interference from well-funded lobbyists hired by the industries they are required to regulate. We help level the playing field by giving communities the legal and technical resources they need to claim their rights under environmental laws.

Political influence should play no role when the government decides whether to enforce laws which keep cancer-causing benzene out of the lungs of children, for example, or deadly coal soot particles out of the bloodstreams of the elderly.

We do this by advocating for fair enforcement of environmental laws and regulations; writing and distributing reports and data; taking legal actions against big polluters and government agencies, when necessary; and by teaching communities how to participate in the public process regarding important state and federal environmental decisions.

Endnotes

[1] U.S. EPA, Trading and Offset Technical Memoranda for the Chesapeake Bay Watershed, available at: https://www.epa.gov/chesapeake-bay-tmdl/trading-and-offset-technical-memoranda-chesapeake-bay-watershed.
[2] For more information, see U.S. Geological Survey, Hydrologic Unit Maps, available at: https://water.usgs.gov/GIS/huc.html.
[3] U.S. EPA, Local Water Quality Protection When Using Credits for NPDES Permit Issuance and Compliance, available at: https://www.epa.gov/sites/production/files/2015-07/documents/localwaterqualitytm20140306pg.pdf.
[4] *See e.g.*, Water Environment Federation and WateReuse, The Economic, Job Creation, and Federal Tax Revenue Benefits of Increased Funding for the State Revolving Fund Programs (April 2016), available at https://watereuse.org/wp-content/uploads/2015/01/WEF-WRA-SRF-Economic-Impact-Study-Report-April-29-2016.pdf.
[5] Chesapeake Bay Program, 2014 Chesapeake Bay Watershed Agreement, available at: https://www.chesapeakebay.net/documents/ChesapeakeBayWatershedAgreemenetFINAL.pdf.
[6] See the Chesapeake Bay Program Toxic Contaminant Workgroup, available at:
[7] The map is available at: https://www.chesapeakebay.net/channel_files/25557/toxics_indicator_2014.pdf.
[8] *See, e.g.*, Cynthia Morgan and Ann Wolverton, Water Quality Trading in the United States, Working Paper # 05-07 for the National Center for Environmental Economics, U.S. EPA, at 15 – 16 (June, 2005); World Resources Institute (WRI), Water Quality Trading Programs: An International Overview, at 9 – 11 (March 2009).
[9] U.S. EPA, Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment, page 7-1 (Dec. 29, 2010) (emphasis added, and certain acronyms converted to full text for clarity).
[10] 33 U.S.C. § 1313(d)(1)(C).
[11] Kieser & Associates, Post-BMP Implementation Monitoring Results for the Cooper Township Agricultural Site #2 Area A, Project 97-IRM-5C (Dec. 31, 2001).
[12] National Research Council (NRC), Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay 73 (2011).
[13] *Id.* at 76.
[14] U.S. EPA, Chesapeake Bay Phase 5.3 Community Watershed Model, page 6-9 (Dec. 2010), available at: http://www.chesapeakebay.net/about/programs/modeling/53.
[15] For more on comparisons between BMP efficiencies and real-world data, see Environmental Integrity Project, Murky Waters: More Accountability Needed for Farm Pollution in the Chesapeake Bay, pp. 29-39 (July 14, 2014), available at: http://www.environmentalintegrity.org/reports/murky-waters/.
[16] T. Simpson and S. Weammert, Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and

Sediment in the Chesapeake Bay Watershed, 114 (University of Maryland Mid-Atlantic Water Program, Dec. 2009).

[17] See, e.g., World Resources Institute, Addressing Risk and Uncertainty in Water Quality Trading Markets, 3, 13 (Feb. 2014).

[18] U.S. EPA, Accounting for Uncertainty in Offset and Trading Programs – EPA Technical Memorandum, 8 (Feb. 12, 2014); see also U.S. EPA Chesapeake Bay Model, supra note 5, at 6-3 ("[t]he objective was to develop BMP definitions and effectiveness estimates that represent the average operational condition of the entire watershed").

[19] Morgan and Wolverton, *supra* note 1, at 15; *see also* Organization for Economic Co-operation and Development, Water Quality Trading in Agriculture 36 (2012) (citing Morgan and Wolverton as evidence that "ratios of 2:1 or higher are common in U.S. programs.").

[20] *See, e.g.*, WRI, *supra* note 1, at 10 ("Uncertainty ratios are often set at 2:1"); M.O. Ribaudo and J. Gottlieb, Point-Nonpoint Trading—Can it Work?, 47 J Am. Water Resources Assn. 5, 9 (Feb. 2011) ("Uncertainty ratios in water quality trading programs generally range from 2:1 to 5:1.").

[21] See EPA, 2014 Technical Memorandum, supra note 11, at 6 ("A number of factors may cause a BMP to produce lower than expected pollutant load reductions").

[22] Id.

[23] *Id.* at 10. The exceptions are for instances where routine monitoring is used to increase the certainty of load reduction estimates, or where BMPs are made permanent through a conservation easement or other deed restriction.

[24] Section .08(C)(1)(c).

[25] Section .08(C)(1)(a).

[26] Bear Creek Watershed Association, Total Phosphorus Trade Program and Nonpoint Source Trading Guidelines (Feb. 8, 2006).

[27] "[T]he Trade Ratio will be 2:1 for all Trade Projects unless the applicant requests an exemption of the 2:1 trade ratio based on adequate water quality data collected on a project-specific basis." Chatfield Water Authority, Water Quality Trading Guidelines, 10 (Apr. 25, 2007).

[28] *Id.*

[29] Morgan and Wolverton, *supra* note 1, at 17.

[30] *Id.*

[31] Jennifer Vogel, A Survey of Trading Ratios Used for Generation of Credits in Water Quality Trading Programs, 6 (UVA Environmental Law Clinic, July 20, 2012).

[32] *Id.* at 6.

[33] Florida DEP, The Pilot Water Quality Credit Trading Program for the Lower St. Johns River: A Report to the Governor and Legislature, at 12–13 (Oct. 2010), available at http://www.dep.state.fl.us/water/wqssp/docs/WaterQualityCreditReport-101410.pdf.

[34] Environomics, A Summary of U.S. Effluent Trading and Offsets Projects, prepared for Dr. Mahesh Podar, U.S. EPA, at 17 (Nov. 1999).

[35] *Id.* at 19.

[36] Morgan and Wolverton, *supra* note 1, at 17.

[37] Michigan regulations require retirement of 50% of nonpoint source credits "to address uncertainty and to provide a net water quality benefit." This would be, in ratio terms, a 2:1 ratio. Mich. Admin. Code r. 323.3016.

[38] The trading ratio is divided into three components: 1.0 to provide an offset, 1.0 to provide an environmental benefit, and 0.6 to account for uncertainty. Environomics, *supra* note 21, at 23; *see also* EcoAgriculture Partners, The Watson Partners and the Southern Minnesota Sugar Beet Cooperative, 18 (May, 2011) (confirming that "the required number of phosphorus reduction trading credits remains 2.6 times the annual phosphorus mass discharge limit for the WWTF.").

[39] Vogel, *supra* note 18, at 10.

[40] Environomics, *supra* note 21 at 29; Morgan and Wolverton, *supra* note 1, at 17.

[41] Vogel, *supra* note 18, at 18.

[42] *See* Environomics, *supra* note 21, at 25.

[43] Morgan and Wolverton, *supra* note 1, at 17.

[44] Vogel, *supra* note 18, at 12.

[45] *Id*. at 14.

[46] Organization for Economic Co-operation and Development, Water Quality Trading in Agriculture 23 (2012)

[47] U.S. EPA, Virginia's Trading and Offset Programs Review Observations, Final Report (Feb. 17, 2012).

[48] Environomics, *supra* note 21, at 36.

Attachment C

July 7, 2017

Via Email:
gary.setzer@maryland.gov

Mr. Gary Setzer
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

Re: Comments on Maryland Department of Environment's Subtitle 08 Chapter 11 Maryland Water Quality Nutrient and Sediment Trading and Offset Program Draft Regulations

Dear Mr. Setzer:

On behalf of the undersigned organizations, please accept these comments on the draft Nutrient and Sediment Trading and Offset Program regulations that were distributed on June 7. These comments were formulated in a collaborative effort between the Maryland Clean Agriculture Coalition (MCAC) and the Choose Clean Water Coalition (CCWC).

Our comments are based upon the MCAC guiding principles on nutrient pollution trading, which are attached. In general, we believe that any nutrient pollution trading program must be designed to reduce pollution to the Chesapeake Bay and its tributaries with a level of transparency and accountability to ensure its effectiveness.

Comments on Draft Regulations

We commend Maryland Department of the Environment (MDE) for listening to many of the concerns of our members and other stakeholders in creating actual regulations rather than trying to establish a trading program simply relying on guidance. We urge MDE to include more details in the regulations and make some changes to improve the regulations in order to make a robust trading program that will not endanger water quality in the Bay or the local level.

1. The regulations must adhere to the EPA technical memoranda on nutrient trading.

The Environmental Protection agency (EPA) has developed a series of technical memoranda that provide details on EPA's expectations for nutrient trading programs designed to meet the Bay TMDL target allocations.[1] Specifically, the technical memoranda elaborate on Appendix S and Section 10 of the TMDL.[2] These are not merely guidance, but reflect the fundamentally important "expectations" of EPA, the Chesapeake Bay Program partner responsible for ensuring accountability in the TMDL

[1] U.S. EPA, Trading and Offset Technical Memoranda for the Chesapeake Bay Watershed, https://www.epa.gov/chesapeake-bay-tmdl/trading-and-offset-technical-memoranda-chesapeake-bay-watershed.
[2] U.S. EPA, Accounting for Uncertainty in Offset and Trading Programs – EPA Technical Memorandum, 4 (Feb. 12, 2014).

implementation. If Maryland chooses to ignore the memoranda, it runs the risk not only of forcing EPA to object to permits and reject credits or offsets for use in meeting TMDL allocations, but also of losing credibility in the eyes of other partners and the public.

2. The draft regulations must require the use of a 2:1 uncertainty ratio for all trades involving nonpoint credit generators.

The pollution loads from nonpoint sources of pollution, which by definition lack discreet "point" source outfalls, are very difficult to measure. When these nonpoint sources implement Best Management Practices (BMPs) to reduce pollution loads, the reductions are equally difficult to measure. In practice, these loads and pollution reductions are never measured, but are instead estimated. Nutrient credits generated by nonpoint sources are therefore inherently uncertain.

