Water Quality in the Shenandoah Valley

Virginia's Cleanup Plans Fail to Solve Bacteria Problem

ENVIRONMENTAL INTEGRITY PROJECT

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THE ENVIRONMENTAL INTEGRITY PROJECT

The Environmental Integrity Project (http://www.environmentalintegrity.org) is a nonpartisan, nonprofit organization established in March of 2002 by former EPA enforcement attorneys to advocate for effective enforcement of environmental laws. EIP has three goals: 1) to provide objective analyses of how the failure to enforce or implement environmental laws increases pollution and affects 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 protection of environmental laws.

For questions about this report, please contact EIP Director of Communications Tom Pelton at (443) 510-2574 or tpelton@environmentalintegrity.org.

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Images: Cover photos of Shenandoah River and polluted tributary near Harrisonburg, Virginia, by Tom Pelton of the Environmental Integrity Project. Photo of swimmers in Shenandoah River by Alan Lehman/Shenandoah Riverkeepers.

Water Quality in the Shenandoah Valley:

Virginia's Cleanup Plans Fail to Solve Bacteria Problem

The waterways of the Shenandoah Valley are among Virginia's most treasured gems, valued for their tranquil beauty, rich history, and recreational bounty for anglers and rafters. But the Valley is also home to the Commonwealth's densest concentrations of livestock operations and industrial-scale poultry houses. Their manure is a major contributor to high levels of fecal bacteria, nutrients, and algae blooms that threaten the fishing and tourism that are an equally valuable part of the region's economy and culture. Key obstacles for improving water quality in the Shenandoah – and elsewhere in Virginia – are a lack of not only adequate regulations to control this agricultural industry pollution, but also insufficient funding and staffing for water-quality improvements and monitoring.

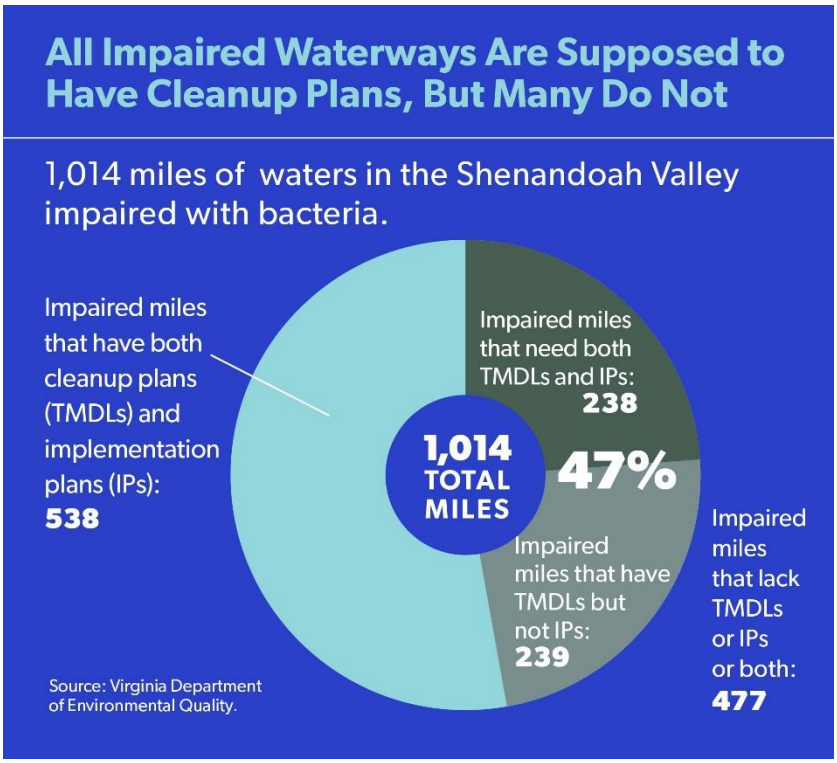
Of the 7,068 miles of rivers and streams in the Shenandoah Valley, the Virginia Department of Environmental Quality (VDEQ) has conducted only enough water quality sampling to determine the pollution status of 26 percent of the miles, according to the state's 2020 Water Quality Assessment Integrated Report.[1] This lack of adequate monitoring is a problem across Virginia, where the state agency – because of limited staff and a long list of small tributaries to evaluate – has assessed only about 22 percent of the total 100,953 miles of rivers and streams statewide to determine if they are "impaired" with pollutants (to use the legal term in the federal Clean Water Act for a waterway that is so polluted it needs a cleanup plan.)[2]

The results of the testing so far are not encouraging. Almost 70 percent of the waterway miles in the Shenandoah Valley that have been examined have enough *E. coli* bacteria to be considered unsafe or "impaired" for swimming, tubing, or other water contact recreation.[3] (To see a detailed online map, click here.[4]) The number of impaired streams and rivers in the Valley is growing, with 10 percent more waterway miles impaired for bacteria in 2020 than in 2010, according to state reports.[5]

Kayaking, tubing, and swimming are popular in the Shenandoah River and its tributaries, although monitoring shows that almost 70 percent of the river miles have too much fecal bacteria for safe contact with the water.

Agricultural pollution is a source of impairment for 71 percent (or 723) of these impaired waters, according to VDEQ.[6]

Under federal and state clean water laws, waterways that are placed on official impaired waters lists created by states and approved by EPA are supposed to have cleanup plans (called Total Maximum Daily Loads or TMDLs) and implementation plans. But 47 percent of the waterways impaired by bacteria in the Shenandoah Valley lack either TMDLs or implementation plans.[7] Two examples of polluted rivers needing cleanup plans are Dog Run, a 23-mile tributary to the Shenandoah River southeast of Berryville, and Gooney Run, a 20-mile tributary to the South Fork of the Shenandoah south of Front Royal (for a complete listing, see Appendix B).



About half of the river miles in the Shenandoah Valley that are impaired but that still lack TMDLs or implementation plans were initially listed as impaired 10 or more years ago.[8] That means that cleanup progress has been slow or nonexistent, and that Virginia has a substantial backlog it must overcome – not only to save the Shenandoah, but also the downstream Chesapeake Bay, which is facing a 2025 cleanup deadline.

Meanwhile, the regulatory landscape is shifting in Virginia. This could mean fewer waterways designated as impaired in the future – and aided by cleanup plans – even though the waters are no cleaner. Water quality standards are changing in the Commonwealth, but not necessarily the water quality itself. On October 21, 2019, Virginia changed its standard for the amount of bacteria that is acceptable for water-contact recreation, such as swimming and rafting. The state adopted new regulations that tolerate higher concentrations of fecal bacteria and that make it harder to designate waterways as "impaired."[9]

Under Virginia's old standards, VDEQ water testing in the Valley showed very high percentages of sampling locations with excessive levels of bacteria. But under the state's new water quality standards, the percentage of testing sites failing the state's standards will drop dramatically, even without any decline in bacteria levels. In 2020, only 24 percent of water sampling locations in the Shenandoah Valley (6 of 25) had enough bacteria to be considered "impaired" under the state's new standards that tolerate more bacteria, compared to under the old standard (52 percent). The state also sampled about half as many sites in 2019 and 2020 than from 2015 to 2018, and eliminated monitoring locations with higher levels of

bacteria (for details, see pages 14 and 15). Virginia officials have not yet moved to formally re-classify these segments that would no longer be considered impaired under its new standards. Such a formal de-listing of impaired waters would take extensive testing and documentation and approval by EPA.

Virginia officials argue they were following EPA guidelines in making the change in bacteria standards, and they did, to some extent. But the Commonwealth also went beyond EPA recommendations by revoking, in October 2019, its threshold for warning swimmers about bacteria in freshwater areas.[10] The state eliminated its so-called "beach action value" for freshwater areas, meant to trigger immediate, short-term health advisories and the posting of no-swimming signs. Such beach warning standards still exist for freshwater swimming areas in Maryland, Pennsylvania, and other states, but not Virginia. Virginia posts signs to warn swimmers only on saltwater beaches, but not in freshwater swimming areas like those along the Shenandoah River. [11]

The Virginia Department of Health (VDH) recently requested an additional $200,000 from the General Assembly to monitor and protect freshwater swimming areas, but the Health Department's valuable proposal was shot down by penny-pinching state lawmakers. A VDH spokeswoman put it this way:[12] "Due to the interest and concerns expressed by public and nonprofit groups for improving the information available on inland beach water quality, VDH has made several attempts to secure funding as recently as 2018, for the 2019-2020 state fiscal budget year. Unfortunately, to date, such efforts have not been successful." Efforts to accurately communicate risks to swimmers and the parents of children splashing and playing in the water is critical for protecting public health, and especially the health of the very young.

The Environmental Integrity Project examined 24 cleanup plans (TMDLs and implementation plans) written by the state and approved by EPA for the Shenandoah Valley's waterways over the last two decades. We found that the plans tend to be toothless – paperwork exercises that suggest voluntary cleanup goals, but have no requirements for landowners and little follow-up or implementation by the state. The plans estimate costs, but fail to specify who should pay for them or provide government funding sources.

This report, which is based upon an examination of state records and water pollution monitoring data, makes the following recommendations. (For a discussion of methodology, see Appendix A).

- Virginia should significantly expand its water quality monitoring program, especially in freshwater areas, so that the nearly 80 percent of waterway miles that lack enough data can be evaluated for impairment decisions and cleanup plans.

- The Virginia General Assembly and VDEQ need to invest enough in staffing and resources to create cleanup and implementation plans for the nearly half of impaired waterway miles in the Shenandoah Valley that lack one or the other of them today.

- The state should take action to implement the cleanup plans it creates, so that TMDLs are more meaningful. The most important way Virginia could better implement its TMDLs would be to impose regulations that reduce the chronic over-

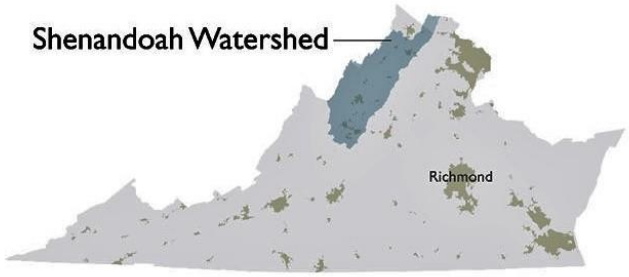
application of manure to farm fields, especially those adjacent to waterways. The Commonwealth should also require that all farmers fence their cattle out of streams and rivers.

- When cleanup plans estimate costs, the state and EPA should specify who should pay these costs, and then track how and whether the money is spent. The state and federal governments, if they require cleanup plans, also should be more willing to step up and underwrite more of the needed investments in clean water.

- The state should tighten up its recently revised water quality standards for bacteria by creating a swimming beach warning standard for freshwater areas and by raising signs to warn people in these areas contaminated by fecal pathogens, including in the Shenandoah Valley. The Virginia General Assembly should approve sufficient funding for the Department of Health to run this swimming area bacteria monitoring and advisory program for freshwater areas. The warning signs could include a website or hotline that people could use to get the most recent bacteria monitoring information.

The Commonwealth already conducts regular bacteria monitoring and raises swimming warnings on saltwater beaches to protect people in Virginia Beach and other wealthier tourist areas. Fairness requires that Virginia do the same for the Shenandoah Valley and other parts of the state where children deserve equal protections of their public health.

Sources of Water Pollution in the Shenandoah Valley



The Shenandoah Valley of Virginia has long been an agricultural powerhouse, as well as a scenic wonder. The Valley's counties, especially Rockingham and Augusta, rank first and second in the state for the value of agricultural products sold. Farmers in the Valley raised an estimated 182 million chickens and had over 271,000 cattle on their farms at the end of 2017, according to data from the U.S. Department of Agriculture's (USDA) Census of Agriculture.[13] Livestock is not only a growing industry, but the average size and weight of chickens and turkeys is also growing, which means more poultry manure.[14] Across the whole Shenandoah Valley, livestock generate more than 410,000 tons of poultry litter and one billion gallons of liquid manure annually.[15] This waste is often overapplied to croplands as fertilizer, creating a large amount of manure runoff into streams and rivers when it rains.[16]

Manure contains fecal bacteria like *E. coli* and other pathogens that can make people ill if they accidentally consume it in drinking water or while swimming. It also contains nutrients and organic matter, which crops and soil need. However, when repeatedly applied to the same cropland at rates above what crops can absorb, nutrients feed algae blooms that foul streams and rivers and fuel low-oxygen "dead zones" downstream in the Chesapeake Bay.

Agriculture is not the only source of water pollution in the Shenandoah Valley. Leaking septic systems, urban stormwater runoff, sewage overflows, industrial contamination, and wildlife also pollute waterways. The Valley is home to 98 wastewater treatment plants, factories, and other major "point sources" of water pollution that pipe their waste directly into rivers and streams.[17] These facilities have Clean Water Act discharge permits issued by VDEQ, which limit the amount of pollution that they can release based on water quality standards and available wastewater treatment technologies. Enforcing the limits in these permits is critical to maintaining water quality in the Valley and throughout the state.

The Federal Clean Water Act and Impaired Waterways

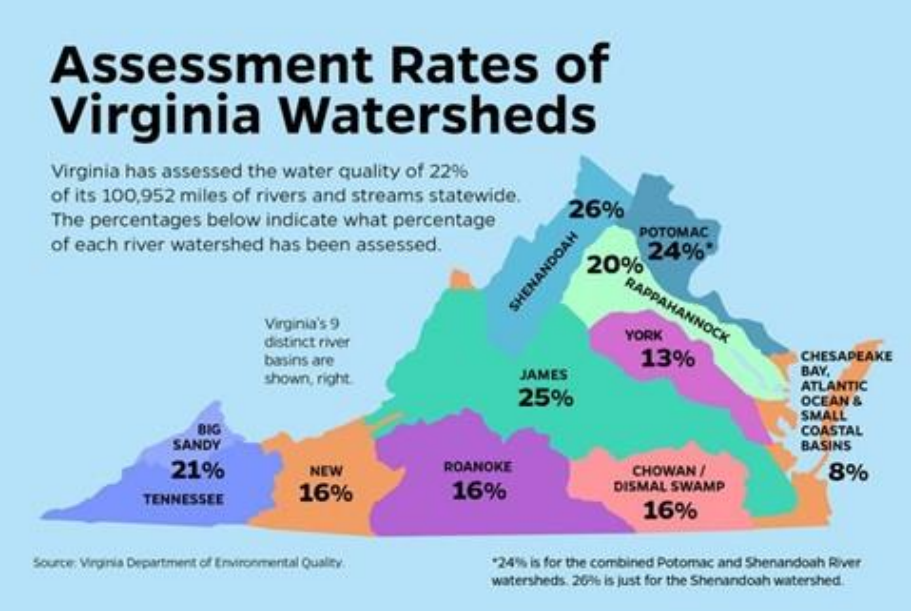
If waterways are polluted to the point that they no longer meet water quality standards, states are required to list them as "impaired" under the federal Clean Water Act.[18] Listing a waterway on the impaired waters list (sometimes called the "303(d) list") requires the state to develop a pollution cleanup plan for that waterway in the form of a Total Maximum Daily Load or TMDL. In Virginia, state law also requires state regulators to develop and implement a Watershed Implementation Plan to put TMDLs into action.[19] Waterway impairments and assessment information can be found in state reports that are issued every two years, called Integrated Reports on Water Quality.[20]

WHAT IS AN "IMPAIRED" WATERWAY?

