Mountain Run, Muddy Run and Lower Hazel River Implementation Plan

Culpeper and Rappahannock Counties, Virginia

Prepared and Submitted by:

Virginia Department of Environmental Quality

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List of Abbreviations

AVMA	American Veterinary Medical Association
BMP	Best Management Practice
BWET	Bay Watershed Education and Training
CBF	Chesapeake Bay Foundation
CBPA	Chesapeake Bay Preservation Act
CDC	Center for Disease Control and Prevention
cfu	Colony Forming Units
C-SWCD	Culpeper Soil and Water Conservation District
CWA	Clean Water Act
DCR	Virginia Department of Conservation and Recreation
DEQ	Virginia Department of Environmental Quality
DOE	Department of Education
DOF	Virginia Department of Forestry
DWR	Virginia Department of Wildlife Resources
E.coli	Escherichia coli (bacteria)
EPA	United States Environmental Protection Agency
FOR	Friends of the Rappahannock
FWS	United States Fish and Wildlife Service
geomean	Geometric Mean Value
GIS	Geographic Information System
HU6	Hydrologic Unit Code, Level 6 (Virginia), 12 digit (USGS)
IP	Implementation Plan
IR	Integrated Report (CWA 305(b)/303(d))
LCSA	Land Cover Stream Assessment
LEF	Livestock Exclusion Fencing
mgd	Million Gallons per Day
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NOAA	National Oceanographic and Atmospheric Administration
NPS	Nonpoint Source
PCBs	Polychlorinated Biphenyls
PDC	Planning and Development Commission
PEC	Piedmont Environmental Council
PM	Pasture Management
RC	Regional Commission
RRRC	Rappahannock-Rapidan Regional Commission
SSM	Single Sample Maximum value
STV	Statistical Threshold Value (410 cfu/100mL)
SWCB	State Water Control Board
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
VACS	Virginia Agricultural Cost Share

VCAP	Virginia Conservation Assistance Program
VCE	Virginia Cooperative Extension
VDH	Virginia Department of Health
VLCD	Virginia Statewide Land Cover Dataset
VPDES	Virginia Pollutant Discharge Elimination System
WIP III	Watershed Implementation Plan, Phase III
WQIF	Water Quality Improvement Fund
WQMIRA	Water Quality Monitoring, Information, and Restoration Act
WQS	Water Quality Standard

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Friends of the Rappahannock
Piedmont Environmental Council
Rappahannock-Rapidan Regional Commission
Town of Culpeper
Virginia Department of Forestry
Virginia Cooperative Extension

Technical analysis and report production were completed by the Virginia Department of Environmental Quality (DEQ).

1.0 Introduction

The Virginia Total Maximum Daily Load (TMDL) program is designed to improve water quality and restore impaired waters in Virginia. A TMDL identifies the maximum amount of a pollutant that a water body can receive without surpassing the state water quality standards. These standards are established to protect six beneficial uses: drinking water, recreational (i.e., primary contact/swimming), fishing, shellfishing, aquatic life, and wildlife. If the water body exceeds the water quality criteria used to measure the standard during an assessment period, Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Management and Planning Regulation (40 CFR Part 130) both require states to develop a TMDL for each pollutant contributing to its impairment.

The watersheds addressed in this Implementation Plan (IP) are part of the Rappahannock River basin. The Rappahannock basin extends nearly 200 miles from its mouth to the Chesapeake Bay, and lies within the northern central portion of Virginia (see map inset in Figure 1.1). The major rivers within the basin are the Rappahannock and Rapidan, with many tributary rivers and streams, including the Hazel River that joins the Rappahannock within the IP project area.

All of the five Virginia Hydrologic Unit 6 (HU6) watersheds included in this IP are located within Culpeper County, with the Lower Hazel River watershed extending slightly into Rappahannock County. These watersheds are contiguous, and together they encompass an area just greater than 100,000 acres. They are located exclusively within the Piedmont region of Virginia.

While much of the watershed is rural in character, with pasture and cropland (47%) and forest (40%) predominant, 12% of the IP watershed area is in developed land uses, and the Town of Culpeper is in the center of the Mountain Run watershed. Population growth in Culpeper County has been moderate, with a 12.7 percent increase from 2010-2019 to reach a total of 52,605 people (U.S. Census Bureau, 2019). However most of this growth has occurred in the area immediately surrounding the Town of Culpeper, and most of the IP project area has retained its rural character.

The initial recreational use impairments within the IP Area were for the lowest segments of Mountain Run and Muddy Run, both were listed on Virginia's 1996 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report (IR) due to exceedances of the State's water quality standard for fecal coliform bacteria. Over the years, many additional water segments in the IP project area have been designated as impaired under the recreational use standard due to excessive levels of bacteria. Figure 1-1 below shows all of the bacteria impaired waters in the project area as reported in the 2020 IR, within the broader surrounding area that has been addressed in several previously completed IPs.