Adding to that basic uncertainty is the fact that most estimates of BMP effectiveness are generated from carefully controlled research experiments – not real-world demonstrations. The National Research Council (NRC) observed that

> *BMP efficiencies are often derived from limited research or small-scale, intensive, field-monitoring studies in which they may perform better than they would in aggregate in larger applications . . . Thus, estimates of load reduction efficiencies are subject to a high degree of uncertainty*.[3]

Note that the NRC authors are suggesting that the uncertainty is largely in one direction—BMP efficiencies are likely to overestimate actual nutrient removals. Indeed, the authors go on to say that "[p]ast experience . . . has shown that credited BMP efficiencies have more commonly been decreased rather than increased in the light of new field information."[4]

In other words, BMP effectiveness estimates tend to overestimate pollution reductions. The Chesapeake Bay Program has modified certain BMP effectiveness estimates to address some, but not all, of this bias (to "remove unwarranted optimism").[5] There has been some confusion on this point. For example, in 2011 Maryland Department of Agriculture (MDA) stated that "[a]ny uncertainty associated with [BMPs] has already been taken into account by the Chesapeake Bay Program in the adoption of the stipulated efficiency."[6] But this is incorrect. Not all BMPs have been adjusted as described above, and not all sources of uncertainty have been addressed. According to EPA:

> *The CBP partnership BMP effectiveness values vary across the Chesapeake Bay watershed for conditions such as implementation date, growth rate of crops, and physiographic region. These adjustments generate BMP effectiveness values that are <u>unbiased and realistic</u> but not necessarily conservative because they were established using realistic estimates for load reductions that do not reflect additional sources of uncertainty, especially hydrological variability and operation and maintenance over the*

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[3] National Research Council (NRC), Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay 73 (2011).
[4] *Id*. at 76.
[5] U.S. EPA, Accounting for Uncertainty in Offset and Trading Programs – EPA Technical Memorandum, 8 (Feb. 12, 2014).
[6] MDA, Producing and Selling Credits in Maryland's Nutrient Trading Market, 9 (Mar. 14, 2011).

lifetime of BMPs. The uncertainty ratio recommended in this technical memorandum is designed partially to account for those additional sources of uncertainty.[7]

Therefore, there is a reasonable probability that a BMP may not generate the pollution reductions that it is given credit for. In order to avoid a net increase in pollution loads, EPA expects the states to use an uncertainty ratio "of at least 2:1" for trades between nonpoint credit generators and point source credit buyers.[8] In other words, a credit buyer hoping to offset one pound of new nitrogen load would have to purchase credits worth two pounds of nonpoint nitrogen. EPA allows for two possible exceptions to this policy. The first is where "direct and representative monitoring of a nonpoint source is performed at a level similar to that performed at traditional NPDES point source."[9] The second is where land conservation is made "permanent" through a conservation easement or other deed attachment.[10]

In general, however, Maryland is required to apply a 2:1 ratio to all nonpoint-point trades. The draft regulation defines uncertainty ratios, but does not include any substantive language about them. Perhaps this is an error in drafting – since MDE included a definition, we presume that the Department intended to include substantive language. Maryland's most recent guidance manual[11] includes some language about uncertainty ratios, but misses the mark. Specifically, the manual requires a 2:1 uncertainty ratio for trades between nonpoint credit generators and "wastewater point sources," but does not require a 2:1 ratio for trades between nonpoint credit generators and "stormwater point sources."[12] This is an arbitrary distinction, and it is impermissible. The characteristics of the credit purchaser are irrelevant to the policy goal that a 2:1 uncertainty ratio is intended to serve. The uncertainty ratio is there to ensure that credits do not overestimate the pollution reductions achieved by the credit generator.

Virginia has adopted an uncertainty ratio requirement that comports with the TMDL and EPA's expectations:

> Credits used to offset new or increased nutrient loads under this subdivision shall be:
>
> (1) Subject to a trading ratio of two pounds reduced for every pound to be discharged if certified as a nonpoint source credit by the board pursuant to § 62.1-44.19:20 of the Code of Virginia. On a case-by-case basis the board may approve nonpoint source to source trading ratios of less than 2:1 (but not less than 1:1) when the applicant demonstrates factors that ameliorate the presumed 2:1 uncertainty ratio for credits generation by nonpoint sources such as:
>
> (a) When direct and representative monitoring of the pollutant loadings from a nonpoint source is performed in a manner and at a frequency similar to that performed at VPDES point sources and there is consistency in the effectiveness of the operation of the nonpoint source best management practice (BMP) approaching that of a conventional point source.

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7 U.S. EPA, Accounting for Uncertainty in Offset and Trading Programs – EPA Technical Memorandum, 8 (Feb. 12, 2014) (emphasis added).

8 U.S. EPA, Accounting for Uncertainty in Offset and Trading Programs – EPA Technical Memorandum, 4 (Feb. 12, 2014).

9 Id. at 5.

10 Id.

11 MDE and MDA, Maryland Trading and Offset Policy and Guidance Manual, Chesapeake Bay Watershed (Apr. 17, 2017).

12 Id. at 13.

(b) When nonpoint source credits are generated from land conservation that ensures permanent protection through a conservation easement or other instrument attached to the deed and when load reductions can be reliably determined;.[13]

MDE should adopt similar language and apply it to all trades and offsets.

Furthermore, the same logic should apply to all trades involving nonpoint credit generators, including the sale of credits to nonpoint credit purchasers. Again, the uncertainty ratio is there to ensure that credits do not overestimate the pollution reductions achieved by the credit generator. The characteristics of the credit purchaser are irrelevant.

In short, MDE must require the use of a 2:1 uncertainty ratio for all trades involving nonpoint nutrient credits, including but not limited to trades between nonpoint credit generators and "stormwater point sources."

3. Use a retirement ratio to ensure net improvement to water quality.

Trading programs must result in actual net improvements to water quality. The current draft regulations do not include a retirement ratio. They include a "reserve ratio", which is inadequate, because it does not ensure that there is a net reduction of pollution from any trade. We urge MDE to reinstate the retirement ratios that have long been part of Maryland's draft trading manual.[14] MDE should require that 5% of credits generated by point sources, and 10% of credits generated by nonpoint sources, be "retired." An earlier iteration of the Maryland Department of Agriculture's nutrient trading policy included the following "fundamental principle":

> *Trades must result in a net decrease in loads. To ensure this net decrease is achieved, 10 percent of the agricultural credits sold in a trade will be "retired" and applied toward Tributary Strategies or TMDL goals. The buyer will retire the credits following the transaction, and this determination should be reflected in the buyer/seller contract*.[15]

At the January 8th, 2016 trading symposium, MDE stated that a percentage of credits will be retired for the sake of net water quality benefit. We agree with this policy and urge MDE to ensure that these levels are included. As noted above, the current draft omits the retirement ratio and instead includes a 'reserve ratio.' The reserve ratio alone is insufficient for two reasons. First, it is not a retirement ratio, and does not ensure a net reduction in pollution loads. Second, at the end of the year there is nothing that prevents MDE from distributing the reserved credits to noncompliant dischargers. This creates a perverse incentive to polluters to fall short of their pollution reduction targets. We have no objection to applying a reserve ratio if MDE also incorporates the appropriate retirement ratio.

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13 9 Va. Admin. Code 25-820-70, Part II.B.1.b.(1).

14 See, e.g., MDE and MDA, Draft Maryland Trading and Offset Policy and Guidance Manual, 19 and 45 (Jan. 2016).

15 MDA, Producing and Selling Credits in Maryland's Nutrient Trading Market, 5 (Mar. 14, 2011).

We recommend the following in words or substance:

> *"A retirement ratio will be applied to each trade, and represents the percentage of the total purchased credits to be retired towards net water quality benefit. The retirement ratio is 1.05 for point source credits and 1.1 percent for nonpoint credits. This means that credit purchasers will have to purchase 1.05 pounds of point source credits, or 1.1 pounds of nonpoint credits, before accounting for any other trading ratios, to offset one pound of pollution."*

4. Ensure that trading does not cause degradation of local waters or pollution hotspots.

We strongly support the intent of the language in section .05.B**.** The TMDL and EPA's technical memorandum on local water quality both prohibit trades that would cause or contribute to local water quality impairments, including any exceedances of water quality standards.[16] We commend MDE for limiting trading to credits generated upstream of where the water discharge reaches impaired waters as a good practice to help ensure compliance with local water quality standards. However, section .05.B.1, as written, is too narrow and is inconsistent with section .05.B, the TMDL, and EPA's technical memorandum. Section .05.B. prohibits trades that would cause or contribute to an impairment or to an exceedance of water quality standards. We would strongly urge MDE to consider language that would avoid creating pollution "hot spots" for local communities by requiring that all trades be executed within a small watershed, with credit generators upstream of credit purchasers. At a minimum, however, we request the following:

Strike:

> "Where necessary to ensure compliance with local water quality standards, the exchange of credits in an area within the Chesapeake Bay Watershed subject to an approved local TMDL for total nitrogen, total phosphorus, or total suspended solids with allocations more stringent than the Chesapeake Bay Watershed TMDL shall be limited to those credits generated upstream of where the discharge reaches impaired waters."

And replace with:

> "Where necessary to ensure compliance with local water quality standards and to prevent local water quality impairments, the exchange of credits in areas where a credit purchaser may cause or contribute to a violation of water quality standards, an impairment, or a violation of a local TMDL, shall be limited to credits generated upstream of where the credit purchaser's discharge reaches impaired waters."

We also urge MDE to ensure that permittees, particularly MS4 jurisdictions, do not use trading to meet the entirety of their pollution reduction requirements. Trading should not be allowed to offset more

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16 U.S. EPA, Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment, S-4 (Dec. 29, 2010); U.S. EPA, Local Water Quality Protection when Using Credits for NPDES Permit Issuance and Compliance, EPA Technical Memorandum, (March 17, 2014).

than 50% of a permittee's requirements. This will ensure that local waters are not significantly degraded and also ensure that MS4s do not abandon all stormwater and polluted runoff reduction efforts within the boundaries of their jurisdictions.

In addition, the three broad "Trading Regions" authorized in Section 05.F(1) are far too broad, and will not ensure the protection of local water quality, unless they are subject to the revised language that we have proposed for Section 05.B(1). Our proposed language would remedy this problem.

5. Include additional details on enforcement: The regulations should ensure greater enforcement against fraud in the program and repeat offenders.

Since nutrient trading creates a host of new enforcement issues, the draft regulation must add significantly more detail on enforcement. Section 11 should outline specific enforcement measures that MDE would pursue in response to credit failure, willfully fraudulent trading or verification misrepresentations, and repeat offenders.

As a starting point, the regulation should clearly and comprehensively state that credit purchasers are responsible for credit failure, and that a credit failure is a permit violation subject to Clean Water Act and state law enforcement. Section .08.A.1(d) states that "in the event of a default in a trade contract or the invalidation of credits, the MS4 permittee using those credits remains responsible for complying with MS4 permit requirements that would apply if the trade had not occurred." This is a step in the right direction, but it does not go far enough and only applies to MS4 credit purchasers. The draft regulation should expand this language to state that permittees are subject to enforcement for permit violations in the cases of credit default, and apply that language to all credit purchasers.

Enforcement provisions should recognize that there will likely be minor infractions, or a failure of a BMP performance, that can be corrected expeditiously. They should authorize administrative compliance orders to address these and other violations, coupled with penalties for failure to comply.

In addition, we recommend that the regulations expand the enforcement sanctions for willfully fraudulent trading or verification, and for repeat offenders. A noncompliant verifier working with a willful counterfeiter of credits could jeopardize the integrity of the entire trading system and the health of the Chesapeake Bay. Greater enforcement mechanisms are necessary to reduce the temptation to falsify credit verification reports, particularly when the verifiers are third party entities.

Both the MDA and MDE should have the authority to impose on any noncompliant party a ban from the nutrient trading system of up to 10 years, as well as a lifetime ban for the most serious and/or repeat offenders. MDA should also refer cases of fraud to the State Attorney General to take appropriate action under the state's general civil and criminal fraud laws.

Finally, we recommend the Department include a definition of "significant noncompliance" since this term is used in .04E.(1) to describe one basis for becoming ineligible to participate in the trading program.

6. The draft regulation must include more detail on certification and verification of credits

The draft regulation currently includes very little detail on verification, despite the fact that Maryland has adopted a comprehensive Best Management Practice verification plan.[17] Much of the verification under this plan will be done by MDA, but the plan also assigns numerous responsibilities to MDE (e.g., stormwater BMP and wastewater treatment plant verification, review and submittal to the Chesapeake Bay Program of MDA verification data, etc.). To the extent that the BMP verification plan may overlap with the nutrient trading regulation, MDE should incorporate the overlapping policies and language.

In addition, section .05.E(5) suffers from both substantive and drafting problems. First, section .05.E(5) states that "permanent credits are available in perpetuity and . . . may be verified annually." This suggests that permanent credits may not be verified at all. Nothing is truly "permanent," and MDE must prescribe some form of follow-up verification for any practice used to generate credits. Maryland's BMP verification plan lays out a schedule for initial and follow-up inspections for virtually every kind of credit-generating practice.[18] EPA's technical memorandum on verification simply says that the Agency expects "all credit generating projects and practices to be verified on an annual basis."[19] MDE must ensure that the draft regulation is consistent with that plan.