Impairments refer to the designated uses of a waterway, i.e. a waterway can be impaired for recreation, aquatic life, fish consumption, or use as a public water supply. Impairments have ***causes***, like bacteria, pH, dissolved oxygen, PCBs, or mercury, which come from ***sources*** like sewage treatment plants, agriculture, livestock, atmospheric deposition, or illegal dumping.

According to VDEQ's latest Water Quality Assessment Integrated Report, published in 2020, the state has assessed 1,804 miles of rivers and streams in the Shenandoah watershed.[21] About 73 percent (1,308 miles) of these assessed miles are listed as impaired because they are unfit for recreation, fish consumption, and/or aquatic life due to pollution. About 524 miles (29 percent of the assessed waters, or 40 percent of those that are listed as impaired) still need cleanup plans (TMDLs) to address impairments. Just 27 percent (497 miles) of the assessed river and streams in the Valley are listed as fully supporting at least one designated use. However, it is important to remember that the vast majority of waters in the Valley – almost three quarters – have not even been assessed by VDEQ in the last six years.

This 26 percent assessment rate for the Shenandoah River watershed is similar to the statewide assessment rate of 22 percent, and higher than the rate in the Rappahannock River watershed, York River watershed, and on Virginia's Eastern Shore, according to VDEQ.[22]



Map A shows which waterways in the Shenandoah Valley have been assessed and found to be impaired because of pollution. Map B shows which waterways have not yet been assessed by the state (often smaller waterways, marked in light green).

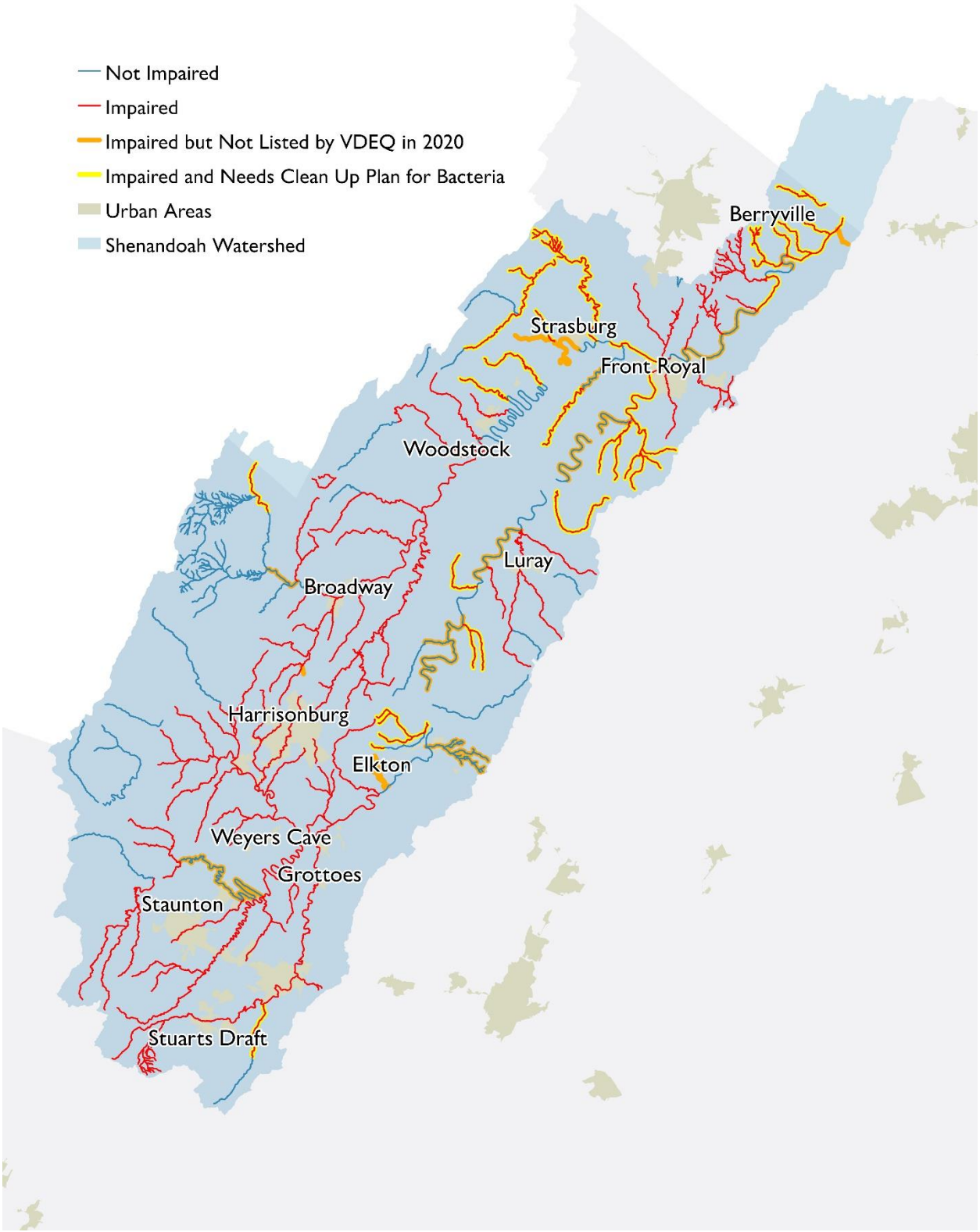
Table 1 shows the status of rivers and streams in the Shenandoah watershed by "designated use," according to Virginia's 2020 assessment of waterways.[23] Designated use is a term that refers to how a waterway is intended to be used, including for recreation, fish consumption, or as a public water supply. For example, rivers and streams designated for water-contact recreation are places where young children should be able to play without worrying about getting sick from pathogens from manure or sewage in the water. Waterways that are considered safe for this kind of contact recreation are listed as "fully supporting" recreational uses. Only 446 miles of rivers and streams in the Valley (or 6 percent of the total) were listed by VDEQ as meeting this standard in 2020.

Table 1. Status of Rivers and Streams in the Shenandoah Valley by Use, 2020

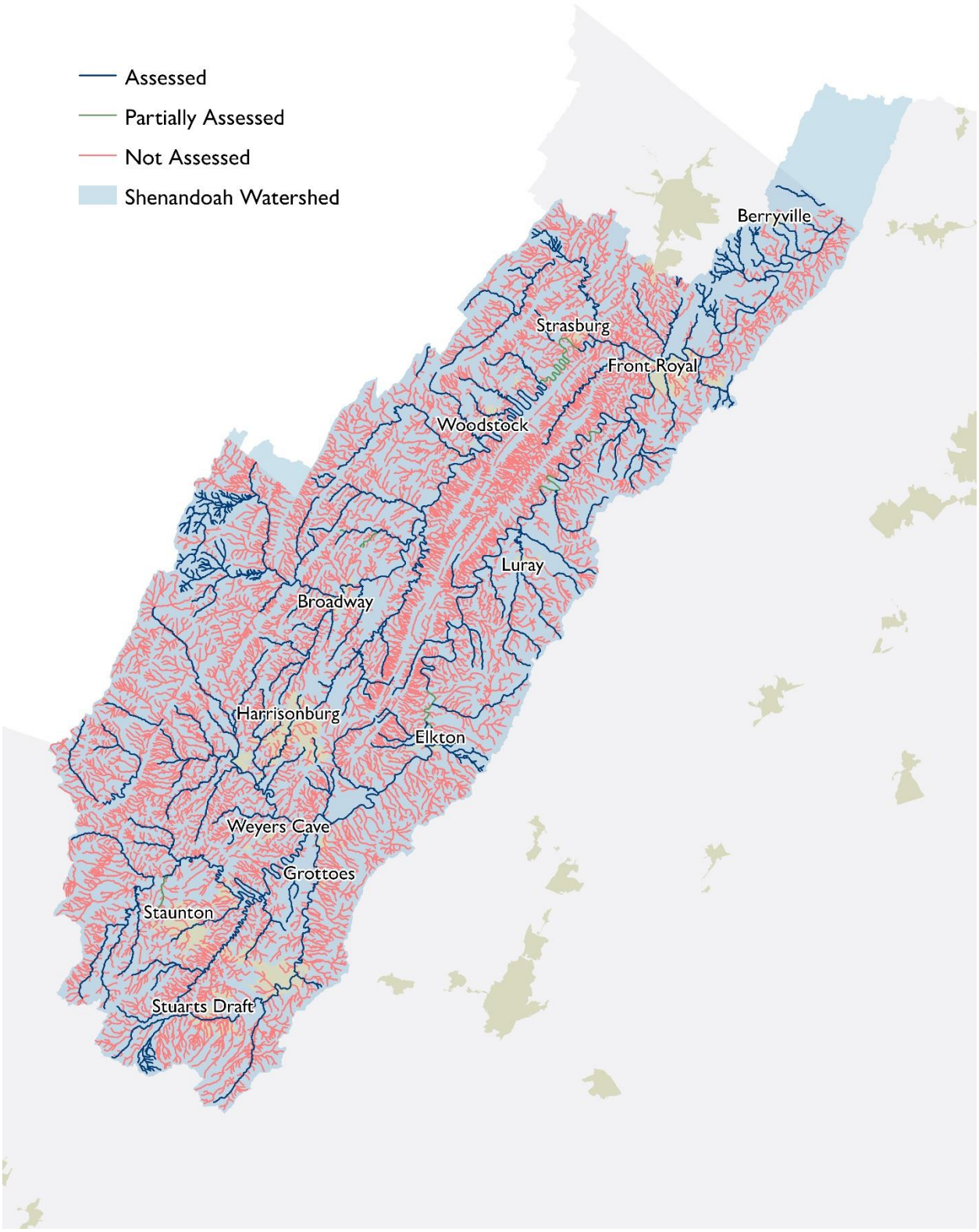
Status	Recreation	Aquatic Life	Fish Consumption	Any Use
Total number of waterway miles	7,068	7,068	7,068	7,068
Miles assessed	1,461	1,756	219	1,804
Percentage of miles assessed	21%	25%	3%	26%
Miles impaired	1,014	658	179	1,308
Percentage of assessed miles that are impaired	69%	37%	82%	73%
Miles not assessed	5,572	5,275	6,842	5,230
Miles with insufficient information	36	38	7	34

Source: EIP analysis of Virginia DEQ's 2020 Water Quality Assessment Integrated Report[24]

Map A. Impaired Waterways in the Shenandoah Valley



Map B. Assessed and Un-Assessed Waterways in the Shenandoah Basin (2020)



Meanwhile, the Commonwealth considered more than 1,014 miles in the Valley impaired for recreational uses in 2020, making this kind of impairment the most prevalent. And even this number may be too low. EIP's analysis of state water quality monitoring data in 2020 revealed that 130 miles of rivers and stream in the Valley, including along the South Fork of the Shenandoah River, were left off of the state's impairment list, even though they had excessive levels of *E. coli* bacteria.[25]

Still, the state's official total of impaired miles in the Valley marked an increase of 10 percent from 2010, when the state considered 921 miles impaired for recreation.[26] This overall increase in impaired miles in the Valley came even though the state removed some portions of waterways from its impaired waters list, including a segment of the South Fork of the Shenandoah, and a portion of the Middle River.[27]

Waterways are also places where fish and other aquatic creatures and plants should be able to thrive, and they should fully support aquatic life. Waters fail to support aquatic life when nutrients, acidity levels, or sediment kill off diverse bottom-dwelling flora and fauna, while making the area only friendly to pollution-tolerant life forms. Aquatic life impairments are the second most common reason for a waterway in the Shenandoah Valley to be listed as impaired, with about 658 miles in this category.[28]

Fish caught in the wild should also be edible, especially where people depend on subsistence fishing as a food source. Mercury and polychlorinated biphenyls (PCBs) have been found in fish tissue in about 179 miles of Shenandoah waterways, largely along the South Fork of the Shenandoah.[29]

Water should also be safe for wildlife other than fish and other creatures that live under water and where possible, waterways should be safe to use as a public drinking water supply. About 1,038 miles of streams and rivers have been assessed and found to be supportive of wildlife, while the rest, 6,030 miles, have not been assessed. About 117 miles of rivers and streams in the Shenandoah Valley have been assessed and found to be supportive of use as a public water supply. But, 513 miles have not been assessed, while most waterways – about 6,438 miles—have been excluded from consideration as a source of public drinking water.[30]

Bacterial Impairments in Waterways

Bacteria is the leading cause of impairment in the Shenandoah Valley. Over 1,014 miles are officially listed as impaired for recreational uses, or 69 percent of the total assessed in 2020.[31] This means that levels of indicator bacteria like fecal coliform or *E. coli* were high enough to fail the state's water quality standards for recreation. High levels of *E. coli* and/or fecal coliforms indicate the presence of pathogens that can make people ill if they swallow the water, often accidentally if they are swimming.

Waterbodies that do not meet federal water quality standards for fishing and swimming during monitoring are listed on a state impaired waters list [32] that is sent to the Environmental Protection Agency. Once a waterbody is on the list, the state must do two things: 1) write a Total Maximum Daily Load (TMDL) cleanup plan that outlines the pollution sources, current water quality, and what pollution reductions must be made from what sources to bring the waterway back to a healthy state;[33] and 2) develop an implementation plan to carry out those controls. That implementation plan outlines how to accomplish the TMDL cleanup goals on what timeframe, and at what estimated cost.