The impaired waters within the IP watersheds have been addressed in three separate TMDL studies completed by the Virginia Department of Environmental Quality (DEQ) in 2001, 2004 and 2008. The 2001 Mountain Run TMDL encompassed the entire Mountain Run watershed, and the 2004 Muddy Run TMDL similarly encompassed the entire Muddy Run watershed. The Lower Hazel River is a different matter, it was a very small part of the 2008 Upper Rappahannock River Watershed TMDL that covered more than 1 million acres. These TMDL studies identified bacteria sources and set limits, allocated to the primary source categories, on the amount of bacteria the waterbodies could receive and still support their designated recreational use standard (though the limits for the Lower Hazel River applied to an area much greater than the IP watershed). All identified bacteria impairments in the Mountain Run, Muddy Run, and Lower Hazel River watersheds are addressed by this plan. More detail on the IP watersheds follows.

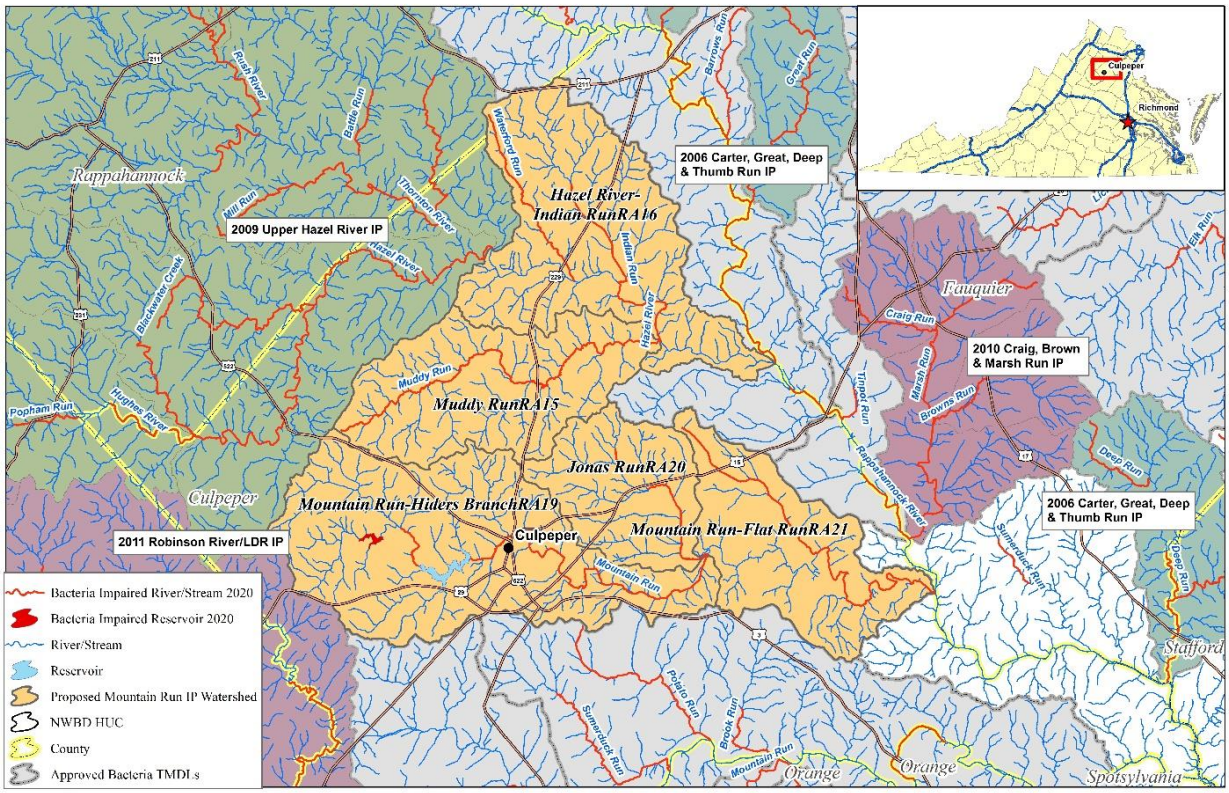


Figure 1-1. Mountain Run, Muddy Run and Lower Hazel River IP watersheds in north-central Virginia

1.1 Mountain Run

Mountain Run is the largest of the IP watersheds, and is comprised of three HU6 watersheds. Mountain Run – Hiders Branch (RA-19) is the largest of these, and captures the entire headwaters area downstream past the Town of Culpeper. This is the most densely populated portion of the IP project area, with nearly 70 percent of the total population of IP project area. The lower section of Mountain Run consists of Jonas Run (RA-20) and Mountain Run – Flat Branch (RA-21), which in contrast to RA-19 are both predominantly rural in character. For simplicity in future references, the Mountain Run – Hiders Branch IP watershed is referred to as Mountain Run #1, the Jonas Run watershed as Mountain Run #2, and the Mountain Run – Flat Run watersheds as Mountain Run #3.

Mountain Run extends over 30 miles from its headwaters to the confluence with the Rappahannock River, at the eastern extent of Culpeper County. The entire Mountain Run watershed encompasses an area of more than 57,000 acres. The lowest-most 7.58 mile segment of Mountain Run was listed as impaired for recreational use due to excess fecal coliform levels in 1996. A Bacteria TMDL was completed in 2001 for Mountain Run, one of the first TMDLs in Virginia.