Section .05.E(5) goes on to exempt two types of practices from the preceding language, but because the preceding language includes three clauses, it is unclear what the practices in .05.E(5)(a) and (b) are exempted from. If the language exempts (a) and (b) from the "may be verified annually" clause, then MDE is effectively stating that these two practices – converting septic systems to wastewater treatment plant hookups and land conversions with deed restrictions – cannot be verified after initial project completion. It makes no sense for MDE to tie its hands in this way. Since .05.E(5) does not require anything beyond initial verification on project completion, there is no reason to exempt any practices, and the word "except" and parts .05.E(5)(a) and (b) should be deleted.

7. Credit timing

The draft regulation presents a conflicted set of requirements for the use of credits over time. On one hand, credits are generally valid for one year and cannot be banked for future years – a good policy (section .05.E(4)). On the other hand, the draft regulation contemplates "permanent credits" (.05.E(5)), and "[p]ermittees are required to secure credits in perpetuity or the term of their permit," (section .05.E(6)), or for up to 20 years (section .07.A.(3)(b)(ii)). The draft regulations fail to explain how a permittee could "secure" credits for 20 years (or in perpetuity) when most credits are annual and expire a year after they are created.

This issue requires careful thought on MDE's part. The Department may wish to require that long-term credit purchases be limited to long-term credit generating practices such as land conversion with deed

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17 Maryland's DRAFT Best Management Practice BMP Verification Protocol (Nov. 2015), http://www.chesapeakebay.net/documents/MD_BMP_Verification_Protocols_Final.pdf.
18 Id.
19 U.S. EPA, Certification and Verification of Offsets and Trading Credits in the Chesapeake Bay Watershed, Technical Memorandum, 7 (July 21, 2015).

restrictions. Alternatively, the Department will have to provide a mechanism by which permittees can "secure" credits in a way that the Department can validate and track. A simple contract between a permittee and a broker, where the broker promises to find annual credits every year for the next 20 years, is plainly insufficient. A binding contract with one or more credit generators to provide future credits by implementing and maintaining BMPs that are already in place or easy to implement and verify might be sufficient to satisfy the requirements in Section 07.A(3) that NPDES permit holders using credits demonstrate their availability during future years.

Unfortunately, EPA has provided very little guidance on this issue, but the Agency does expect that "[t]he procurement of credits should be documented in the permit, the fact sheet, and the administrative record. This includes documented assurances in place to show that credits have been <u>secured from a project and/or practice</u> certified by a person properly authorized to do so for the duration of the authorization to discharge."[20]

MDE must adhere to EPA's expectations in the following ways: (1) It must revise the draft regulation to specify that "securing" credits means lining up credits from specific projects and/or practices (not from brokers), and (2) it must include details about how the credits were secured in the relevant permit, fact sheet, and administrative record.

8. The draft regulations should explicitly prohibit bubble permits and interstate trading

As written, the draft regulation would allow for "multiple facilities in a watershed" to form an association and obtain a single permit (a "bubble permit") as co-permittees (Section 07.A(4)).This provision is not authorized under the Clean Water Act and has no basis for inclusion in nutrient trading regulations.

Moreover, even if a way could be found to design a bubble permit that is consistent with the Clean Water Act, we have serious concerns about the impact of bubble permits, which create a laundry list of potential problems for local water quality, transparency, accountability, and enforcement, and must be avoided. For example, as drafted, the term "watershed" is not defined and could allow permittees anywhere within the Chesapeake Bay watershed to combine their discharge limits. Worse, the draft regulation establishes no restrictions at all on the number of owners forming an association. Theoretically, a single bubble permit could be written for all nutrient dischargers in Maryland's part of the Chesapeake Bay watershed.

Even a bubble permit involving a limited number of facilities poses significant permit-writing and enforcement questions. For example, how will MDE ensure that there are no local water quality impacts at all locations? How will MDE even conduct a "reasonable potential" analysis, which it must do pursuant to the Clean Water Act, to determine whether Water Quality-Based Effluent Limitations are required? Will co-permittees report their discharges individually, as a group, or both? These are just a few of the questions that are not addressed in the draft regulations.

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[20] U.S. EPA, Permanence of Credits Used for NPDES Permit Issuance and Compliance, Technical Memorandum, 5 (Aug. 19, 2014).

MDE should initiate an entirely new rulemaking process and create a new set of regulations to address all of the complex issues and potentially dangerous consequences of bubble permitting. It is inappropriate to address this issue with only five lines of text in an unrelated regulatory proposal that contains no reference to bubble permits in the Statement of Purpose.

9. Interstate trading

The draft regulation is silent about interstate nutrient trading, but we are aware that Maryland is considering this possibility. We are strongly opposed to interstate trading for several important reasons:

- Accountability and transparency, which are both difficult enough to achieve at the state level, will be much harder to achieve on an interstate basis, as each state will have its own system for credit tracking.

- Interstate trading increases the likelihood of local water quality issues by increasing the distance between credit generators and credit purchasers (making it more likely that they are in different sub-watersheds).

- Interstate trades will be complicated by the fact that a credit is calculated differently in each state. How would Maryland ensure that interstate trades are "apples-to-apples?"

- We are concerned that interstate trading will lead to a "race to the bottom" in terms of trading program standards. For example, consider a credit buyer in state A, and two credit sellers, one in state A and one in state B. Assume that state A has a stringent trading program, and that state B has a weak program. It would presumably be more expensive for a credit generator in state A to install and maintain the practices necessary to qualify for credit generation, and to generate the pollution reductions. The credit seller in state A would set its price accordingly. The credit seller in state B could offer much cheaper credits. The credit buyer would probably buy the credits from state B. If this became a pattern, pollution reductions would tend to accrue to state B. State A, trying to meet TMDL goals for pollution reduction, would have a strong incentive to weaken its program to facilitate more in-state trades.

- Interstate trading would create major obstacles to enforcement. If a Maryland permittee purchased credits from a Pennsylvania credit seller, and those credits failed, how would MDE enforce the permit across state lines? In the meantime, how would MDE verify that the credits secured for 20 years continued to materialize (in Pennsylvania)? Appendix S of the TMDL specifically lists as one its "common elements" the following language under the "certification and enforceability" element: "Ensuring that transactions can be enforced by the jurisdiction. Articulating how transactions can otherwise be protected by the jurisdiction."[21] MDE has no authority to inspect BMPs in another state, or to bring enforcement actions in the event of violations.

[21] TDML, Appendix S, S-5.

For all of these reasons, we strongly believe that interstate trading is impermissible, vulnerable to abuse, and would likely lead to net increases in pollution loads. We strongly encourage MDE to avoid interstate trading.

10. Baselines must be better defined

Section .07.B(2)(d) is unclear. Subsection (d)(i) begins with "If greater than 6,100 pounds per year total nitrogen load cap and 457 pounds per year total phosphorus load cap." It is unclear what is (or is not) greater than these load caps. It may be baselines, but it may also be "previously assigned 2004 Point Source Tributary Strategy" goals (section .07.B(2)(d)(i)). MDE should clarify.

That section goes on to describe how the baseline can be "no more than 50 percent of the amount that is above [the load caps]." This is unclear mathematically. Why would the baseline be half of the excess above the load caps? We strongly encourage MDE to clarify this language as well.

Furthermore,, section .07.B(4) suggests that the baseline for significant industrial dischargers will be "based on a combination of historical performance levels, the amount of loading reductions already achieved since the initial baselines established in 1985, and establishment on a case-by-case basis of additional potential loading reductions." This language is ambiguous and appears to be a statement of purpose, but is not appropriate in the context of a regulation. MDE should settle on a baseline definition and provide a precise statement for the benefit of the regulated community and public.

The baseline provisions must be rewritten to ensure full compliance with EPA's Technical Memorandum on Establishing Offset and Trading Baselines (February 2, 2016). In particular, for any point source discharger, the baseline must include compliance with any technology-based requirements and with any Water Quality Based Effluent Limitations (WQBELs) established by the permit. For nonpoint source dischargers, baseline requirements must ensure compliance with any applicable load allocation "for the appropriate sector [of which the nonpoint source is a member]…and…needed to facilitate improved environmental compliance with WQS."[22] The load allocated to an individual nonpoint source within a sector should be calculated to ensure that that source is doing its fair share to contribute towards achieving compliance with any applicable Water Quality Standards so as to avoid inequitable burdens being placed on members of the sector whose baselines are established at a later date. While many, if not most, baselines for nonpoint sources will be established by MDA under its regulations, MDE will likely be called on to establish some of these, and its regulations therefore must include appropriate provisions to enable it to do so.

11. MDE cannot allow capacity credit generation or capacity trading

The Water Quality Trading Advisory Committee rightly reached a decision that wastewater treatment plants should not be allowed to sell credits representing their extra capacity. Not only does it fail to comport with Clean Water Act principles and the fundamentally important principle of *additionality*

[22] See EPA , Technical Memorandum, Establishing Offset and Trading Baselines p. 4 (February 2, 2016).

embedded in the TMDL,[23] capacity trading can also flood the market with 'free' credits that interfere with the creation of the viable marketplace that MDE is trying to create.

Several MS4s have already declared their intent to use this allowance as a loophole to get out of financing new stormwater projects if it becomes available. In subparagraph .08A.(1)(b)(iv), the regulations allow an MS4 to purchase capacity credits if other sources of credit generation do not "reasonably" meet the demand. This provision is both ambiguous and inappropriate. The entire purpose of these regulations is to create the rules for the marketplace. This open-ended provision does not precisely define what is "reasonable." It furthermore represents a very clear and bold loophole that could sabotage the marketplace and, more importantly, all of the past and present efforts to meet our commitment to the Bay TMDL and attain local water quality standards. By making capacity credits the trade of last resort, the Department is in essence declaring that (a) capacity credits are not an appropriate or effective means of reducing pollution; (b) the purchase of these undesirable credits is preferable to stimulating demand for new and effective pollution reduction projects and practices through market signals (higher prices); and (c) that giving pollution allowances away is preferable to the enforcement of existing pollution limits set out in Clean Water Act permits.

Wastewater treatment plants should only be able to generate credits if they invest in new projects or undertake other new initiatives that create additional pollution load reductions which would not otherwise occur. Credits fail this additionality test if, for example, they are not set at a baseline consistent with the nutrient load concentrations envisioned in state law (3 mg/L for nitrogen; and 0.3 mg/L for phosphorus) and created by wastewater treatment plant upgrade projects that have already been completed and financed with taxpayer dollars. We strongly urge MDE to create clear eligibility requirements for credit generation by wastewater treatment plants. These criteria could include, for example, the submission by the facility of an application created by the department that allows the proposed credit generator to describe what additional capital projects or operational changes the facility will undertake, an estimate of the load reduction to be achieved, and the formula that the applicant will use in this estimate and that the department will use to ultimately certify the number of credits created. The formula must ensure that credits are only certified for reductions that are based on (1) new or additional projects, investments, or actions taken; (2) reductions below the "enhanced nutrient removal" load concentration levels set by the General Assembly and codified in Title 9, Subtitle 16 of the Environment Article; and (3) load concentration levels which are, in fact, lower than historic levels for the facility.

Again, the trading of excess capacity fails the principle of additionality and violates the TMDL and the Clean Water Act. MDE is not authorized to permit capacity trading.

12. Increase Transparency: Provide an opportunity for the public to comment on an application for credit approval when MDA or MDE receives a completed Certification and Registration Form.

[23] See, e.g., U.S. EPA, Components of Credit Calculation, Technical Memorandum, 5 (May 14, 2014).

The regulation needs to include more opportunities for transparency in the nutrient trading program. The MDA regulations give some guidance as to what MDE should include in the regulations. These regulations state in Sections 07.B and C the essential requirements that must be met before a credit can be certified. Section 07.F of the MDA regulations specifies that credits may be "certified" once these requirements are met, and Section 07.G says that following approval each credit shall be given a "unique registration number" and registered. This or similar language should also be included for other nonagricultural credit generation.