The Shenandoah River is a critical part of Virginia's history and culture, but many waterways in the Shenandoah Valley are impaired by farm runoff pollution and lack needed cleanup and implementation plans.

Of the 1,014 total waterway miles in the Valley that are impaired for bacteria, all of them – under state and federal laws – should have cleanup plans (TMDLs) and implementation plans. But only slightly more than half (53 percent, or 538 total miles) so far have both. Another 47 percent, or 477 of the impaired miles, fall short, lacking either TMDLs or implementation plans, or both. As subsets to the waterways that lack what they need, 238 of the miles (or 23 percent) do not have TMDLs, and another 239 miles (or 23 percent) have TMDLs but not implementation plans.[34]

Among the waterways in the Shenandoah Valley that are impaired but still lack TMDLs and implementation plans are Dog Run, a 23-mile-long tributary to the Shenandoah, and Gooney Run, a 20-mile tributary to the river. See Appendix B for a full listing of the Valley waterways that lack TMDLs or implementation plans, or both.

Besides broadly defined non-point sources, agriculture is the leading source of bacteria to impaired waterways, contributing to over 71 percent (722 miles) of impairments, according to state figures.[35] This bacteria is carried into waterways in poultry and cattle manure runoff from farm fields. *E. coli* and fecal pathogens also come from livestock feed lots, dairy farms, and pastures where cattle and dairy cows are allowed to wander freely into waterways or defecate near the water's edge.

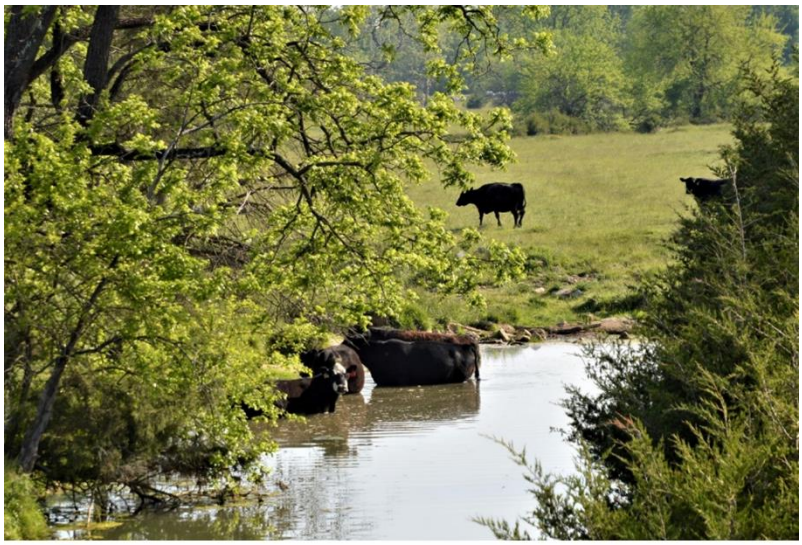
However, the definition of exactly how much fecal bacteria is too much – and what, exactly, "impairment" means – has recently changed in Virginia. This 2019 change in water quality standards could have a significant impact on the future designation of waterways as

"impaired" or not, and therefore the state's decisions about which rivers and streams should have cleanup plans and pollution reduction goals. It also significantly impacts the state's water quality sampling program, because more sampling will need to occur in order to demonstrate compliance with the new standard.

This question is a major issue because more than three quarters of Virginia's river and stream miles have not yet been assessed by the state – meaning that impairment decisions about these waterways are still coming up in the future. Real-estate developers, manufacturers, food processing plants and other industries have a financial interest in the state designating as few water miles as possible as "impaired," because this listing means the state may impose tighter pollution control limits on water-pollution control permits it issues for wastewater treatment plants and other point sources of pollution. Virginia and EPA can also deny permits for sewage plants and other facilities piping wastewater into impaired waterways.

Bacteria Monitoring and Changing Standards in Virginia

Virginia and other states routinely sample for bacteria in waterways for two reasons. As mentioned in the previous section, the first reason is to determine if a waterway is so polluted it should be put on a government list of "impaired" waterways that require long-term cleanup plans and tighter permit limits for point sources of pollution. The second reason is to find out if and when the levels of fecal pathogens in a swimming area are so high that they exceed a health-warning threshold called a "beach action value." This is a trigger value that authorities can use if the water is too bacteria-laden for safe swimming so that officials can warn the public through posting of signs and issuing public health advisories. Two types of bacteria are used as indicators of pathogens and harmful bacteria in waterways, and which bacteria are used depends on the salinity of the water. *E. coli* are used in fresh water, while enterococci are used in salt water. The presence of these bacteria types indicate the likely presence of more dangerous pathogens and parasites, such as *Cryptosporidium* or *Giardia*, from the feces of humans and other warm-blooded animals.



One major source of fecal bacteria in Valley waterways is cattle. About 80 percent of livestock farms in Rockingham and Augusta counties have not fenced their cattle out of streams and rivers on their property.

For decades, Virginia has collected bacteria sampling data in both fresh and saltwater areas of the state but has only posted warning signs for swimmers on ocean and saltwater beaches. The state has never issued public health advisories or posted signs in freshwater areas like the Shenandoah River, even though rafting, tubing, and swimming are common in the scenic waterway. At least 23 waterfront campgrounds are located along the Shenandoah River and its tributaries, and many of them – including Watermelon Park and Campground in Berryville and Outlanders River Camp in Luray – advertise swimming and tubing to their customers.[36] The Shenandoah Riverkeeper Swim Guide lists over 70 water access points on the three major reaches of the Shenandoah River.[37]

Monitoring by VDEQ shows that many of these areas that people use for tubing and swimming have high enough *E. coli* bacteria levels to warrant public signs or warnings. In 2020, 72 percent of the 25 state water monitoring sites in the Shenandoah Valley had levels of *E. coli* that exceeded EPA's recommended swimming advisory "beach action value" of 235 units of *E. coli* per 100 ml of water.[38] For example, a monitoring site on the South Fork near Luray had 2,481 counts of *E. coli* in September 2020. This monitoring site is adjacent to a 'premier camping resort' where swimming, tubing, boating, and fishing are advertised as recreational activities.[39]

Table 2. Monitoring for *E. Coli* Bacteria in Shenandoah Waterways

Year	Number of Sites Sampled	Number of Sites Where Bacteria Exceeded EPA's Swimming Advisory Value	Percent of Sites Over EPA Swimming Advisory Value	Annual Rainfall (inches)
2015	70	65	93%	40.5
2016	74	56	76%	37.5
2017	66	48	73%	37.6
2018	69	56	81%	59.7
2019	35	26	74%	35.5
2020	25	18	72%	42.6

Water sampling data from the VDEQ, for sites sampled at least twice in the last six years. Sampling locations often change from year to year. The threshold used in this graph is EPA's recommended "beach action value" for swimming, which recommends states to notify the public when bacteria levels exceed 235 counts of E. coli *bacteria/100 ml water.*

The percentage of water monitoring sites registering levels of *E. coli* that would be unsafe for swimming go up and down from year to year, in part because the state changes its sampling locations, and some locations are worse than others. Rainfall also impacts bacteria levels, with years of higher rainfall (such as 2018) often having higher bacteria readings, because more rain washes more manure, dog waste, and other pollutants off the land. As noted earlier, manure spread on farm fields or directly deposited into streams and rivers by herds of cattle are the source of about 71 percent of bacterial impairments in the Shenandoah Valley.[40]

Officials at the Virginia Department of Health (VDH) say they issue bacteria warnings for saltwater beaches, but not freshwater swimming areas like those along the Shenandoah River, because the Virginia General Assembly does not provide the funding or staff to conduct adequate testing in freshwater swimming areas, despite the department's requests for additional funding for this.[41] By contrast, for saltwater areas, EPA provides VDH with grants for regular bacteria testing and swimming advisories at 46 ocean beaches, including Virginia Beach. In 2018, VDH asked the General Assembly for about $200,000 in additional funding to hire more staff, conduct more sampling in freshwater areas, and start posting bacteria warning signs across the state on waterways that are officially listed as "impaired" for bacteria.[42] The General Assembly rejected those requests for additional funding and an expanded freshwater testing program, according to Margaret Smigo, Waterborne Hazards Program Coordinator for the Virginia Department of Health.[43]

"VDH applies for and receives funding annually from EPA for the coastal beach monitoring program. No such federal or state funded program exists for inland waterbodies," Smigo wrote in an email. "In the absence of a mechanism for conducting frequent seasonal bacteria monitoring at freshwater beaches, VDH lacks the data necessary to make advisory decisions for these waters. Due to the interest and concerns expressed by public and nonprofit groups for improving the information available on inland beach water quality, VDH has made several attempts to secure funding as recently as 2018, for the 2019-2020 state fiscal budget year. Unfortunately, to date, such efforts have not been successful."

The Virginia Department of Health says it does not have the funding or staff to post swimming warnings for fecal bacteria in freshwater parts of the state, like the South Fork Shenandoah River, pictured here.

In October 2019, Virginia revoked its swimming beach warning standard for *E. coli* in freshwater areas. VDH argued that it would be pointless to have such a "beach action value" when the agency lacked the staff or capacity to issue health warnings in these freshwater areas.[44] Since then, the Commonwealth has only had a swimming beach warning value for saltwater beaches. By contrast, Maryland and Pennsylvania both use the freshwater "beach action value" recommended by EPA (235 colony forming units of *E. coli*/100 ml of water).

Revision of Impairment Standards for Bacteria

In October 2019, Virginia also issued new water quality standards for deciding whether a waterway is "impaired" by bacteria and should be placed on a long-term list of waterways that need cleanup plans.[45] The Commonwealth's new impairment standard tolerates higher concentrations of *E. coli* bacteria (410 counts of *E. coli* bacteria per 100 ml of water, a revised figure suggested by EPA, instead of 235 counts under the old standard). It also requires more frequent testing to designate a waterway as impaired or show that it meets a recreational standard. Under the state's old standard, if sampling showed a waterway exceeded 235 counts of *E. coli* at least twice or in 10 percent of samples over a **six-year period,** it could be considered impaired. Under the new standards, a waterway will be considered impaired if more than 10 percent of tests **within 90 days** exceed 410 counts of *E. coli*.[46] (For more details about Virginia's old and. new impairment standards for bacteria, including use of a geometric mean, see Appendix C).

Considering the reality that the state has not yet even assessed 78 percent of the 100,953[47] miles of streams and rivers in Virginia to determine if they are impaired, these higher hurdles to prove impairment – higher counts of *E. coli* required to demonstrate impairment, and more frequent testing needed to calculate the required statistics – could mean that fewer waterways will be placed on the state's impaired waters list in the future. That would mean fewer cleanup plans and actions, even if the waterways remain just as polluted.

Under Virginia's new standard, significantly fewer water monitoring locations in the Shenandoah Valley would be considered to have excessive levels of *E. coli* bacteria, even if the waterways continue to be as contaminated. In 2020, Virginia sampled 25 waterway locations in the Shenandoah Valley. Water at 13 of these sites (or 52 percent) would have enough bacteria to be considered "impaired" under the state's old standard.[48] However, water at only six of these 25 sites (or 24 percent) would be considered impaired under the state's new bacteria standard.[49]

Table 3. Waterway Impairment Under VA's Old vs. New Bacteria Standards, 2020

Standard	Number of sites considered impaired	Percent of sites considered impaired
Virginia's old impairment standard	13 of 25	52%
Virginia's new impairment standard	6 of 25	24%

This table compares VDEQ sampling results in the Shenandoah Valley using Virginia's old impairment standards for bacteria vs. the new standard adopted in October 2019. Under the old standard, impairment meant exceeding 235 counts of E. coli *in at least 10% of samples over six years, compared to the new standard of 410 counts in more than 10% of tests within 90 days.*

As a graphic illustration of this difference in percentages, see the maps in Appendix D that show the monitoring locations in the Shenandoah Valley in 2020 and *E. coli* levels that would be considered impaired or not impaired under the old vs. new bacteria standards. If we look at Virginia's bacteria sampling results in the Shenandoah Valley over the last five years and compare the state's old standard for *E. coli* to the one it adopted in 2019, we find that 68 percent of the monitoring sites over this five-year period would have exceeded the old bacteria standard, while only 51 percent of the sites would have exceeded the new standard.

Table 4. Summary of Shenandoah Bacteria Measured at Monitoring Sites, 2015-2020

Standard	Number of sites considered impaired	Percent of sites considered impaired
Virginia's old impairment standard	93 of 136	68%
Virginia's new impairment standard	70 of 136	51%

This table includes only sites in the Shenandoah Valley sampled more than twice over the last six years. It compares Virginia's old impairment standards for bacteria (exceeding 235 counts of E. coli in at least 10% of samples over six years) to the state's new standard, adopted in October 2019 (exceeding 410 counts of E. coli in more than 10% of tests within 90 days.) Data collected by VDEQ.

The long-term implication of the change is that fewer waterways may be placed on Virginia's "impaired waters" list in the future, requiring fewer cleanup plans and more relaxed permit limits for point sources. Some waterways may even be taken off the impaired waters list, even though they are no cleaner. However, the new standard also raises the bar for removing a waterway from the impaired waters list because the state will need to document and justify that removal with significantly increased monitoring.

Officials with the Virginia Department of Environmental Quality cautioned that just because fewer unassessed waterways might qualify as impaired in the future under the new standards does not mean that Virginia will automatically remove waters from the "impaired waters" lists if they are already listed. [50] Virginia's new requirements for more frequent testing (including at least 10 water samples in 90 days) mean that it will take a considerable amount of time, testing, and government review to remove waterways from the impaired waters list once they are listed.

Reasons for Changing Bacteria Standards

The Virginia Department of Environmental Quality said the state changed its bacteria standards in 2019 to follow updated federal criteria issued by EPA in 2012. "The Virginia State Water Control Board recently adopted nationally recommended bacteria criteria published by the Environmental Protection Agency," said Greg Bilyeu, Director of Communications for VDEQ.[51] "Periodically, EPA reviews all of its recommended water quality criteria so that they reflect the best available science. The criteria rely on the latest

research and science, including studies that show a link between illness and fecal contamination in recreational waters."