There are also additional components MDE should add to this regulation. After credits are certified, MDE must include a system for tracking each credit, as required by the EPA Technical Memorandum on Certification and Verification of Offset and Trading Credits in the Chesapeake Bay Watershed.[24]

Furthermore public notice and comment should be required when MDA or MDE receives a completed Certification and Registration Form, along with the other documents and information required by Sections 07.A and .B. of the MDA trading generation regulations. Without the publication by the department of an announcement of the credit request and a reasonable period for comments, there is no meaningful transparency in the program. Requiring public notice and comment is the only opportunity for interested parties to review the proposed credit(s) and supporting documentation and evaluate and comment on whether: (1) the applicant has properly complied with baseline requirements, (2) the requirements that the Nutrient Management Plan and Soil Conservation and Water Quality Plan be fully implemented are demonstrated, (3) the effectiveness and likely duration of the credits have been properly calculated, (4) whether calculations requiring application of the Maryland Nutrient Trading tool have been properly performed and documented, and (5) the other information required by Section 07.A and B has been provided by the applicant.

In addition, MDA and MDE should both receive a copy of the application no later than the date of the public announcement. MDE has an important interest in any measure that could affect achievement of TMDL goals and water quality standards. In most, if not all cases, any credit purchased and used by a point source discharger will be incorporated into an NPDES permit, which is issued by MDE. In cases where a credit application is submitted to MDA, MDE should have an opportunity at this time to review the credit application and provide comments to MDA. In the event MDE believes there is anything unsatisfactory in the credit, the correction should be addressed before the credit has been approved, registered, purchased, and included with a permit application to MDE.

The MDA regulations in Section 08.D appear to recognize the important role played by MDE because they require that MDE be provided with a copy of the verifier's report generated after an annual verification inspection. However, MDE regulations should also require the original application be shared with MDE as well to assist in verification.

These important elements of the process can be effectively accomplished by adding a new subsection C under Section .07. The existing Subsection 07.C should then be designated as 07.D. The new Section 07.C should provide, in words or substance, as follows:

> *C. Promptly after a determination by MDE or MDA that an application for approval and registration of one or more credits includes all of the documents specified in this Section*

[24] U.S. EPA, "Certification and Verification of Offset and Trading Credits in the Chesapeake Bay Watershed", p. 9 (July 21, 2015).

07, and Sections 08, 09 and 10, as applicable,, the Department shall post on its website an announcement of the application and identifying a location where the application and related documents can be inspected and copied, and allowing a time for public comments on the application of not less than 30 days following the date of publication of the announcement. In addition, not later than the date of publication, MDE or MDA, as appropriate, shall provide the other with a copy of the application and supporting information.

Finally, the Department should get copies of disputed information reports. Section 09.E of the MDA regulations allows the owner or operator of a facility to "dispute information in" the verifier's report by filing a statement of written concerns with the Maryland Department of Agriculture within 30 days of his or her receipt of the report. MDE should require that a copy of the written concerns be provided to MDE at the same time as MDA. MDE will have received the verifier's report, and should be advised if there is a challenge to it by the owner/operator.

We appreciate the opportunity to submit these comments. We would be pleased to discuss any aspect of them and answer any questions. Please contact Abel Russ, with Environmental Integrity Project, with any questions, comments, or concerns at aruss@environmentalintegrity.org.

Respectfully submitted,

Audubon Naturalist Society
Common Cause Maryland
Environmental Integrity Project
Maryland League of Conservation Voters
Maryland Sierra Club
Midshore Riverkeeper Conservancy
Rachel Carson Council
Waterkeepers Chesapeake
West/Rhode Riverkeeper

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APPENDIX F

Urban Toxic Contaminants:
Removal by Urban Stormwater BMPs

Urban Toxic Contaminants: Removal by Urban Stormwater BMPs

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Presentation Outline

1. Introduction
2. Definition of Urban Toxic Contaminants
3. The Dirty Dozen UTCs in Urban Watersheds
4. Effectiveness of Urban BMPs in Removing Them
5. Risk that UTCs Accumulate in BMP Sediments
6. Watershed Strategies for Reducing Toxics
7. Discussion and Resources

Why Worry About Toxics?

- The N and P we deal with most often are not particularly cuddly, scary or photogenic
- Toxins exert a real impact on both human health and harm aquatic life, fish and wildlife
- The public is justifiably concerned about the presence of toxins in the environment
- Most of the TMDLs in the country are for toxins
- Rationale for industrial stormwater permits
- Implications for long term maintenance of stormwater practices

Toxics and TMDLs in the US

Rank	Pollutant	# of TMDLs in US
1	Mercury	21,545
2	Pathogens	13,016
3	Metals (excluding Hg)	9,828
4	Nutrients	6,034
5	Sediment	3,922
11	Pesticides	1,233
13	PCBs	698
17	PAH and Toxic Organics	158
Source: EPA OWOW Website, Accessed July 2015		

Project Background

One year research synthesis project that evaluated 35 group of toxins generated by the agricultural, urban and wastewater sectors

Goal: Investigate toxic reduction benefits associated with Bay BMP implementation for the TMDL

Chesapeake Bay Program
A Watershed Partnership

2. Criteria to Define Urban Toxic Contaminants

1. The toxin is primarily associated with **urban land use**, compared to other sectors in the watershed.

2. The toxin is either **generated within the urban sector** or is deposited from the atmosphere onto impervious surfaces and subsequently washed off.

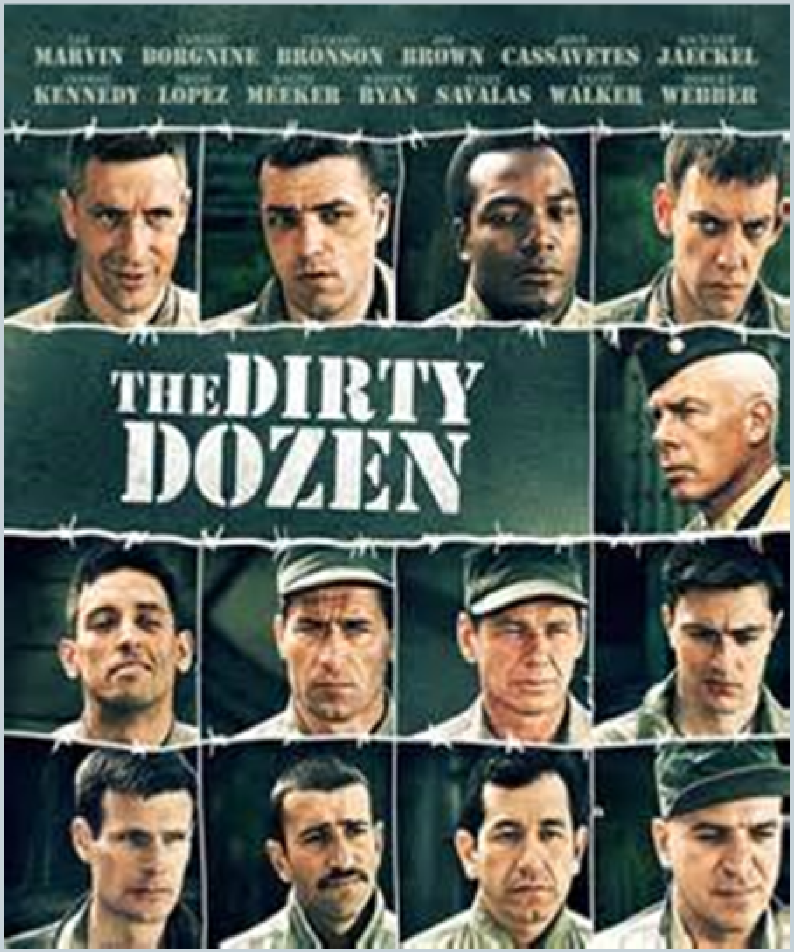
3. Urban **stormwater runoff** is the predominant pathway for transporting it thru the watershed.

4. The toxin has "**sediment-like characteristics**" and can be removed by settling or filtering practices.

5. The toxin is generated or produced in an **upland landscape position** in the watershed where it can be effectively treated by an urban BMP that captures surface runoff.

6. Physical evidence exists that the toxin is **captured** and/or retained within an **urban stormwater BMP**.

2. The Dirty Dozen UTCs



- PCBs
- PAH
- TPH
- Mercury
- UTM (Cd, Cu, Pb, Zn)
- OTM (As, Cr, Fe, Ni)
- Pyrethroid Pesticides
- Legacy OC Pesticides
- Legacy OP Pesticides
- Plasticizers (Phthalates)
- Flame Retardants (PBDE)
- Dioxins

Polychlorinated Biphenyls (PCBs)

- Still detected in fish and wildlife tissues four decades after they were banned (although levels are gradually declining)

- PCBs moving through urban watershed as contaminated sediments are mobilized, deposited and re-suspended

- Older commercial and industrial land use are key watersheds source

Polychlorinated Biphenyls (PCBs)

- Good data on sources, generating sectors, and pathways
- Less data to define levels in runoff and sediment and establish BMP removal rates
- Most data collected outside of Chesapeake Bay
- Meets UTC criteria and behaves like sediment
- Should be removed like sediments in urban BMPs

Polycyclic Aromatic Hydrocarbons (PAH)

- Highest contributor to overall toxicity in urban creeks
- Unique urban sources: coal tar sealants and vehicle emissions
- First flush pollutant, behaves like sediment
- BMP studies show high removal rates (80 to 90%)
- Strong concern about PAH accumulation in pond sediments and possible toxicity

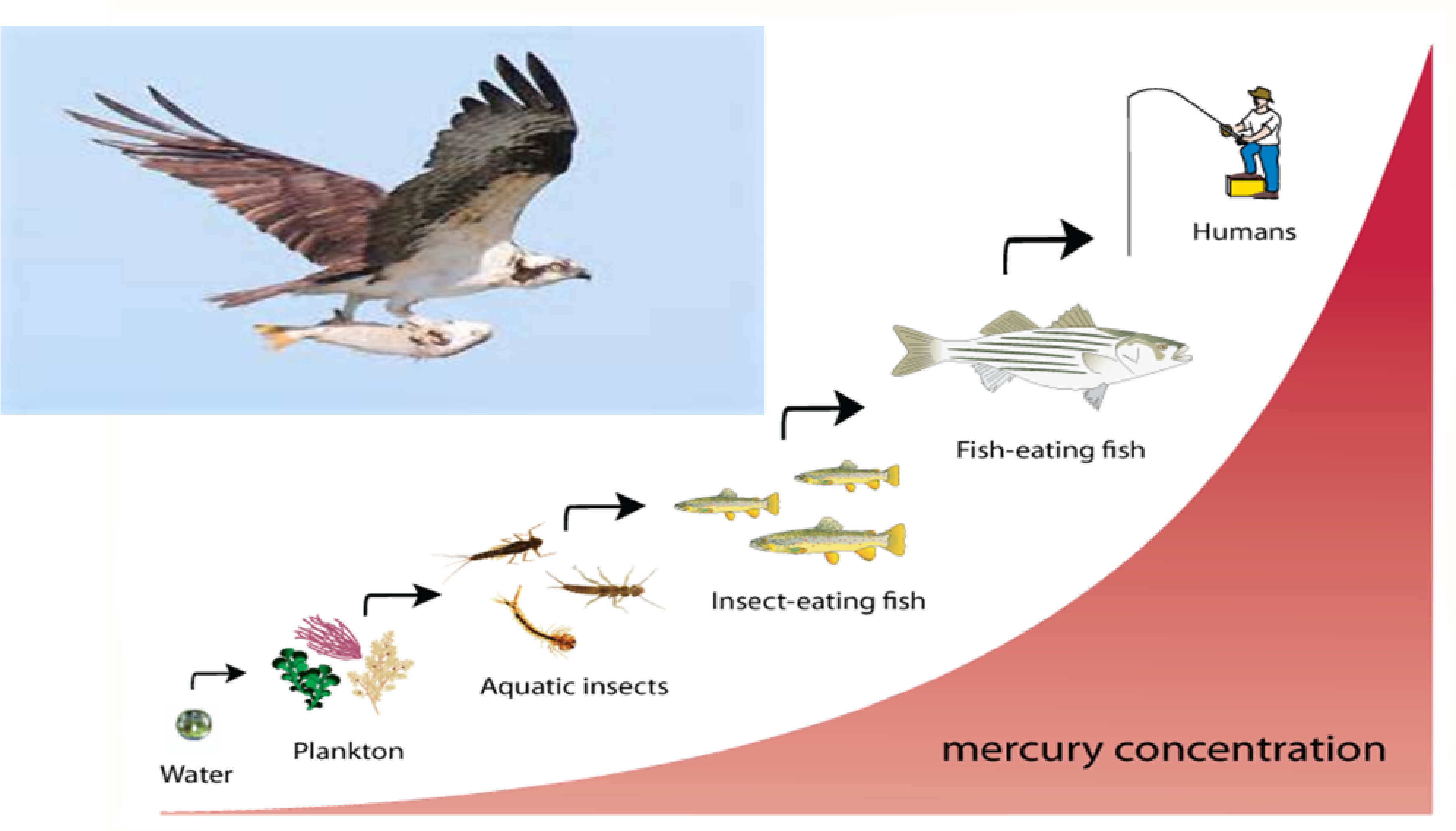
Total Petroleum Hydrocarbons (TPH)

- Term for the oil, grease, gasoline and other hydrocarbons found in urban runoff (i.e., the oil sheen)
- No numerical standards for TPH
- TPH meets all 6 UTC criteria
- Limited monitoring shows very high removal rates in most stormwater BMPs
- Microbes in bioretention media are especially effective in rapidly breaking down TPH

Mercury (Hg)

- Hg is a global pollutant and is deposited from the atmosphere across all Bay land uses (including open water)
- Hg accumulates in fish, birds of prey, and fish-eating mammals and humans
- Hg is leading cause of water quality impairment in the Bay watershed and across the nation
- Urban areas are a key source when Hg is deposited and washed off impervious surfaces or contaminated soils are eroded
- Acts like a UTC.
- Limited monitoring data show high Hg removal by stormwater BMPs

Hg Biomagnification



Mercury Methylation

- Methylation is the process whereby Hg rapidly accumulates in fish tissue and becomes magnified up the food chain
- The process is enhanced in anoxic and organic rich sediments of natural wetlands and estuarine sediments
- Hg is the least treatable UTC due to methylation and air deposition over open waters
- Limited data show that constructed wetlands also enhance methylation
- Hg bioacccumulation in eagles and osprey is trending down in the Chesapeake Bay

Urban Trace Metals (UTMs)

- Cd, Cu, Pb and Zn are detected in nearly 100% of urban stormwater samples, and soluble levels of these metals often exceed aquatic life standards
- Abundant research on EMC and BMP removal for all four metals
- Unique urban sources: roofing materials, brake pads, tire wear, vehicle emissions and air deposition
- Despite solubility, monitoring data generally show high to very high UTM removal by BMPs (especially bioretention).

Comparative Ability of Stormwater BMPs to Remove Urban Trace Metals

Stormwater BMP	Urban Trace Metals			
	Cadmium	Copper	Lead	Zinc
Bioretention	H	VH	VH	VH
Wet Pond	M	H	H	H
Wetland	M	H	M	M
Sand Filter	H	M	VH	H
Permeable Pavement	L	M	VH	VH
Dry Swale	L	H	--	VH
Grass Channel	M	L	L	M
Grass Filter	L	M	L	M
Dry Pond	L	L	M	M

VH: Very High Removal (76% to 100%) H: High Removal (50% to 75%)
M: Moderate Removal (26% to 50%) L: Low Removal (0% to 25%)

Other Trace Metals (OTM)

- Include Arsenic, Chromium, Iron and Nickel
- Greatest risks are for potential drinking water contamination
- Violations of water quality standards are uncommon but operators must closely monitor them during storms
- The source of OTMs are corrosion of urban landscape surfaces often by acid rain
- Most urban BMPs appears to have a moderate to very high ability to remove OTMs

Trends in Insecticides

- The insecticides applied to crops and urban areas have changed over time, and are now less persistent in the environment and do not bioaccumulate in tissues.
- However, they are still mobile in the environment and are deadly to aquatic invertebrates at the part per trillion level

Evolution in Insecticides Over Time

Era	Insecticide	Types	Notes
1940 to 1970	Organochlorines (OC)	DDT	Banned in the 1970s
		DDD/DDE	DDT degradation products
		Dieldrin	Banned in 1985
1960 to 2000	Organophosphate (OP)	Chlordane	Banned in 1978
		Chlorpyrifos	Restricted in 2002
		Diazinon	Restricted
		Dichlorvos	Increased use after 2002
2000 to present	Pyrethroids	Bifenthrin	Replacements for OCP and OPP
		Permethrin	Less toxic than bifenthrin
2005 to present	Fipronil	Fipronil	Most aquatic life toxicity in recent surveys
	Neonictinoids	Imdiacloprid	Emerging concerns about aquatic toxicity

Pyrethroid Pesticides

- Pyrethroid pesticides include bifenthrin, permethrin and others
- New class of insecticides introduced in the last decade
- Non-persistent in the environment and unlikely to bio-accumulate in vertebrates
- Extremely lethal to aquatic invertebrates in urban streams, even at part per trillion level
- Routinely detected in urban creek sediments

Pyrethroid Pesticides

- Meet criteria to qualify as an UTC, although some data gaps remain
- Strong affinity for sediment and organic matter
- BMP removal rates should be comparable to suspended sediment
- More research needed on persistence and toxicity in BMP sediments.

Legacy Organochlorine Pesticides

- Organochlorine (OC) pesticides include DDT, DDE and dieldrin that were banned decades ago but still persist in the urban and agricultural watersheds
- Soils contaminated by OC pesticides more mobile in urban watersheds. Likely present in older pond sediments
- Sharply declining trends in OC pesticide levels in urban runoff and creek sediments -- reduced bioaccumulation in fish, eagles and marine mammals.

Legacy Organophosphate Pesticides

- Organophosphate (OP) pesticides include chlorpyrifos, diazinon and dichlorovos and were introduced 15 to 20 years ago to replace OC pesticides.
- Relatively non-persistent but still very highly toxic to aquatic life in urban streams, most were banned by the turn of the century
- Found in urban watersheds, are highly mobile, are carried by urban stormwater runoff and generally behave like a sediment particle.
- Sharp declines in OP pesticides in stormwater runoff and urban creek sediments after they were banned
- Less persistent pesticides can be eliminated from the environment due to short watershed lag times.

Emerging Toxins of Concern

Flame retardants (PBDE)

Plasticizers (pthalates)

Dioxins

- Very limited monitoring data available -- most collected in Europe or West coast
- Municipal wastewater and biosolids are also key sources of emerging toxins of concern

4. Capability of Stormwater BMPs to Remove UTCs

Urban BMPs are Very Effective at Removing UTCs

- Most UTCs have sediment-like properties, so they are effectively trapped by most urban BMPs before they get to local waterways and the Bay.

Suspended sediment and UTCs

- Share many characteristics
  - UTCs bind, adsorb or otherwise attach to sediment particles
  - UTCs are hydrophobic, have very limited solubility and a strong affinity for organic matter.
  - Both are also relatively inert, persistent, and not very bio-degradable.
  - Both are often associated with fine and medium-grained particles that are easily entrained in stormwater runoff.
  - Both are subject to high removal rates simply through gravitational settling in the water column and/or filtering through sand, soils, media or vegetation.

BMP Treatability for Urban Toxic Contaminants

Toxin Category	BMP Removal Rate?	Measured or Estimated?	Behaves like Sediment?	BMP Retention?	Sediment Toxicity Concern?
PCBs	TSS	E	Y	Y	Mod
PAH	> TSS	E	Y	Y	High
TPH	> TSS	M	Y	Y	Low
Mercury	> TSS	E	Y	Y	Mod
UTM	< TSS	M	Y	Y	Mod
OTM	< TSS	M	Y	Y	Mod

BMP Treatability for Urban Toxic Contaminants
continued

Toxin Category	BMP Removal Rate?	Measured or Estimated?	Behaves like Sediment?	BMP Retention?	Sediment Toxicity Concern?
PP	TSS	E	Y	y	High
OCP	> TSS	E	Y	y	Low
OPP	< TSS	E	Y	?	Low
Plasticizers	Not Really Sure				
PBDE					
Dioxins					

UTC Accumulation In BMP Sediments

- Persistent UTCs accumulate in BMP sediments over many decades at levels that trigger sediment toxicity guidelines.
- As many as 8 UTCs pose a risk for sediment toxicity: PCB, PAH, Hg, Ni, Cr, Cu, Cd, and Zn
- Most research on older stormwater pond sediments

PAH and Pond Sediments

Percent of MD Stormwater Ponds with Potential PAH Sediment Toxicity		
Individual PAH	**TEC**	**PEC**
Napthalene	3%	0%
Flourene	12%	1%
Phenanthrene	46%	12%
Anthracene	15%	1%
Flouranthene	34%	13%
Pyrene	34%	15%
Benzo[a]anthracene	24%	7%
Chrysene	34%	10%
Benzo[a]pyrene	38%	7%
Dibenz[a,h]anthracene	44%	NA
Source: Gallagher et al, 2010		

Managing the BMP Sediment Toxicity Risk

- Are BMP sediments an acceptable place to trap toxics in the urban landscape ?
- Where is the **next** place that sediments should go after are cleaned out from BMPs ?
- Is UTC sediment accumulation only a concern for older stormwater ponds in highly urban/industrial watersheds ?

Not a Bad Place, After All ?

Toxicity risk to aquatic life in the stormwater pond environment may be limited:

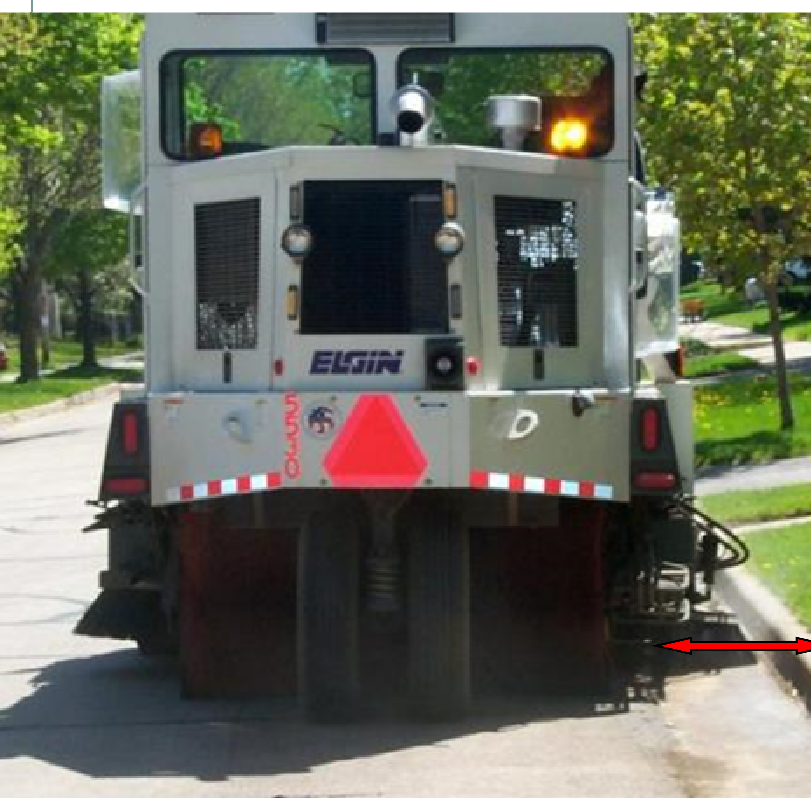
- Simplified food webs and low species diversity reduce bio-accumulation in urban fish and wildlife tissues.
- Not much of a benthic community in pond sediments
- Ponds appear to be effective at retaining UTCs over time
- UTC levels are also high in other non-BMP sediments (e.g., urban creeks, rivers and estuaries).
- Extremely limited fish consumption from ponds and recreational contact with sediments is non-existent

New LID practices (e.g., bioretention) do not create aquatic habitat and removal of surface sediments is frequent

Watershed Strategies for Toxic Reductions

1. Targeted Street Cleaning
2. Industrial and Municipal Pollution Prevention
3. Bans and Product Substitution
4. Stormwater Treatment and Retrofits

Targeted Street Cleaning in Older Watersheds with a lot of Legacy industrial land use



Street Dirt is Highly Contaminated

Toxic Contaminant	Sediment Concentration
Petroleum Hydrocarbons	Diesel range: 200 to 400 mg/kg Motor Oil: 2,200 to 5,500 mg/kg
PCB's	0.2 to 0.4 mg/kg
PAH	Total: 2,798 ug/kg Carcinogenic 314 ug/kg
Pthalates	1,000 to 5,000 ug/kg
Pesticides	Pyrethroids present
Chloride	980 mg/kg
Mercury	0.13 mg/kg
Based on 3 West Coast Studies of street dirt and/or sweeper waste contamination. Source: Expert Panel Report	

Industrial and Municipal Pollution Prevention

Potential Reduction By Pollution Prevention Practices

- No data on impact of pollution prevention practices in reducing toxins required under industrial and municipal stormwater permits.
- The potential effect of these practices could be considerable, given that:
  - 2,700 industrial sites have stormwater permits in Bay watershed (25,000+ acres of impervious cover)
  - 1,000 MS4 facilities and public works yards are subject to the same regulations.