EPA, in its 2012 criteria document, said that it was revising its bacteria standards to reflect more recent scientific studies, updated since the standards were set in 1986, that show how much bacteria in water actually makes a significant number of people sick.[52] The implication is that swimmers actually have more tolerance for *E. coli* than the agency thought a quarter century ago, when the old standard was issued. EPA said that its goal was to "accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare that might be expected from the presence of pollutants," and that the agency's old standard created a "level of protection much more stringent than intended."[53]

However, the Natural Resources Defense Council and other environmental groups criticized EPA's 2012 change in water quality criteria, arguing that it allowed too much bacteria in the water and would permit too many swimmers to become sick with diarrhea, eye and ear infections, and other illnesses. "EPA's Draft Criteria are far less protective of the public health of swimmers than current science and good public policy dictate," wrote Steve Fleischli, Senior Attorney for NRDC.[54] "Commenters are concerned that the draft Recreational Water Quality Criteria does not adequately assess the health risks to children and other vulnerable populations from exposure to contaminated waters," wrote Phillip Musegaas, Director of the Hudson River Program with Riverkeeper Inc., in a joint letter with the New York/New Jersey Baykeeper and Hackensack Riverkeeper to EPA in 2012.[55]

"We believe EPA's new criteria offer weaker national protections than the original 1986 criteria and do not reflect the best available science," wrote Lara Meeker, Water Quality Coordinator with the Santa Monica Baykeeper to EPA in 2012.[56] "The draft criteria implies that 2 million cases a year of gastroenteritis, including diarrhea, vomiting, ear, eye, skin and lung infections is an acceptable risk…It is unacceptable that the draft Recreational Water Quality Criteria knowingly allows for such a high illness rate."

Since EPA issued its 2012 criteria, it reported during a 2018 review and update on the issue that the science is still evolving on the question of how much bacteria makes a swimmer sick. For example, recent studies have found that kids tend to swallow a lot more water when swimming than adults, which means they have higher exposure rates.[57] Epidemiological data from the U.S. Centers for Disease Control and Prevention also show that over half of all natural water swimming-related illnesses occurred from exposure to fresh water, rather than from salt water beaches.

Virginia adopted some, but not all, parts of the 2012 EPA criteria. For example, the EPA criteria suggested more frequent testing than Virginia is performing. EPA recommended at least 10 samples within 30 days to determine if water meets the criteria, but Virginia chose 10 samples within 90 days.[58] While not part of the formal criteria, EPA also recommended that states continue using a "beach action value" for issuing advisories to swimmers in freshwater areas with excessive amounts of bacteria – a warning trigger of 235 counts of *E.*

coli/100 ml water. However, Virginia did not follow EPA's recommendation on that, and instead eliminated its state freshwater "beach action value."

Virginia's Reduction in Water Sampling Sites

An examination of VDEQ water monitoring data shows that Virginia has been sampling in far fewer locations in the Shenandoah Valley in recent years. From 2015 through 2018, the state agency sampled an annual average of 70 locations in the Valley more than once. Those numbers dropped to 35 sites sampled in 2019 and 25 in 2020. VDEQ plans to sample for bacteria at 73 locations in the Valley 2021, according to its latest water quality monitoring plan.[59] Infrequent sampling makes it nearly impossible to know if water is safe for swimming, nor does it provide a clear picture of water quality.

The Environmental Integrity Project examined the data from 20 monitoring locations in the Valley that VDEQ sampled every year from 2015 to 2018, but not at all in 2020. The average exceedance rate of the EPA "beach action value" threshold for safe swimming for all samples across all four of those years was 46 percent – suggesting high levels of bacteria (Table 5).

Table 5. 20 Shenandoah Valley Sites Sampled From 2015-2018, But Not 2020

	2015	2016	2017	2018
Number of Sites Monitored	20	20	20	20
Number of Samples	191	182	175	178
Number. of Samples Over EPA Swimming Action Value	87	75	80	88
Percent of Samples Over Swimming Action Value	46%	41%	46%	49%

Source: VDEQ monitoring data. The table shows the number of waterway sites sampled for E. coli more than once in the Shenandoah Valley in the above years.

By contrast, below in Table 6 are bacteria averages for 19 locations that were monitored all six years. They had lower bacteria levels, averaging only 33 percent (Table 6). This suggests that Virginia removed from its sampling list locations that were more bacteria-laden.

Table 6. 19 Shenandoah Valley Sites Sampled Every Year From 2015-2020

	2015	2016	2017	2018	2019	2020
Number of Sites Monitored	19	19	19	19	19	19
Number of Samples	218	198	198	195	222	210
Number of Samples over EPA Swimming Action Value	71	70	49	89	75	52
Percent of Samples Over Swimming Action Value	33%	35%	25%	46%	34%	25%

Source: Data from VDEQ and analyzed by EIP. Sampling is during warm months, from May through June.

It should be noted that, overall, a smaller percentage of samples exceeded EPA's safe-swimming advisory levels in 2020 than in 2015.[60]

Reaction from Virginia Department of Environmental Quality

Greg Bilyeu, Director of Communications for VDEQ, said his agency since 2019 has been moving toward increasing the frequency of its bacteria monitoring in a smaller number of select waterways where people actually swim.[61] This means fewer monitoring sites, tested more often. "More frequent monitoring (i.e., approximately weekly over a 90-day period) is necessary to implement the updated standard. Beginning in 2019, the agency began conducting a pilot study at selected stations to determine the resources needed to collect weekly bacteria samples versus the monthly samples previously required," Bilyeu wrote.[62] "As high-frequency bacteria monitoring cannot be performed everywhere, DEQ identified known recreational waters with public access for prioritization in the pilot study so that resources could be directed toward those areas. To conduct the high-frequency monitoring to support assessments, some monthly and bimonthly monitoring was temporarily halted. The agency had to pause the high-frequency bacteria pilot study (and all other monitoring) in spring and early summer 2020 because of the COVID-19 pandemic."

He also said VDEQ plans to release an updated bacteria-monitoring strategy in the fall of 2021. As part of that process, the agency has been soliciting suggestions of additional waterway locations that the state should sample for bacteria. The Environmental Integrity Project on April 30, 2021, sent VDEQ a letter with a list of 23 sites along the Shenandoah River and its tributaries that the state should consider for E coli monitoring. (For a copy of the letter, see Appendix E). At two of the sites – Riverside Park in Elkton, and the Shenandoah Valley Campground in Verona – the state has not sampled for bacteria in several years, but people are known to use the waterways there for contact recreation. At an additional 21 waterfront campsites along the Shenandoah, bacteria monitoring, and possible warning signs should be considered because they advertise river swimming and tubing the public. Bilyeu added[63] that only about 22 percent of river and stream miles in Virginia have been assessed by the state (21,834 of 100,953 miles statewide), including 24 percent in the

combined Shenandoah and Potomac River basins, in part because of a 2014 expansion of the number of smaller streams mapped through improved technology and imaging used by the U.S. Geological Survey's National Hydrography Dataset.[64]

He said that VDEQ has not created cleanup plans (TMDLs) or implementation plans for many impaired waterways because of a lack of staff and funding. "DEQ consistently strives to complete additional TMDLs. The development of TMDLs is undertaken within the constraints of funding and resources and under the scope of identifying priorities for TMDL development over a cycle," Bilyeu wrote.[65] "DEQ works to develop additional implementation plans within the constraints of resources and funding." And he noted that Virginia is restrained by law in what it can include in these cleanup and implementation plans – which are largely based on suggestions to landowners and voluntary incentives to control runoff pollution, not requirements. "An Implementation Plan does not have the effect of a permit or regulation, and TMDLs and Implementation Plans do not confer additional implementation authorities," he wrote.[66]

To be fair, however, VDEQ does have authority to propose regulations to make TMDLs more enforceable and effective, which is what EIP is urging the state agency to do (see recommendations on page 28). For example, VDEQ could require effective best management practices for managing waste at livestock and poultry operations, or adopt rules that restrict the over-application of manure to soils containing too much phosphorus (as Maryland has done with its "phosphorus management tool" regulations).[67]

Effectiveness and Cost of TMDLs in the Shenandoah Valley

For this report, the Environmental Integrity Project examined 24 cleanup plans (TMDLs) and 11 implementation plans in the Shenandoah Valley that were designed to reduce loads of fecal bacteria.[68] Some of these cleanup plans date back nearly two decades, reflecting the state's response to Shenandoah Valley waterways that have been impaired for recreation even longer than that. For the 24 TMDLs we reviewed, livestock and agricultural runoff were by far the largest contributors of bacteria to the Shenandoah Valley's streams and rivers.

EIP's review of implementation reports and monitoring data from 2015 through 2020 show that bacteria levels are still high in many rivers, even where TMDLs and implementation plans have been in place for years. The state has largely failed to meet water monitoring commitments it made in TMDLs and implementation plans. Of 11 implementation plans that EIP reviewed, seven included requirements for monthly bacteria monitoring by the state. Two of the plans require even more frequent monitoring, twice a month. However, only one, the Smith Creek watershed in Shenandoah and Rockingham counties, was monitored in 2015 through 2020 at the frequency laid out in its implementation plan.

The completion deadlines for four of the eleven implementation plans in the Valley have passed, but bacteria levels in them remain high. Monitoring data from 2015 through 2020 for Mossy Creek and Long Glade Run in Augusta and Rockingham counties show that an average of 75 percent of samples were above the state's pre-2019 standard of 235 counts of *E. coli* bacteria. This suggests that these waterways have not been able to meet water quality standards even though their implementation deadline was in 2019.[69] The cleanup deadline for Smith Creek's passed in 2014, but 54 percent of water samples from this waterway since then have been above the pre-2019 standard for bacteria.[70] Mill Creek, Muddy Creek, Dry River, and Pleasant Run in Rockingham County were supposed meet water quality standards by 2011, but 25 percent of samples from them since then have had bacteria levels above the pre-2019 standard.[71]

The voluntary nature of implementing best management practices on agricultural land make it difficult to track whether those practices have been installed and are being maintained. VDEQ only performs sporadic tracking of farms that use these practices – such as planting rows of trees along streams -- when there is a project specific to a watershed that is funded under an EPA grant that requires such tracking.

The big picture is that Virginia will need to significantly strengthen its oversight, monitoring program, and regulatory requirements for farms if it is ever going to remove a significant number of waterways in the Valley from the impaired waters list.

Costs of Implementation

Implementation plans propose a wide variety of pollution control projects, set timetables, and estimate costs. The estimated cost of the 11 implementation plans for reducing *E. coli* bacteria in the Shenandoah Valley is over $257 million spread out over a decade and more. However, the plans do not specify who should pay these costs or provide government funding, leaving many of these plans to go unfunded and unexecuted. It is also important to put these costs in the context of the much greater value of healthy waterways and natural areas. For example, one 2020 study found that the economic value of tourism and recreation in Shenandoah Valley communities from the Shenandoah National Park alone was $129 million *per year*.[72]

Table 7: Estimated Cost of Pollution Control Measures in Shenandoah Watersheds

Implementation Plan Watershed	Counties	Year EPA Approved TMDL	Year EPA Approved Implementation Plan	Estimated Total Cost ($)
Cook's Creek and Black's Run Watershed	Harrisonburg, Rockingham	2002	2006	$101,590,000
Christians Creek Watershed	Augusta	2002	2010	$48,047,066
South River Watershed	Augusta, Rockingham, Waynesboro	2009		
Middle River and Upper South River Watersheds	Augusta, Staunton	2004	2010	$24,548,237
Linville Creek Watershed	Rockingham	2003	2014	$14,401,022
Smith Creek Watershed	Rockingham, Shenandoah	2004	2009	$13,244,251
Spout Run and Tributaries	Clarke	2010	2013	$13,190,000
Mill Creek Watershed	Rockingham	2001	2003	$12,106,000
Muddy Creek Watershed		1999		
Dry River Watershed		2001		
Pleasant Run Watershed		2001		
Mossy Creek and Long Glade Run Watersheds	Augusta, Rockingham, Waynesboro	2004	2009	$10,065,654
Naked Creek Watershed	Augusta	2002		
Shenandoah Tributaries	Clarke, Frederick, Warren	2015	2016	$7,397,173
Hawksbill Creek Watershed	Page	2004	2008	$6,899,000
Mill Creek Watershed		2005		
Holman's Creek Watershed	Rockingham, Shenandoah	2001	2005	$5,550,000
Total				**$257,038,403**

The above numbers represent the estimated costs of cleanup plans to reduce bacteria for watersheds in the Shenandoah Valley. The years indicate when the TMDLs and implementation plans for these watersheds were approved by EPA. The

TMDLs and plans are also approved by the State Water Control Board. Watersheds that are managed by the same cleanup plan are shaded and grouped together.[73] TMDLs and plans obtained via a Freedom of Information Act request to VDEQ.

For agricultural sources, implementation plans often recommend voluntary steps like planting trees along streams to act as natural filtration systems and allowing grassy strips of non-fertilized land along waterways. All these plans recommend excluding livestock from waterways, often suggesting that farmers fence their cattle out of 100 percent of streams and rivers. There are also some other ways to manage the runoff from pastures and farms, including through improved management of poultry litter, better manure storage facilities, improved pasture management and no-till farming practices. For urban and residential areas, recommended measures mostly center on septic system improvements and halting the piping of untreated waste into Shenandoah Valley waterways. These plans also recommend public education programs to help curb pollution from pet waste. Counties and cities are advised to improve their stormwater management practices, such as installing green infrastructure, including rain gardens.

For most of these waterways, urban stormwater contributes only a small proportion of bacteria (sometimes less than one percent), with larger amounts coming from agricultural runoff. Yet the implementation plans include costly pollution control measures for these sources because state law requires that failing septic systems and illegal sewer pipes that direct feces and urine straight into waterways be corrected. The cleanup plan for Mill and Hawksbill creeks, near Luray, Virginia, mentions that there were as many as 18 illegal sewage pipes discharging waste into those waterways.[74] The plans note that reducing bacteria from human waste is important because it carries pathogens that "can cause health problems above and beyond those associated with livestock waste."[75]

Voluntary Nature of Cleanup Plans

The TMDLs and implementation plans developed for the Shenandoah Valley tend to be detailed and lengthy – but depend entirely on voluntary solutions, especially for runoff pollution, and lack funding and enforcement mechanisms. The problem comes in part from the inherent nature of these plans and their limited ability to address non-point sources of pollution, including agriculture. Federal and state regulations require the state to conduct TMDL studies and develop and implement cleanup plans.[76] What the law does not require is for individual landowners to follow the recommendations for controlling runoff pollution, or for the state or counties to raise taxes or appropriate money to pay for the recommended projects. The elected representatives in Virginia and its counties must make political decisions to do that separately, and those decisions to implement or enforce the TMDLs are not as frequent as they should be to meet the goals of the cleanup plans.

For most sources of runoff pollution, like farms or suburban neighborhoods, the TMDLs act mostly as goals or targets. However, for industrial or municipal sources of pollution that is piped into waterways, regulators use TMDLs to set legally binding pollution limits in permits issued under the federal Clean Water Act.[77] By contrast, for most farms, financial incentives from the state and federal government are the main method of convincing landowners to install pollution-control projects. For agricultural practices such as excluding

livestock from streams, farmers can apply for up to 100 percent reimbursement for building fences and installing alternative watering devices so animals do not have to drink from streams.[78] Conservation practices come with financial incentives from the government, including through the Virginia Department of Conservation and Recreation and the USDA's Natural Resources Conservation Service. The incentives for farmers to participate in these programs would be enhanced if the state used a stick as well as a carrot and imposed regulations to require streamside livestock fencing and other best management practices. Maryland regulations, for example, have required farmers exclude their livestock from rivers and streams since 2012,[79] while Virginia has no similar regulations.

Beyond the agricultural sector, the recommendations for non-point source pollution control projects would be stronger if they designated specific funding mechanisms for each recommended practice and if EPA required states to implement the measures described in their implementation plans. Because the plans are often expensive to implement, local governments and private landowners are unlikely to be able to achieve them without increased state and federal financial assistance.

Examples of Cleanup Plans and Results

The following are four examples of cleanup and implementation plans issued in the Shenandoah Valley over the last two decades that have fallen short of their goals.

Mossy Creek, Long Glade Run, and Naked Creek, southwest of Harrisonburg: The goal of Virginia's $10 million[80] TMDL and implementation plan for these waterways, approved by EPA in 2009,[81] was cleanup of fecal bacteria contamination within ten years and a removal of the waterways from the state's impaired waters list by 2019.[82] Among the recommended (but not required) practices for reducing agricultural pollution was fencing to exclude 94 to 100 percent of livestock from streams and rivers.[83] The state did not achieve even a quarter of this goal.[84] By 2021, the waterways were still impaired with fecal bacteria and choked with excessive algae growth fed by phosphorus and nitrogen in farm manure runoff. It is not clear how much of the $10 million was ever spent or even appropriated.

Large mats of algae choke Long Glade Creek, west of Bridgewater, Virginia, near a cattle farm that allows a herd of the animals to wade into and defecate in the stream.

An aerial survey and report by the Environmental Integrity Project and Shenandoah Riverkeeper, released in 2019, found that only 25 percent of farmers in the Mossy Creek watershed had fenced their cattle out of streams, along with only 5 percent of farmers in the Long Glade Run watershed.[85]

Hawksbill Creek as it runs through Luray, Va. The state's cleanup plan for this waterway demanded monthly bacteria monitoring, but VDEQ has not sampled in the creek since 2017.

A visit to a section of Long Glade Run west of Bridgewater, Va., on May 20, 2021, revealed a herd of cattle wading into the stream. The waters were muddy and covered with floating mats of blue-green algae (see photo above). A cattle feedlot sloped right down into the stream, and the creek's banks were trampled and crumbling, with mud, manure, and algae blobs drifting downstream.

Based on state monitoring data, *E. coli* bacteria concentrations exceeded state impairment standards[86] in 81 percent of water samples on Long Glade Run since 2015. The exceedance rate was 62 percent on Mossy Creek, and 83 percent on Naked Creek, using Virginia's old (pre-2019) bacteria standards.[87] Bacteria levels were so high the waterways would still be considered impaired under the state's revised 2019 *E. coli* standard.

However, it should be noted that these conclusions rely mostly on old numbers because Virginia has not monitored for bacteria in these waterways in recent years. The cleanup plans for these waterways specify that the state is supposed to monitor them monthly for bacteria. But VDEQ has sampled Mossy Creek only once for *E. coli* since 2015, with a single sample taken in January of 2019, according to state records. The state agency has not sampled Long Glade Run or Naked Creek since 2018.[88]

Mill and Hawksbill Creeks, near Luray, Va: The TMDL and implementation plan for the Mill and Hawksbill Creek watersheds recommend pollution control projects with estimated costs that total $6.8 million.[89] The implementation plan, approved by EPA in 2008,[90] suggests (but does not require) a combination of runoff reduction strategies on farmland, including livestock fencing, improved pasture management, and other measures to stop fecal contamination of the streams. Livestock is responsible for about 50 percent of *E. coli* bacteria in the creeks, and wildlife 25 to 35 percent, according to the state.[91] The goal of the state's cleanup plan was a 100 percent reduction in bacterial contamination by August 2022.[92]

In 2021, the waterways remain impaired by fecal bacteria.[93] State water quality monitoring in Hawksbill Creek has been scarce. The state's implementation plan for both these

waterways called for the state to monitor them for *E. coli* monthly.[94] But the state has not sampled Hawksbill Creek since 2017. Virginia sampled Mill Creek six times in 2020, and two of those samples exceeded EPA's recommended threshold for swimming alerts (the "beach action value" of 235 units of E coli/100 ml water). The last time the state sampled the waters of Hawksbill Creek, in 2017, six of 12 samples showed levels of bacteria that EPA would consider unsafe for swimming.

Smith Creek Watershed, north of Harrisonburg, Va: The Smith Creek watershed has been listed as impaired since 2002.[95] The TMDL implementation plan for the Smith Creek watershed was approved by EPA in 2009 with cost estimates of $13 million for runoff pollution control projects. [96]The plan suggests that 100 percent of farmers fence their cattle out of streams. The plan also calls for landowners to build better manure containment facilities, plant buffer strips of trees as filters along streams, manage pastures to prevent muddy runoff, and allow forests to regrow over 5 percent of grazing land.[97] But the plan contains no mandates. Instead, the plan says that "implementation to address the bacteria and sediment-related biological impairments on Smith Creek will be carried out primarily through the use of voluntary…best-management practices and education."[98] The plan had a goal of cleaning up the waters so they could be removed from the state's impaired waters list by 2014.[99]

EPA approved a Virginia cleanup plan for Smith Creek, north of Harrisonburg, in 2009, to reduce excessive fecal bacteria from surrounding poultry operations and livestock. Twelve years later, the waterway remains

That goal was not met. By 2021, Smith Creek was still impaired for bacteria. Data from 2015 to 2020 show that three monitoring sites in Smith Creek exceeded the state's pre-2019 bacteria standard for impairment in 58 percent of the samples. The waterway would also be considered impaired under the state's new bacteria standard. Only about 20 percent of farms in surrounding Rockingham County have fenced their cattle out of streams – far short of the 100 percent goal set by Virginia.[100]

A visit to a section of the creek near Indian Trail Road on May 20, 2021, found feathers floating down the stream and an intense odor of poultry manure, with two aircraft-hanger-sized poultry houses nearby. Herds of cattle also have access to the waterway.

Mill Creek, Muddy Creek, Dry River, and Pleasant Run Watersheds in Rockingham County: The cleanup plan for these waterways, approved by EPA in 2003, set a goal of reducing bacteria in the creeks substantially enough that they could be removed from the state's impaired waters list by 2011.[101] Virginia estimated that 92 percent[102] of the fecal bacteria in the waterways came from livestock. So the state's recommendations to control the bacteria problem included farmers fencing all their livestock from streams, better managing feedlots to reduce runoff, building manure-holding facilities, and planting cover crops to absorb extra nutrients. The state also suggested that homeowners better maintain aging septic systems, which sometimes leak pollutants.[103] The estimated cost was $12 million.[104] But the plan did not specify who was to pay the tab, and it is not clear how much money was spent.

Back in 2010, Virginia created a cleanup plan for Mill Creek in Rockingham County that was supposed to reduce fecal contamination enough so that the stream could be removed from the state's impaired waters list by 2021. That did not happen, and the creek is still impaired by bacteria and choked by thick algae growth.

A decade later, in 2021, these waterways are still listed by the state as impaired for bacteria. In the past five years, the state has not monitored at any of the 25 monitoring stations they mentioned in the cleanup plan. A visit to a section of Mill Creek near Pineville Road on May 20, 2021, found a thick growth of blue-green algae on the creek and badly eroded streambanks near farm pastures.

Conclusion and Recommendations

It is clear by the examples of failed cleanup plans detailed above, and the persistently high fecal bacteria levels in the Shenandoah Valley's waterways, that Virginia needs to do more to both control and monitor water pollution from agriculture.

Because large scale agricultural operations, such poultry Concentrated Animal Feeding Operations, or CAFOs, continue to grow and proliferate, this is not an issue that can be ignored without sacrificing public health and the fishing, rafting, and tourism industries that are also critical parts of the Shenandoah region's identity. Virginia has made some progress in recent years, especially by increasing funding for its state reimbursement program in July 2019 to encourage more livestock fencing to keep herds of cattle out of streams and rivers. But the Commonwealth has also taken some steps backward, notably by cutting back on its number of bacteria monitoring sites and by watering down the state's water quality standards. The solution must be to clean up the waterways, not to clean up the numbers through weaker standards and less monitoring.

A restoration of the Shenandoah River's health – and the survival of the downstream Chesapeake Bay – will require not only stronger state regulations to limit manure runoff into rivers and streams, but also increased vigilance, more monitoring, and more vigorous implementation of pollution cleanup plans backed up by state and federal funds.

This report makes the following recommendations:

- Virginia should significantly expand its water quality monitoring program, especially in freshwater areas, so that the nearly 80 percent of waterway miles that lack enough data can be evaluated for impairment decisions and cleanup plans.

- The Virginia General Assembly and VDEQ need to invest enough in staffing and resources to create cleanup and implementation plans for the nearly half of impaired waterway miles in the Shenandoah Valley that lack one or the other of them today.

- The state should take action to implement the cleanup plans it creates, so that TMDLs are more meaningful. The most important way Virginia could better implement its TMDLs would be to impose regulations that reduce the chronic over-application of manure to farm fields, especially those adjacent to waterways. The Commonwealth should also require that all farmers fence their cattle out of streams and rivers.

- When cleanup plans estimate costs, the state and EPA should specify who should pay these costs, and then track how and whether the money is spent. The state and federal governments, if they require cleanup plans, also should be more willing to step up and underwrite more of the needed investments in clean water.

- The state should tighten up its recently revised water quality standards for bacteria by creating a swimming beach warning standard for freshwater areas and by raising signs to warn people in these areas contaminated by fecal pathogens, including in the Shenandoah Valley. The Virginia General Assembly should approve sufficient funding for the Department of Health to run this swimming area bacteria monitoring and advisory program for freshwater areas. The warning signs could include a website or hotline that people could use to get the most recent bacteria monitoring information.

In the end, facing up to the reality of the agricultural runoff problems in the Shenandoah Valley is the only way that Virginia can preserve one of its most beautiful, historic, and beloved regions. Problems can't be solved unless they are first acknowledged, and then addressed not only with plans and paperwork, but also effective government action. This is what Virginia must do now to save the great Shenandoah River.

Appendix A: Methodology

This report is based on EIP's review the following sources of public information:

- VDEQ's 2020 Water Quality Assessment Integrated Report and supporting geospatial data, available online at: https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report and https://geohub-vadeq.hub.arcgis.com/pages/Water%20Datasets.
- TMDL reports and TMDL Implementation Plans obtained through Freedom of Information Act (FOIA) request to VDEQ on __.
- State water quality monitoring data for *E. coli*, covering January 2015 through December 2020, obtained from the National Water Quality Monitoring Council's Water Quality Portal, available online at https://www.waterqualitydata.us/.
- VDEQ's 2018 IR and supporting geospatial data, available at: https://geohub-vadeq.hub.arcgis.com/pages/Water%20Datasets.
- VDEQ's 2010 IR and supporting geospatial data, obtained through a FOIA request to VDEQ on March 31, 2021.
- VDEQ's Water Quality Assessment guidance manuals for the 2022 and 2020 assessment periods.

GIS analysts at EIP summarized the geospatial data available from VDEQ to quantify how many miles of rivers and streams were listed as impaired in 2020 and 2010. To determine how many were impaired and still needed TMDLs by designated use, we cross-referenced the geospatial data layer for streams with the impaired waters list and fact sheets published as part of Virginia's official Water Quality Assessment Integrated Reports. We also compared stream locations to TMDL and implementation watershed boundaries published by VDEQ.

EIP identified 132 miles of impaired rivers and streams that should have been listed as impaired in 2020. We identified these waterways by comparing water monitoring results for *E. coli* for the time period from 2013 to 2018 covered by the 2020 integrated report, the state's publicly available point layer of water quality monitoring stations and its assessment of monitoring results for each station, its final polyline layer of freshwater rivers and streams in Virginia, and the impaired waters lists and fact sheets published in Virginia's final 2020 water quality assessment report. We confirmed the results with VDEQ via email. The waterways that were listed in a way that was inconsistent with VDEQ's monitoring station data are shown on Map A on page 9.

Using water quality data retrieved from Virginia Department of Environmental Quality's (DEQ) monitoring programs, we assessed water quality over the period of 2015 through 2020. We then reviewed water quality monitoring data to determine whether waterways in

the Shenandoah Valley met or failed state water quality standards for bacteria and EPA's freshwater beach action value. We also determined the impact that Virginia's new water quality standards for bacteria will have on the state's ability to protect, monitor, and clean up rivers and streams under state and federal laws and regulations. We excluded from our analysis monitoring locations that VDEQ only sampled once. We also took the average of duplicate samples. We used methods stated in VDEQ's 2020 and 2022 Water Quality Assessment Guidance documents, and analyzed results in R. The bacteria levels measured at each monitoring location were compared to EPA's beach action value and Virginia's new and old water quality standards for bacteria (See Appendix C).