Bans and Product Substitutions

- Past bans and/or product substitution have worked
  - Lead
  - PCB
  - DDT and Diazinon
- New bans and product substitution
  - coal tar sealant for PAH
  - brake pads and rotors for UTMs
  - more sustainable roofing materials for UTMs
- Improved recycling and disposal (batteries, thermostats, fluorescent light bulbs, etc).

Assessing Stormwater BMPs

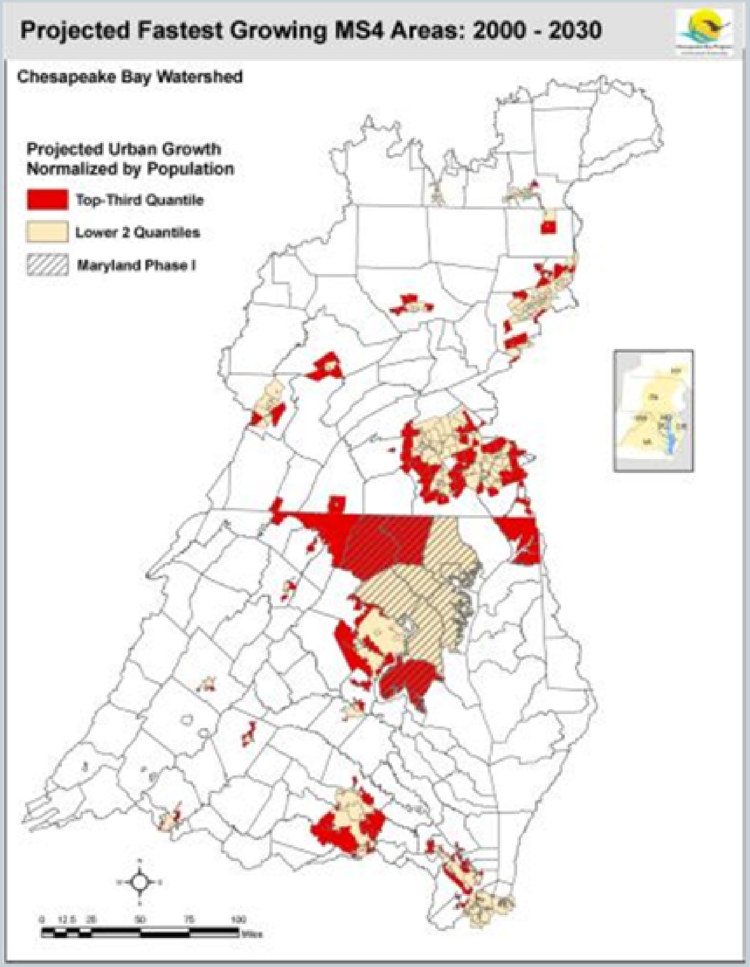
Step-wise Approach

1. Evaluate Urban Land Uses
2. Estimate Loading Rates w/ Simple Method
3. Use TSS Removal Rates as a Benchmark
4. Estimate TSS Removal Rates for Current and Future BMPs
   - Adjustor Curves
   - CBP Removal Rates
   - Estimating Existing BMP Coverage in the Watershed
5. Assess Impact of Other Toxin Reduction Strategies (e.g., Pollution Prevention and Street Cleaning).

Use TSS Removal as a Benchmark

- Linking UTCs to a benchmark TSS removal rate
- Allows users to project UTC removal rates based on known TSS removal rates
- Can calculate reductions based on much larger CBP database on sediment removal by urban BMPs

Urban BMP Coverage in Bay Watershed



- Urban BMPs now cover 30% of urban land in the watershed – most of any region in the nation
- BMP coverage could increase to 40 or 50% by 2025 due to TMDL compliance in the urban sector
- UTC removal by nearly all urban BMPs is moderate to very high

Conservation Tillage and Herbicides

- Profound shift to conservation tillage as a cornerstone BMP for corn and soybeans in the Bay watershed has changed herbicide use and impacts over the last 3 decades

Toxins Produced from Livestock Production and Wastewater Treatment

CSN Toxic Resources

- CSN Report on Urban Toxic Contaminants
- CSN Report on Toxics from the Agricultural and Wastewater Sectors
- Archived Webcasts on Industrial Stormwater
- Industrial Stormwater Benchmarking Tool

Available @ www.chesapeakestormwater.net

Other CSN Resources

- Street and Storm Drain Cleaning Expert Panel Report
- Floating Treatment Wetland EPR
- Pond Management Protocol
- Visual Indicators for LID Practices
- Nutrient Performance Enhancers for LID Practices
- FREE CSN Webcast Series

- Go To CSN WEBSITE AND JOIN 9,000 of YOUR STORMWATER COLLEAGUES

Questions and Answers

APPENDIX H

Maps illustrating water quality changes based on BWB analysis

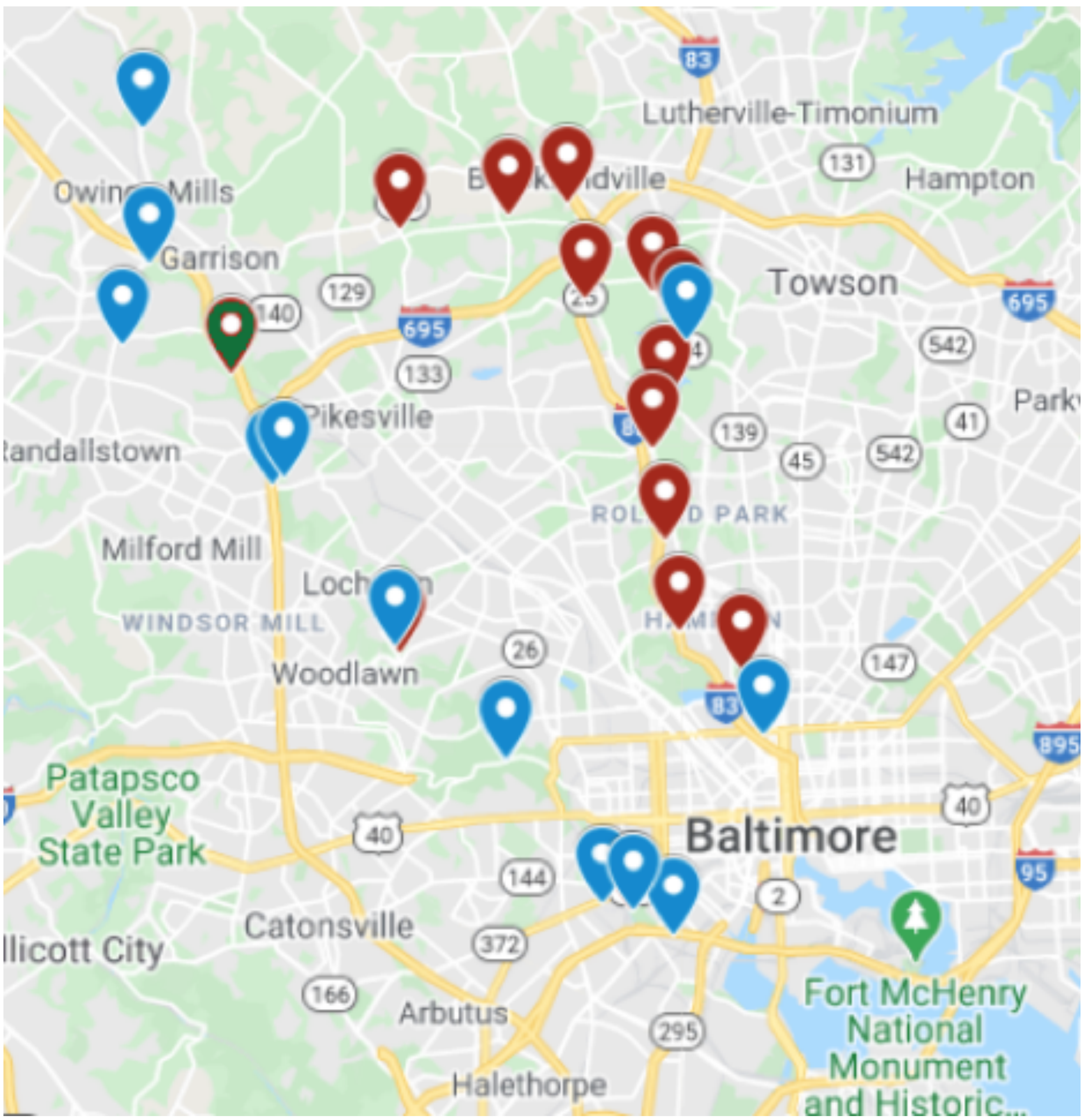
Water Quality Sampling Trends for Parameters Related to Stormwater in the Jones Falls and Gwynns Falls Watersheds