Appendix B: Impaired Shenandoah Valley Waterways That Need TMDLs and Implementation Plans

Watershed	Miles that are impaired and need a TMDL for bacteria
Dog Run-Shenandoah River	23.1
Gooney Run	20.1
Boone Run-Elk Run-South Fork Shenandoah River	15.3
Fall Run	15.2
Meadow Brook-Cedar Creek	13.6
Brown Hollow Run-South Fork Shenandoah River	12.6
Duck Run-Cedar Creek	12.5
Chapel Run-Shenandoah River	11.8
Jeremys Run-South Fork Shenandoah River	11.7
Lower Passage Creek	10.4
Punches Run-South Fork Shenandoah River	10.3
Stony Run-South Fork Shenandoah River	10
Toms Brook- North Fork Shenandoah River	9.5
Paddy Run-Cedar Creek	7.6
Long Marsh Run	7.1
Narrow Passage Creek-North Fork Shenandoah River	7
Molly Booth Run-North Fork Shenandoah River	6.7
Hawksclaw Creek-South Fork Shenandoah River	6.4
Inch Branch-Back Creek	6
Long Branch-Shenandoah River	5.4
Froman Run-Cedar Creek	4.5
Tumbling Run-North Fork Shenandoah River	4.3
Crab Run	3.9
Capon Run-North Fork Shenandoah River	2.6
Total	237.6

Source: Virginia's 2020 Water Quality Assessment Integrated Report

Impaired Shenandoah Waterways That Have TMDLs, But Need Implementation Plans

Watershed Name	Miles of impaired waterways
Long Meadow-North Fork Shenandoah River	23.4
Narrow Passage Creek-North Fork Shenandoah River	22.3
Thorny Branch-North River	18.3
Pleasant Run-North River	16.7
Borden Marsh Run	15.7
Crooked Run-Mill Creek	15.7
Manassas Run	15.1
Keezletown-Cub Run	14.8
Runion Creek-North Fork Shenandoah River	14.8
Mt Jackson-North Fork Shenandoah River	12.2
Lewis Creek	10.1
Painter Run-Stony Creek	9.3
Happy Creek	8.5
Big Run-South Fork Shenandoah River	7.9
Briery Branch	7.8
Turley Creek-North Fork Shenandoah River	7.0
Riles Run-Stony Creek	5.7
Mill Creek-North River	4.7
Yellow Spring Run-Stony Creek	4.7
Long Branch	3.9
Hawksbill Creek-South Fork Shenandoah River	0.1
Total	238.7

Appendix C: Virginia's Revisions to Water Quality Standards

Virginia's revised bacteria impairment criteria, issued in October 2019, are used by the state to determine whether a water body should be placed on the state's impaired waters list, triggering a requirement for a cleanup plan (a Total Maximum Daily Load or TMDL.) The criteria are intended to apply to water contact recreation, including swimming, surfing, water skiing, tubing and water play by children, and similar water contact activities where a high degree of prolonged bodily contact with the water, immersion and ingestion are likely.

Freshwater (*E.coli*)				Saltwater (Enterococci)			
Old Criteria (counts/100 ml)		Revised Criteria (counts/100 ml)		Old Criteria (counts/100 ml)		Revised Criteria (counts/100 ml)	
Monthly Geometric Mean (never to be exceeded)	126	90-Day Geometric Mean (never to be exceeded)	126	Monthly Geometric Mean (never to be exceeded)	35	90-Day Geometric Mean (never to be exceeded)	35
Not to be exceeded more than 10% of the time over a 6-year period	235	Not to be exceeded more than 10% of the time over a 90-day period	410	Not to be exceeded more than 10% of the time over a 6-year period	104	Not to be exceeded more than 10% of the time over a 90-day period	130

The revised criteria contain three components:

1. A number of culturable colony counts of either the bacteria *E. coli* or enterococci.
2. A duration of 90-days as an averaging period for a measure of central tendency called a geometric mean (GM).
3. An allowable excursion rate of no more than 10% of samples allowed to be greater than a Statistical Threshold Value (STV).

The magnitude of the bacterial indicators is described by both the GM and the STV for the bacteria samples, and both the GM and the STV must be assessed to determine that a waterbody is fully supporting the recreational designated use. The GM is a "never to be exceeded" value in a 90-day period, and no more than 10% of the data in a 90-day period may exceed the STV.

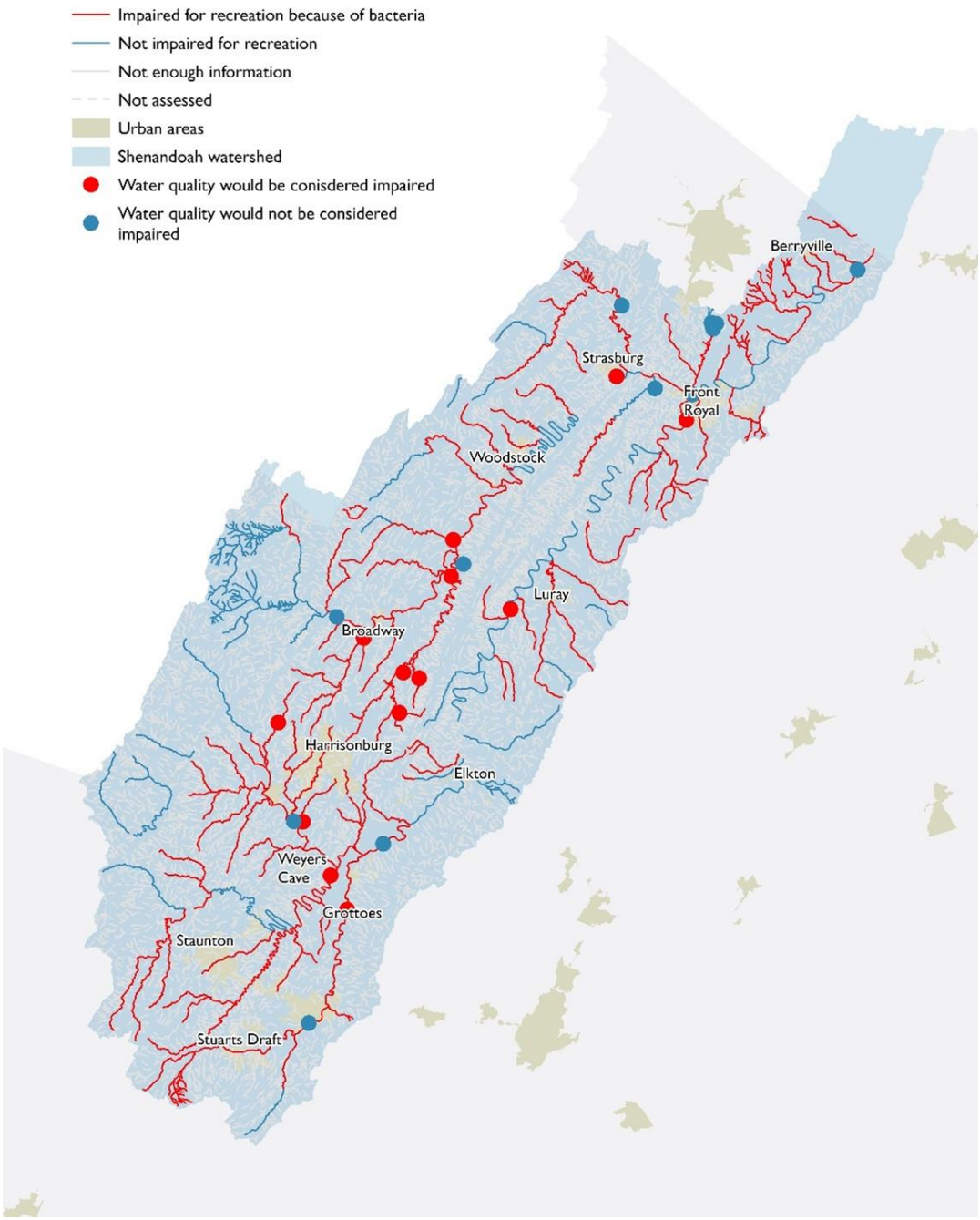
The value of the STV is higher than the geometric mean and is derived from the 90th percentile of the epidemiological dataset used by EPA to develop the criteria. For example, for *E.coli* the GM value is 126 bacteria colony counts per 100 milliliters (counts/100 ml) and

a STV of 410 counts/100 ml. This is because in the data set of bacteria samples and the epidemiological studies used to establish the criteria, the geometric mean was calculated to be 126 and 90% of the bacteria counts were at or below 410 counts/ml.

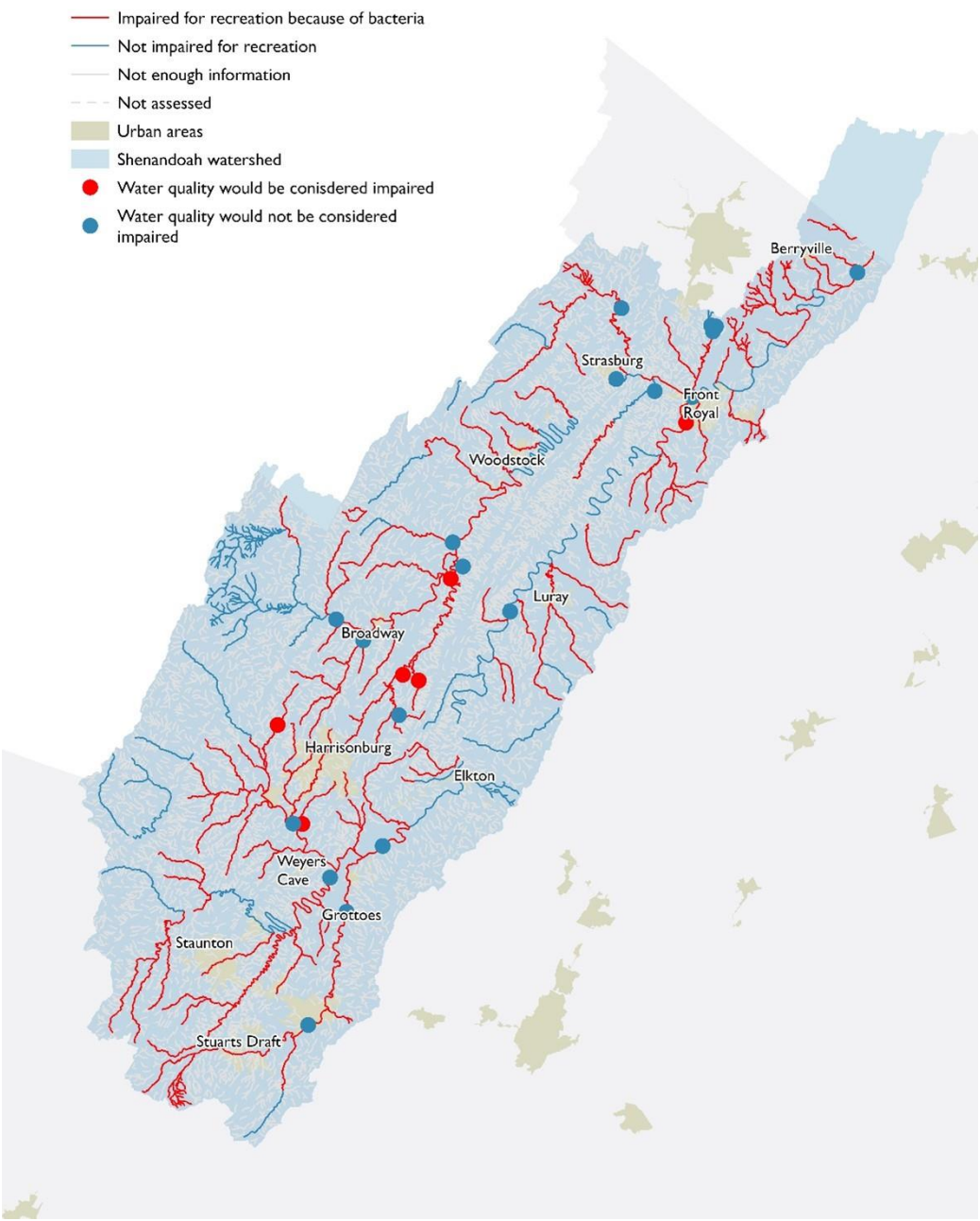
The STV is intended to avoid incorrectly classifying a water body as posing an excessive risk to swimmers, when in fact it is likely just demonstrating the same level of variability in bacteria values that would be consistent with a geometric mean of 126 counts/ml. That is, given the normal variability of bacteria counts in surface waters, we expect about one half of the samples to be above the mean value, but as long as the higher counts are below the 90% STV, this is deemed to be acceptable.

Appendix D: 2020 Water Monitoring in Shenandoah Valley Under Virginia's Old Vs. New Standards for Bacterial Impairment

2020 Monitoring Results Under Pre-2019 *E. Coli* Standards



2020 Monitoring Results Under Post-2019 *E. Coli* Standards



The smaller number of red dots in the post 2019 standards map shows that about half as many monitoring locations in the Valley would be considered impaired for E..coli under Virginia's new bacteria standards.

Appendix E: Letter from EIP to VDEQ Nominating Additional Sites for Bacteria Monitoring

April 30, 2021

Mr. Stuart Torbeck
VA Dept. of Environmental Quality
P.O. Box 1105
Richmond, VA. 23218
Sent via email to: charles.torbeck@deq.virginia.gov

Dear Mr. Torbeck,

Thank you for the opportunity to nominate locations for sampling by the Virginia Department of Environmental Quality (VDEQ). The Environmental Integrity Project (EIP) has been advocating for more state action to reduce and inform community members about elevated bacteria levels in Shenandoah Valley waterways for some time. Recent reductions in the state's monitoring efforts in this area are concerning, given the fact that these waterways are heavily used in summer months for activities like rafting, kayaking, swimming, and fishing.

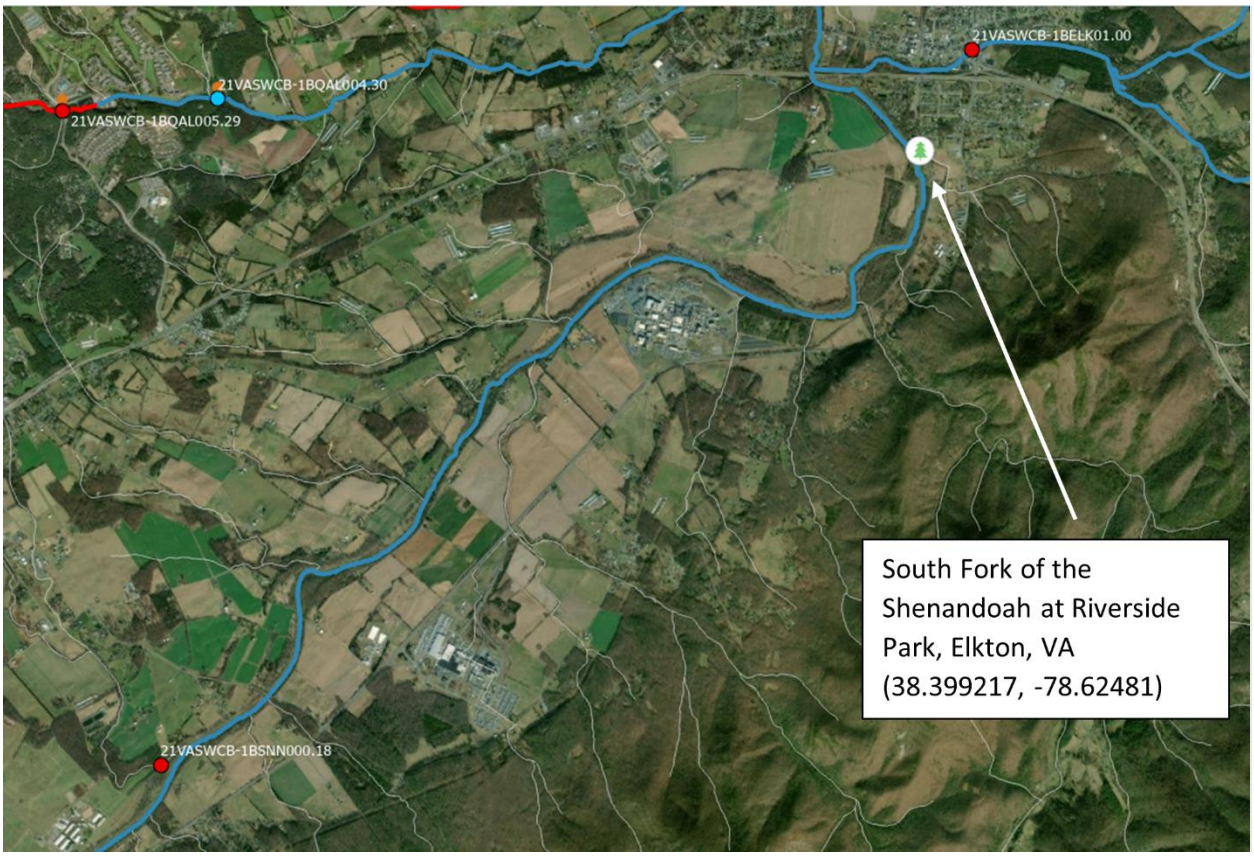
The Shenandoah watershed contains approximately 7,068 miles of streams and rivers. Of those, only 20.6 percent were assessed by the Department as part of Virginia's 2020 integrated report on water quality. About 1,460 miles are listed as impaired for recreational uses. More data are needed to inform the public of when water is safe for swimming or other contact recreation, to determine where additional protective measures are needed, and to determine if current cleanup strategies are working.

This is particularly important in areas where young children play on riverbanks or wade in shallow water. Children under 10 may be more exposed and/or are more sensitive to pathogens in recreational waters, according to the U.S. Environmental Protection Agency's 2012 Recreational Water Quality Criteria (at pg. 3). It is imperative that the health risks associated with contaminated waterways be communicated to the public so that river-goers can make informed decisions to protect their health.

EIP reviewed VDEQ's *E. coli* sampling data from 2015-2020 and its 2021 monitoring plan. We also reviewed the locations of public parks and private and public campgrounds in the area where people are likely to recreate in Shenandoah Valley waterways. First, we nominate two sites—Riverside Park and the Shenandoah Valley Campground—where people are known to use waterways for contact recreation and where VDEQ has not sampled for bacteria in several years. Second, we also suggest that VDEQ consider monitoring at 21 additional waterfront camping sites, many of which advertise river swimming and tubing, that are listed in an attachment to this letter—including Watermelon Park and Campground and Outlanders River Camp—to determine the potential public health risk.

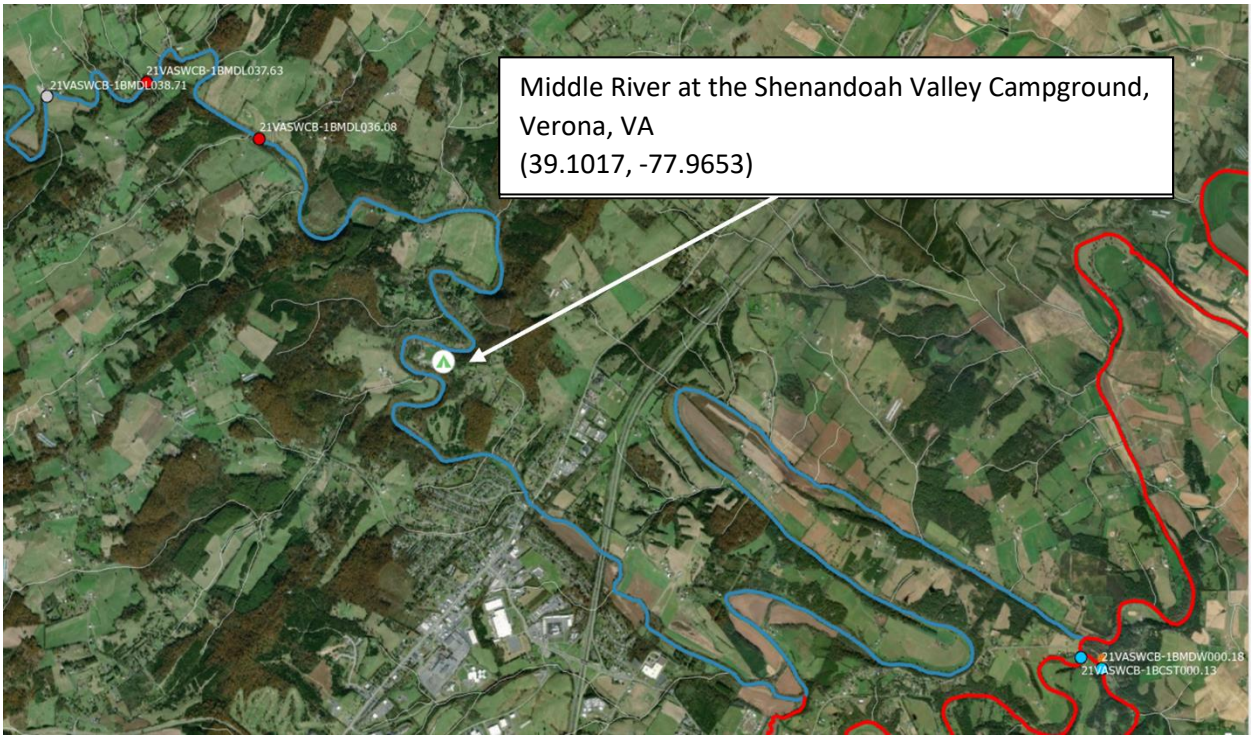
We respectfully nominate the following locations for sampling:

Site 1: The South Fork of the Shenandoah River at Riverside Park, Ore Wash Rd, Elkton, VA 22827 (38.399490, -78.625240). The town of Elkton advertises tubing as an attraction at this location. This portion of the South Fork is currently listed as supporting recreational uses, but the closest upstream sampling location is over 5 miles away and VDEQ has not sampled there since 2018 (1BSSF096.03). This site was sampled 12 times in 2018, and more than 10.5 percent of samples exceeded the pre-2019 recreational standard for *E. coli*. Assessed tributaries downstream of this monitoring location had high bacteria levels, according to VDEQ sampling at 1BCBR000.03 and 1BSNN000.18 that last occurred in 2018. An unassessed tributary (identified by VDEQ as part of the segment VAV-B35R_ZZZ01A00) empties into the South Fork just upstream of the park. This unassessed stream segment runs through pasture and near two poultry operations. VDEQ's current sampling plan does not suggest that sampling will occur in the vicinity of this park in 2021. The location of the park is identified on the map below.



Site 2: Middle River at Shenandoah Valley Campground, 296 Riner Rd., Verona, VA 24482 (39.1017, -77.9653). River tubing is an advertised activity at this campground. This section of the Middle River is listed as supporting recreational uses, but DEQ sampling from 2015 through 2018 at two upstream sampling locations, at 1BMDL036.08 and 1BMDL037.63, measured bacteria levels that would exceed Virginia's new recreational water quality standard. No VDEQ sampling in the vicinity of this campground

is planned for 2021. Unassessed tributaries upstream of the campground run through agricultural and pasture land. The location of the campground is located on the map below.



Bacteria levels in the Shenandoah waterways remain a widespread concern. Our nominations above are not meant to serve as an exhaustive or definitive list, and we encourage VDEQ to look at where people swim and to collect data in a way that could be used to better communicate risk to the public while also meeting VDEQ's waterway assessment and TMDL development and implementation obligations. For those reasons, we also recommend VDEQ to consider monitoring at the locations identified on the list of campsites attached to this letter.

Thank you for considering these nominations. EIP looks forward to learning more about VDEQ's forthcoming bacteria monitoring strategy and supports efforts to increase sampling frequency and coverage throughout the Shenandoah Valley and across Virginia.

Thank you,

Courtney Bernhardt
Director of Research
Environmental Integrity Project
cbernhardt@environmentalintegrity.org

Campsites with waterway access

Name	Zipcode	Latitude	Longitude
North River Campground	22843	38.33952	-79.2072
Todd Lake Recreation Area Campground	24485	38.36581	-79.2095
Hone Quarry Campground	22821	38.46226	-79.135
Harrisonburg / Shenandoah Valley KOA Holiday	22815	38.53378	-78.7046
Riverside Camping	22849	38.57864	-78.5958
River Run Campground, LLC	22650	38.79612	-78.3685
Twin Rivers Campground	22630	38.94463	-78.1955
Gooney Creek Campgrounds	22630	38.86955	-78.2501
Low-Water Bridge Campground	22610	38.84465	-78.3294
JR Campground	22650	38.76825	-78.3937
Camp OutBack	22835	38.75677	-78.4295
Creekside Campground	22824	38.82011	-78.5637
Outlanders River Camp	22835	38.64373	-78.5371
Swift Run Campground	22827	38.37372	-78.5879
Stokesville Campground	22843	38.35381	-79.1499
Walnut Hills Campground & RV Park	24401	38.04765	-79.0977
Stoney Creek Resort and Campground	24440	37.98872	-79.1238
Little Fort Campground	22652	38.86694	-78.4444
Shenandoah Acres	24477	37.99663	-79.0263
Watermelon Park & Campground	22611	39.09627	-77.9378
Natural Chimneys Park and Campground	22843	38.35477	-79.0865

End Notes

[1] "2020 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, December 2020, https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report.
[2] Data from Virginia Department of Environmental Quality, sent via email on May 10, 2021, by Gregory Bilyeu, Director of Communications, Virginia Department of Environmental Quality.
[3] Ibid.
[4] EIP online data map using state records and data to show impaired waterways in the Shenandoah Valley and the impaired waters that lack TMDL's: https://environmentalintegrity.org/shenandoah-valley-bacteria/
[5] "2010 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, 2010, obtained via FOIA request to VDEQ.
[6] The Environmental Integrity Project examined 24 Total Maximum Daily Load (or TMDL) documents for waterways in Virginia's Shenandoah Valley, as well impaired waters lists prepared by the Virginia Department of Environmental Quality and approved by EPA, under the Federal Clean Water Act's Section 303 (d), to determine the impairment mileage and other numbers used in this report.
[7] Calculated using geospatial data available from https://geohub-vadeq.hub.arcgis.com/datasets/56b9c1e2419f4211a610199f8a4ff973_173, accessed January 2021.

[8] EIP review of Total Maximum Daily Loads and Implementation Plans in the Shenandoah Valley provided by Virginia Department of Environmental Quality.
[9] Until October 2019, exceeding the bacteria impairment standard in Virginia meant more than 235 colony forming units (cfu) of *E. coli* per 100 ml water in at least 10 percent of samples over six years, or at least two samples when there are fewer than 10 samples. But after October 2019, the standard shifted to more than 410 cfu of *E. coli* /100 ml in 10 percent of samples over 90 days. If there are fewer than 10 samples, at least two over 90 days must be over 410 cfu E. coli/100 ml water. The new standards make it harder to designate a waterway as impaired because samples must now exceed a higher threshold of bacteria, and exceedances must be documented with more testing results.
[10] On October 3, 2019, VDEQ repealed 9VAC25-260-170 A 5, which reads: "For beach advisories or closures, a single sample maximum of 235 E. coli cfu/100 ml in freshwater and a single sample maximum of 104 enterococci cfu/100 ml in saltwater and transition zones shall apply." Link: http://register.dls.virginia.gov/details.aspx?id=7665
[11] "Recreational Water Quality Criteria", Environmental Protection Agency, 2012, p.3 https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf; "2017 Five-Year Review of the 2012 Recreational Water Quality Criteria", Environmental Protection Agency, May 2018, p. 10-12,://www.epa.gov/sites/production/files/2018-05/documents/2017-5year-review-rwqc.pdf.
[12] Email from Margaret Smigo, Waterborne Hazards Program Coordinator for the Virginia Department of Health, on March 31, 2021
[13] "2017 Census Full Report",United States Department of Agriculture, April 11, 2019, https://www.nass.usda.gov/Publications/AgCensus/2017/.
[14] Ibid.
[15] "Water Pollution from Livestock in the Shenandoah Valley," Environmental Integrity Project, April 26, 2017, https://environmentalintegrity.org/wp-content/uploads/2017/02/Shenandoah-Report.pdf.
[16] Ibid.
[17] "Enforcement and Compliance Online" (ECHO), United States Environmental Protection Agency, accessed June 3, 2021,, https://echo.epa.gov/facilities/facility-search.
[18] Clean Water Act, 33 U.S.C. §1251 et seq., " Restoration and maintenance of chemical, physical and biological integrity of Nation's waters; national goals for achievement of objective", https://www.govinfo.gov/content/pkg/USCODE-2018-title33/pdf/USCODE-2018-title33-chap26.pdf.