Data and maps from Blue Water Baltimore

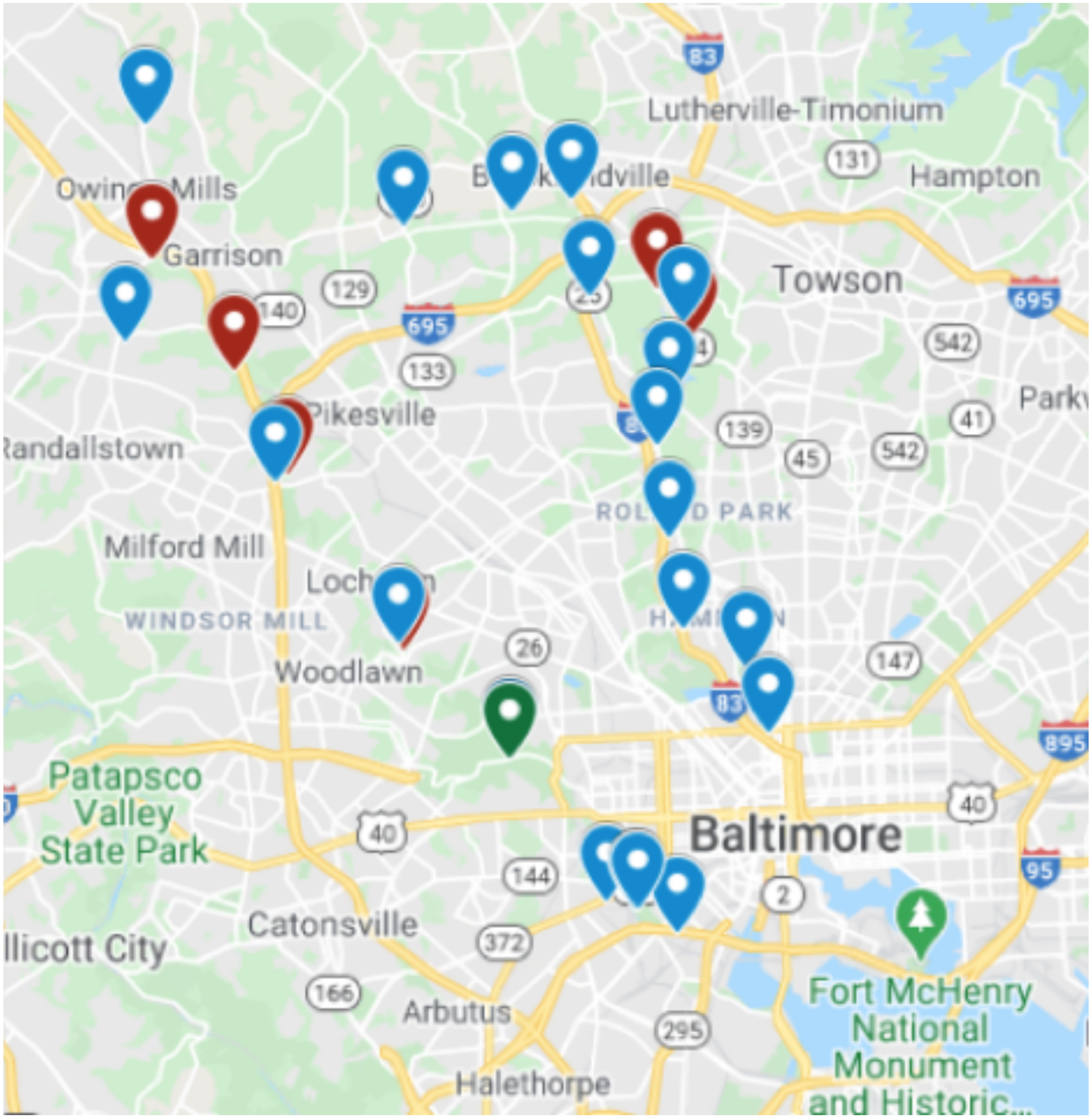
Stations are coded red (significantly worsening); blue (no change); or green (significantly improving).

Trends in Nitrogen 20013-2019 at nontidal stations

Statistically significant trends in Total Nitrogen (mg/L) discerned from an analysis of Blue Water Baltimore's ambient water quality monitoring data at 27 nontidal stations in the Gwynns Falls and Jones Falls watershed from 2013-2019.

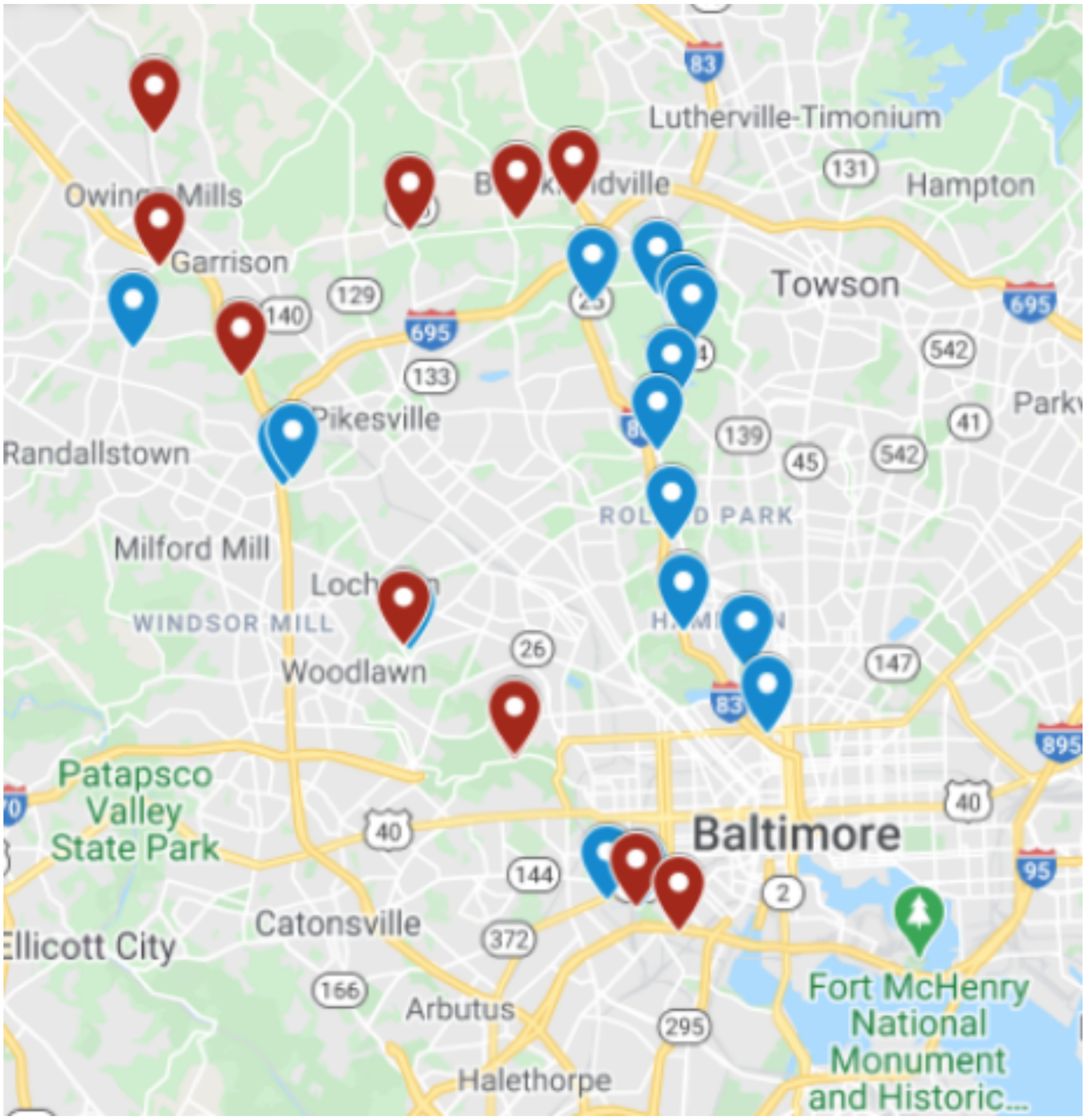


Trends in Phosphorus 2013-2019
Statistically significant trends in Total Phosphorus (mg/L) discerned from an analysis of Blue Water Baltimore's ambient water quality monitoring data at 27 nontidal stations in the Gwynns Falls and Jones Falls watershed from 2013-2019.



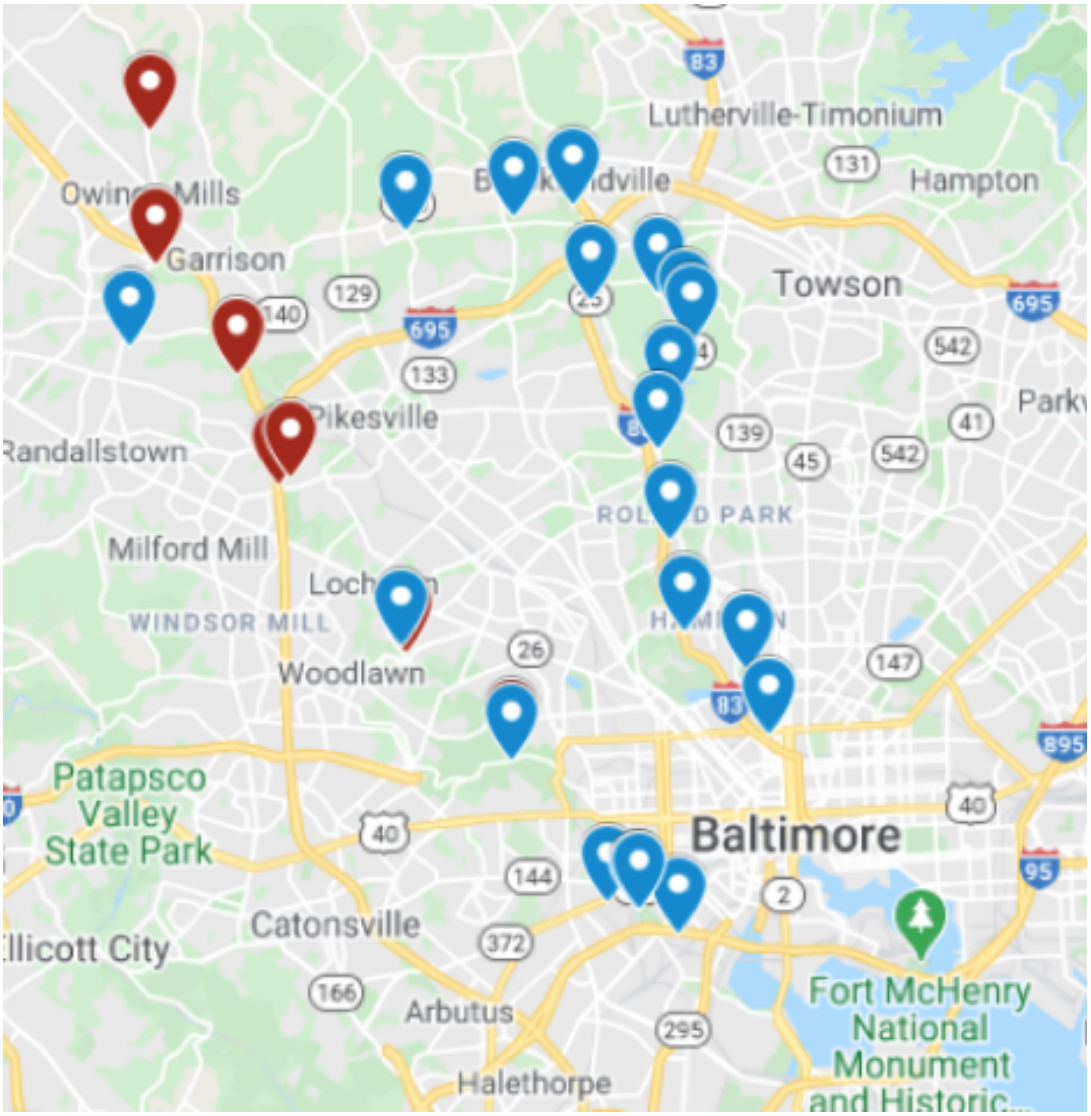
Trends in Specific Conductance 2013-2019

Statistically significant trends in Specific Conductance (µS/cm) discerned from an analysis of Blue Water Baltimore's ambient water quality monitoring data at 27 nontidal stations in the Gwynns Falls and Jones Falls watershed from 2013-2019.