[19] Va. Code.Water Quality Monitoring, Information, and Restoration Act §62.1-44.19:4 through 19:8 (1997). WQMIRA directs the SWCB to "develop and implement a plan to achieve fully supporting status for impaired waters."

[20] "2020 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, December 2020, https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report.
[21] Calculated using geospatial data available from https://geohub-vadeq.hub.arcgis.com/datasets/56b9c1e2419f4211a610199f8a4ff973_173, accessed January 2021.
[22] Email from Greg Bilyeu, Director of Communications for the Virginia Department of Environmental Quality, on May 10, 2021
[23] "2020 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, December 2020, https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report.
[24] River and stream miles needing TMDLs are listed as Categories 5A and 5D. Some are listed as not supporting multiple designated uses and may already have a TMDL to address one or more impairment. To accurately quantify the river and stream miles that still need TMDLs by designated use, we cross-referenced the GIS data file and the fact sheets for impaired waters "2020 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, December 2020, https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report.

[25] EIP email correspondence with VDEQ staff water quality assessment data analyst Cleo Baker on June 4, 2021.
[26] "2010 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, 2010, obtained via FOIA request to VDEQ.
[27] Calculated using geospatial data available from https://geohub-vadeq.hub.arcgis.com/datasets/56b9c1e2419f4211a610199f8a4ff973_173, accessed January 2021.
[28]Ibid.
[29] Calculated using geospatial data available from https://geohub-vadeq.hub.arcgis.com/datasets/56b9c1e2419f4211a610199f8a4ff973_173, accessed January 2021.
[30] Ibid.
[31] Ibid.
[32]"Overview of Listing Impaired Waters under CWA Section 303(d)", United States Environmental Protection Agency, May 28, 2021, https://www.epa.gov/tmdl/overview-listing-impaired-waters-under-cwa-section-303d#:~:text=The%20term%20%22303(d),causing%20the%20impairment%2C%20when%20known.
[33] "Guidance for Water Quality-Based Decisions: The TMDL Process", United States Environmental Protection Agency, 1999, https://www.epa.gov/sites/production/files/2018-10/documents/guidance-water-tmdl-process.pdf.
[34] Calculated using geospatial data available from https://geohub-vadeq.hub.arcgis.com/datasets/56b9c1e2419f4211a610199f8a4ff973_173, accessed January 2021.
[35] "2020 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, December 2020, https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report.
[36] Website of Watermelon Park in Berryville, Va. https://watermelonpark.com/recreation/. Website of Outlanders River Camp: https://www.outlandersrivercamp.com/river-activities.
[37] Shenandoah Riverkeeper Swim Guide, accessed May 12, 2012. https://www.theswimguide.org/affiliates/shenandoah-riverkeeper/
[38] Environmental Integrity Project analysis of *E. coli* bacteria monitoring data collected by the Virginia Department of Environmental Quality
[39] Monitoring site 1BSSF054.20 is near Outlanders River Camp. https://www.outlandersrivercamp.com/river-activities
[40] "2020 Water Quality Assessment Integrated Report", Virginia Department of Environmental Quality, December 2020, https://www.deq.virginia.gov/water/water-quality/assessments/integrated-report.
[41] Email from Margaret Smigo, Waterborne Hazards Program Coordinator for the Virginia Department of Health, on March 31, 2021.
[42] Interview with Margaret Smigo, Waterborne Hazards Program Coordinator for the Virginia Department of Health, on April 14, 2021.
[43] See note 2.
[44] Ibid.

[45] Va. Administrative Code, 9VAC25-260-170, "Bacteria; other recreational waters," https://law.lis.virginia.gov/admincode/title9/agency25/chapter260/section170/.
[46] VDEQ's 2022 Assessment Methodology states two ways for regulators to make an impairment decision based on exceedances of the statistical threshold value of 410 counts per 100mL of water. If there are more than 10 samples in a 90-day period, at least 10 percent must exceed 410. If there are fewer than 10 samples, at least 2 samples taken over a 90-day period must exceed 410. Very few freshwater recreation sites are monitored 10 times during any 90-day period by the VDEQ.
[47] Calculated using geospatial data available from https://geohub-vadeq.hub.arcgis.com/datasets/56b9c1e2419f4211a610199f8a4ff973_173, accessed January 2021.
[48] The different between Virginia's old "impairment" value for bacteria and EPA's recommended "beach action value" for issuing swimming advisories is that Virginia's old impairment value required more than 10 percent of samples over six years to exceed 235 units E coli/100 ml of water, while EPA's "beach action value" says that even one sample over 235 units of E coli/100 ml water shows a waterway is unsafe for swimming.
[49] Environmental Integrity Project analysis of *E. coli* bacteria monitoring data collected by the Virginia Department of Environmental Quality
[50] Email from Virginia Department of Environmental Quality Director of Communications Greg Bilyeu on April 7, 2021. To remove a water body from the impaired waters list, the water body must have a 90-Day geometric mean below 126 counts of E. coli/100 ml water AND a statistical threshold value not to exceed 410 units per 100 ml water more than 10 percent of the time over a 90-day period.
[51] Ibid.
[52] "Recreational Water Quality Criteria," United States Environmental Protection Agency, 2012, https://www.epa.gov/wqc/2012-recreational-water-quality-criteria.
[53] Ibid.
[54] Letter from Steve Fleischli, Senior Attorney, NRDC, to EPA Administrator Lisa Jackson on February 21, 2012.
[55] Letter from Phillip Musegaas, Director of the Hudson River Program with Riverkeeper Inc., as well as the New York/New Jersey Baykeeper and Hackensack Riverkeeper, to EPA on February 21, 2012, about the agency's proposed revisions to recreational water quality criteria.
[56] Letter from Lara Meeker, Water Quality Coordinator with the Santa Monica Baykeeper, to EPA about is revised recreational water quality criteria on February 21, 2012.
[57] EPA, "Research to Support and Implement Recreational Water Quality Criteria (RWQC)," 2018, available on EPA website:https://www.epa.gov/water-research/research-support-and-implement-recreational-water-quality-criteria-rwqc
[58] "Recreational Water Quality Criteria," 2012, https://www.epa.gov/wqc/2012-recreational-water-quality-criteria;Va. Administrative Code, 9VAC25-260-170, "Bacteria; other recreational waters," accessed June 3, 2021, https://law.lis.virginia.gov/admincode/title9/agency25/chapter260/section170/.
[59] Viriginia Department of Environmental Quality, "Water Quality Monitoring Plan," available on VDEQ website: https://www.deq.virginia.gov/water/water-quality/monitoring/water-quality-monitoring-plan
[60] Ibid.
[61] Email from Greg Bilyeu, Director of Communications for the Virginia Department of Environmental Quality, on April 7, 2021.
[62] Ibid.
[63] Email from Greg Bilyeu, Director of Communications for the Virginia Department of Environmental Quality, on May 10, 2021.
[64] National Hydrography Dataset, United States Geological Survey, accessed June 3, 2021, https://www.usgs.gov/core-science-systems/ngp/national-hydrography.
[65] Email from Greg Bilyeu, Director of Communications for the Virginia Department of Environmental Quality, on May 10, 2021.
[66] Ibid.
[67] Maryland Phosphorus Management Tool. Link: https://mda.maryland.gov/pages/pmt.aspx
[68] Obtained via FOIA request to Virginia Department of Environmental Quality.

[69] "Mossy Creek, Long Glade Run and Naked Creek, Water Quality Improvement Plan", Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation, June 18, 2009, obtained via FOIA request to VDEQ.
[70] "Smith Creek Watershed; Rockingham and Shenandoah Counties, City of Harrisonburg, and Town of New Market, Virginia", Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation, February 19, 2009, obtained via FOIA request to VDEQ.
[71] "A Total Maximum Daily Load Implementation Plan for Fecal Coliform and Nitrate Reductions", Virginia Department of Conservation and Recreation, June 26, 2001, obtained via FOIA request to VDEQ.
[72] National Park Service press release, "Tourism to Shenandoah National Park Creates $129 million in Economic Benefits," June 18, 2020. Link: https://www.nps.gov/shen/learn/news/tourism-to-shenandoah-national-park-creates-129-million-in-economic-benefits.htm
[73] Cub Run, North River, Beaver Creek, North Fork Shenandoah River/Mill Creek/Stony Creek, Hogue Creek, and South Fork Shenandoah River watersheds have TMDLs but no implementation plan.
[74]"Mill and Hawksbill Creek TMDL Implementation Plan", Virginia Department of Environmental Quality, September 13, 2007. Obtained via FOIA request to VDEQ. P.8,9
[75] "Guidance for Water Quality-Based Decisions: The TMDL Process", United States Environmental Protection Agency, 1999, https://www.epa.gov/sites/production/files/2018-10/documents/guidance-water-tmdl-process.pdf.
[76] "Guidance for Water Quality-Based Decisions: The TMDL Process", United States Environmental Protection Agency, 1999, https://www.epa.gov/sites/production/files/2018-10/documents/guidance-water-tmdl-process.pdf. Va. Code, §62.1-44.19:7, "Plans to address impaired waters", accessed May 28, 2021, https://law.lis.virginia.gov/vacode/title62.1/chapter3.1/section62.1-44.19:7/.
[77]"National Pollutant Discharge Elimination System (NPDES)", United States Environmental Protection Agency, accessed May 27, 2021, https://www.epa.gov/npdes/about-npdes#:~:text=An%20NPDES%20permit%20is%20typically,or%20beneficially%20use%20sewage%20sludge.
[78]"Stream Fencing and Alternative Watering Systems", Shenandoah Valley Soil & Water Conservation District, accessed May 27, 2021, https://svswcd.org/agriculture/.
[79]"Maryland Animal Agriculture Program Assessment", United States Environmental Protection Agency, accessed May 27, 2021, https://www.epa.gov/sites/production/files/2015-09/documents/marylandanimalagriculturepro gramassessment.pdf . p. 22,23.
[80] "Water Quality Improvement Plan, Mossy Creek, Long Glade Run, and Naked Creek, A plan to reduce bacteria and sediment in the creeks," Virginia Department of Environmental Quality, June 2009. Obtained via FOIA request to VDEQ. P. 47
[81] EPA approved the implementation plan for these waterways in 2009. Virginia listed Mossy Creek and Long Glade Run as impaired in 1996 and added Naked Creek to the list in 1998.
[82]"Water Quality Improvement Plan, Mossy Creek, Long Glade Run, and Naked Creek, A plan to reduce bacteria and sediment in the creeks," Virginia Department of Environmental Quality, June 2009. Obtained via FOIA request to VDEQ. p. 48, 56.
[83] Ibid. at 19.
[84] "Livestock Fencing in the Shenandoah Valley," Environmental Integrity Project, April 2019, https://environmentalintegrity.org/wp-content/uploads/2019/04/Livestock-fencing-report-4.4.19.pdf
[85] "Livestock Fencing in the Shenandoah Valley," Environmental Integrity Project, April 2019, https://environmentalintegrity.org/wp-content/uploads/2019/04/Livestock-fencing-report-4.4.19.pdf
[86] Va. Administrative Code, 9VAC25-260-170, "Bacteria; other recreational waters," accessed June 3, 2021, https://law.lis.virginia.gov/admincode/title9/agency25/chapter260/section170/.
[87] Based on water quality monitoring results from VDEQ stations 1BLGC000.96 sampled from 2015 and 2018, 1BMSS001.35 sampled from 2015 and 2019, and 1BNKD000.80 sampled from 2015 and 2018.
[88] The state ended its implementation of this project. Virginia Department of Environmental Quality, Implementation Projects. Link: https://www.deq.virginia.gov/water/water-quality/implementation/tmdl-implementation-projects
[89] "Mill and Hawksbill Creek TMDL Implementation Plan", Maptech, Inc. September 13, 2007. Obtained via FOIA request to VDEQ.p. 18.

[90] Although EPA approved the implementation plan for the cleanup of these waterways in 2008, Virginia first listed Hawksbill Creek as impaired in 1998, with additional sections of the creek deemed impaired by 2004. Mill Creek was listed as impaired in 1998.
[91] "Mill and Hawksbill Creek TMDL Implementation Plan", Maptech, Inc. September 13, 2007. Obtained via FOIA request to VDEQ , p.5.
[92] Ibid. at 12
[93] Based on EIP's analysis of data provided by VDEQ in a FOIA request.
[94] "Mill and Hawksbill Creek TMDL Implementation Plan", Maptech, Inc. September 13, 2007. Obtained via FOIA request to VDEQ , p. 22.
[95] "Total Maximum Daily Load (TMDL) Development for Smith Creek", Virginia Department of Environmental Quality, April 2004. Obtained via FOIA request to VDEQ. p. viii
[96]"Smith Creek Watershed TMDL Implementation Plan; Rockingham and Shenandoah Counties, City of Harrsionburg, and Town of New Market, Virginia", Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation, February 19, 2009. Obtained via FOIA request to VDEQ.
[97] "Smith Creek Watershed TMDL Implementation Plan; Rockingham and Shenandoah Counties, City of Harrisonburg, and Town of New Market, Virginia", Virginia Department of Environmental Quality, February 19, 2009. pp. 28-34.
[98] Ibid. at 39.
[99] Ibid. at 37, 38.
[100] "Livestock Fencing in the Shenandoah Valley," Environmental Integrity Project, April 2019, https://environmentalintegrity.org/wp-content/uploads/2019/04/Livestock-fencing-report-4.4.19.pdf
[101] "A Total Maximum Daily Load Implementation Plan for Fecal Coliform and Nitrate Reductions", The Commonwealth of Virginia: Department of Conservation and Recreation, June 26, 2001. Obtained via FOIA request to VDEQ. p. 18.
[102] "Fecal Coliform TMDL for Mill Creek and Pleasant Run", Virginia Department of Environmental Quality, March 2001. Obtained via FOIA request to VDEQ p. 124
[103] Ibid. at 8-11.
[104] Ibid. at 11.