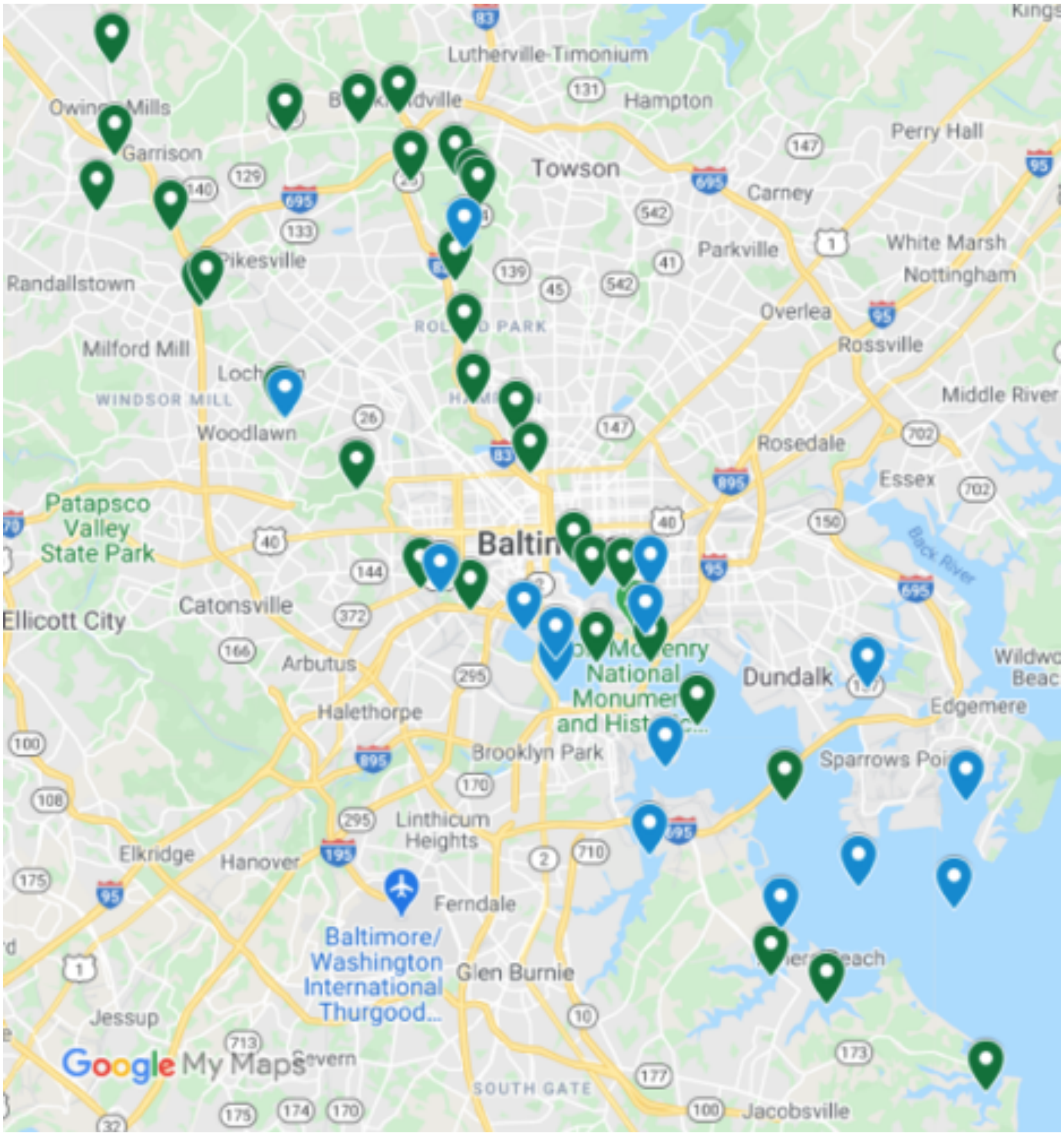
Trends in Turbidity 2013-2019 at non-tidal stations

Statistically significant trends in Turbidity (NTU) discerned from an analysis of Blue Water Baltimore's ambient water quality monitoring data at 27 nontidal stations in the Gwynns Falls and Jones Falls watershed from 2013-2019.



Trends in Bacteria 2009-2019

Statistically significant trends in *Enterococcus* bacteria (MPN/100mL) discerned from an analysis of Blue Water Baltimore's ambient water quality monitoring data at 49 tidal and nontidal stations in the Patapsco River and its tributaries, and streams within the Gwynns Falls and Jones Falls watershed from 2009-2019.



Statistically significant p-values from a long-term trends analysis of data collected at Blue Water Baltimore's 27 nontidal water quality monitoring stations in the Jones Falls and Gwynns Falls watersheds. These p-values were generated by conducting a linear regression analysis of BWB's data from 2013-2019, and significant trends ($p < 0.05$) are marked as improving (green) or worsening (red) based upon the coefficient variable of the resulting equation. A simple linear regression analysis was performed for every water quality parameter at each monitoring site. Data was parsed by "wet" and "dry" weather to account for any influence by precipitation. Wet weather is defined as the 48-hour period following rainfall of at least 0.5 inches, as recorded by the Maryland Science Center NWS station. Based upon this simple analysis, significant trends were identified where p-values were less than 0.05, and trends were categorized as "improving" or "worsening" over time based upon the coefficient variable of the resulting equation. BWB's full dataset is available to download online at www.BaltimoreWaterWatch.org, and upon request.

Station	Station Location (GPS)	Nitrogen	Wet Nitrogen	Dry Nitrogen	Phosphorus	Wet Phosphorus	Dry Phosphorus	Turbidity	Wet Turbidity	Dry Turbidity	Conductivity	Wet Conductivity	Dry Conductivity
BWB-GWN-46	39.431952,-76.780615	0.915	0.804	0.821	0.274	0.590	0.988	0.040	0.262	0.573	0.550	0.283	0.028
BWB-GWN-48	39.404778,-76.779113	0.100	0.397	0.112	0.007	0.130	0.086	0.023	0.228	0.145	0.443	0.336	0.016
BWB-GWN-49	39.388219,-76.786521	0.091	0.519	0.101	0.065	0.135	0.885	0.216	0.599	0.535	0.277	0.581	0.073
BWB-GWN-50	39.360515,-76.747163	0.128	0.201	0.242	0.323	0.484	0.351	0.035	0.244	0.551	0.213	0.971	0.092
BWB-GWN-51	39.382851,-76.758001	0.307	0.037	0.782	0.032	0.113	0.965	0.044	0.297	0.289	0.487	0.357	0.049
BWB-GWN-52	39.361679,-76.744143	0.660	0.284	0.243	0.028	0.187	0.167	0.044	0.304	0.049	0.400	0.465	0.074
BWB-GWN-53	39.327719,-76.715773	0.524	0.097	0.435	0.224	0.136	0.225	0.115	0.284	0.104	0.231	0.494	0.023
BWB-GWN-54	39.326739,-76.713847	0.000	0.281	0.000	0.000	0.033	0.000	0.025	0.286	0.020	0.450	0.985	0.208
BWB-GWN-55	39.305226,-76.686705	0.166	0.442	0.151	0.377	0.647	0.026	0.872	0.465	0.964	0.113	0.927	0.027
BWB-GWN-56	39.276287,-76.661812	0.729	0.547	0.470	0.777	0.748	0.344	0.127	0.351	0.586	0.482	0.891	0.349
BWB-GWN-57	39.305516,-76.686663	0.575	0.682	0.291	0.227	0.436	0.793	0.285	0.879	0.019	0.048	0.826	0.003
BWB-GWN-58	39.275039,-76.654306	0.010	0.617	0.005	0.309	0.349	0.691	0.057	0.378	0.138	0.134	0.661	0.021
BWB-GWN-59	39.269954,-76.643608	0.296	0.721	0.294	0.072	0.399	0.203	0.313	0.911	0.120	0.160	0.972	0.027
BWB-GWN-60	39.274733,-76.653716	0.176	0.520	0.160	0.417	0.899	0.529	0.345	0.502	0.182	0.310	0.077	0.240
BWB-JON-32	39.414279,-76.685635	0.031	0.265	0.003	0.055	0.521	0.081	0.245	0.250	0.751	0.000	0.825	0.000
BWB-JON-33	39.416890,-76.671058	0.009	0.730	0.004	0.834	0.239	0.525	0.523	0.995	0.493	0.058	0.573	0.002
BWB-JON-34	39.399126,-76.649026	0.002	0.908	0.000	0.158	0.414	0.028	0.901	0.534	0.533	0.736	0.343	0.103
BWB-JON-35	39.411946,-76.714130	0.164	0.260	0.028	0.395	0.659	0.569	0.070	0.295	0.117	0.373	0.553	0.004
BWB-JON-36	39.397539,-76.665811	0.034	0.282	0.001	0.554	0.451	0.451	0.162	0.468	0.296	0.598	0.501	0.114
BWB-JON-38	39.392176,-76.641976	0.002	0.709	0.000	0.126	0.137	0.244	0.333	0.243	0.763	0.556	0.434	0.129
BWB-JON-39	39.389352,-76.639826	0.240	0.798	0.259	0.052	0.571	0.020	0.583	0.321	0.274	0.582	0.367	0.097
BWB-JON-40	39.349367, -76.645433	0.008	0.962	0.004	0.697	0.675	0.673	0.236	0.316	0.506	0.912	0.360	0.117
BWB-JON-41	39.377520,-76.645140	0.002	0.611	0.002	0.188	0.376	0.265	0.800	0.616	0.939	0.675	0.215	0.123
BWB-JON-42	39.367626,-76.648901	0.039	0.759	0.001	0.592	0.461	0.779	0.859	0.997	0.626	0.622	0.204	0.173
BWB-JON-43	39.323027,-76.625699	0.125	0.547	0.028	0.885	0.951	0.762	0.481	0.709	0.312	0.299	0.270	0.958
BWB-JON-44	39.331360,-76.641786	0.035	0.466	0.047	0.262	0.870	0.267	0.535	0.508	0.875	0.632	0.207	0.131
BWB-JON-45	39.310614,-76.620007	0.139	0.800	0.118	0.554	0.443	0.779	0.230	0.175	0.844	0.808	0.289	0.106

APPENDIX I

Email correspondence from MDE in response to Commenters' PIA request

CHESAPEAKE LEGAL ALLIANCE

Angela Haren <angela@chesapeakelegal.org>

BACo & BACity Phase I Large MS4 PIA Requests 2020-02374 (ver. 6/24/20) and 2020-02462 (ver. 10/23/20)

Amanda Redmiles -MDE- <amanda.redmiles@maryland.gov> Thu, Dec 10, 2020 at 9:46 AM
To: Angela Haren <angela@chesapeakelegal.org>
Cc: Kathy Mohan -MDE- <kathy.mohan@maryland.gov>, Suzanne Dorsey -MDE- <suzanne.dorsey1@maryland.gov>

Angela, I will forward your response to the Sediment, Stormwater & Dam Safety Program personnel and get back to you shortly with their response.

CHANGING Maryland FOR THE BETTER

Amanda R. Redmiles
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Because of the COVID-19 virus and the need for safety precautions, many state employees are working remotely.

On Wed, Dec 9, 2020 at 10:47 PM Angela Haren <angela@chesapeakelegal.org> wrote:

Hi Amanda,
Thank you for your email. As I believe was explicit in our original request, the reason we submitted these two PIAs was so that we could have adequate information to provide meaningful public comment on the tentative determinations. As you know, MDE has a duty to facilitate the public comment process. If MDE does not provide the documents requested in a timely manner, we will not have them to inform our comments by the January 21 deadline. It's confusingly circular to suggest that MDE's response to our comments will address the very issue that we are requesting documents on so that we can adequately comment.

If there is something I can do to narrow the scope of our request, I am happy to do so. But not responding to a PIA request that we submitted expressly to inform our comments until after the comment deadline really hinders our ability to participate in the public comment process.

Thank you,
Angela

Angela Haren
Senior Attorney, Director, Legal Innovation
Pronouns: she/her/hers
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www.chesapeakelegal.org
Admitted to the California and District of Columbia Bars

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On Tue, Dec 8, 2020 at 4:45 PM Amanda Redmiles -MDE- <amanda.redmiles@maryland.gov> wrote:

Angela,

I am writing on behalf of the Sediment, Stormwater & Dam Safety Program regarding your PIA requests 2020-02374 and 2020-02462. As you know they are related to the Tentative Determination NPDES MS4 Phase I Large permits for Baltimore County and Baltimore City. These tentative determination permits are currently out for public review, and the comment period ends on January 21, 2021. MDE will provide information in response to the public comments received on the permit after the public comment period has expired.

It is likely that the information provided in the response to comments will provide an adequate response to your specific PIA requests for 2020-02462 and 2020-02374. I am contacting you to see if you are willing to wait until the response to comments for the tentative determination permits is produced. This may help narrow your request.

Thank you.

CHANGING **Maryland** FOR THE BETTER

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Because of the COVID-19 virus and the need for safety precautions, many state employees are working remotely.

Click here to complete a three question customer experience survey.

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