The upper section of the watershed (Mountain Run #1) has experienced significant population growth/land use development in the years since the 2001 TMDL. A majority of this population is within the sewer use area of the Culpeper wastewater treatment facility, although nearly 2,600 homes in Mountain Run #1 are outside the service area. Nonetheless, this watershed continues to have considerable forest cover (44%) and agricultural land use (32%), as determined from analysis of the 2016 Virginia Land Cover Dataset (VLCD), The lower two IP watersheds within the combined Mountain Run watershed addressed in the 2001 TMDL have an even higher share of land in agricultural and forested land use.

1.2 Muddy Run

Muddy Run adjoins the Mountain Run watershed to the north, and is identified as Muddy Run (RA-15) in the VA HU6 classification. Muddy Run is a tributary of the Hazel River, which flows into the Rappahannock River upstream of the confluence of Mountain Run and the Rappahannock. The lower section of Muddy Run was listed as an impaired stream in 1996 based on DEQ monitoring at station 3-MUU000.82, which indicated that the recreational use goal was not being met. A second segment of Muddy Run was listed as an impaired stream in 2002 based on DEQ monitoring at station 3-MUU010.72, and subsequent refinements of these designations have resulted in the entire length of Muddy Run now being identified as impaired.

The watershed area is just under 19,000 acres and is mainly forested (60%), with 28% of the area in pasture, 10% developed, and 2% in cropland based on analysis of 2016 VLCD. The population of Muddy Run is estimated to be approximately 4,400, and all wastewater within the watershed is treated with individual septic systems.

A Bacteria TMDL was completed for Muddy Run in 2004, with separate TMDL equations for the upper and lower impaired segments, which are identified in the report as Upper and Lower Muddy Run.

1.3 Lower Hazel River

The Hazel River is a major tributary to the Rappahannock River, with its confluence approximately 10 miles upstream of the point where Mountain Run flows into the Rappahannock. The Lower Hazel River watershed is designated as RA-16 in the VA HU6 classification system and contains the lowest portion of the Hazel River. The remainder of the Hazel River watershed, which is comprised of multiple HU6 watersheds, constitutes the Upper Hazel River IP project area, as can be seen in Figure 1.1 above. At the time the 2009 Upper Hazel River IP was under development, there were no bacteria impairments designated in the lowest segment of the watershed.

Although the Lower Hazel River IP watershed was not addressed in the 2009 IP, it is included in the large area (> 1 million acre) covered by the 2008 Upper Rappahannock River Watershed Bacteria TMDL report. A 6.09 mile segment of the Hazel River (VAN-E07R_MUU01A00) was listed as impaired due to excessive levels of *Escherichia coli* (*E.coli)* bacteria in the 2006 Virginia Integrated Report (which wasn't approved until after the 2009 Upper Hazel River IP was underway). More recently additional recreational use impairments have been identified on two tributaries to the Hazel River within the IP watershed.

The Lower Hazel River watershed is nearly 25,000 acres in size and, like the Muddy Run watershed, is mainly forested (59%). It also has a similar amount of land in agricultural use, though it has a higher share (8%) in cropland. The population of Muddy Run is estimated to be approximately 4,100 and, again like Muddy Run, all wastewater within the watershed is treated with individual septic systems.

This IP focuses on addressing the bacteria impairments, and it explains and quantifies the actions needed to reduce bacteria levels to meet water quality standards and allow a delisting of the impaired waters from the Section 303(d) List. The IP describes control measures, commonly called best management practices (BMPs), to be implemented in a staged process over the next 15 years.

In addition to bacteria levels that exceed benchmarks of the recreational water quality standard (WQS), there are other impairments within the Mountain Run watersheds. A new TMDL report is underway to address aquatic life use impairments based on elevated Polychlorinated Biphenols (PCBs), as the sources and corrective actions needed to address PCBs are quite different from bacteria.

Another impairment of the aquatic life standard in Mountain Run is due to degraded benthic community health. For brevity, the impairment determined from the benthic macroinvertebrate bioassessment is referred to in this report as a "benthic impairment." In contrast to PCBs, the pollutant sources and the corrective actions needed to address the benthic impairment have much in common with actions needed

to address excess bacteria levels. With an eye toward achieving maximum water quality improvement, this IP gives priority to BMPs that have the potential to reduce both bacteria and benthic impairments.

Local support and successful implementation of the plan will result in restoring the impaired waters of the Mountain Run, Muddy Run and Lower Hazel River IP watersheds. An approved IP will increase opportunities for the town and county, the Soil and Water Conservation District (SWCD), non-governmental organizations, and watershed residents to obtain funding to support installation of the recommended BMPs.

This technical document can be obtained at: http://www.deq.virginia.gov/_____, accessed _____.

2.0 Watershed Planning Requirements and Approaches

Development of this plan has been completed consistent with several federal and state policies and requirements, and guided by a comprehensive water quality management approach, as discussed below.

2.1 Federal and State Watershed Planning Guidelines

Both federal and state requirements and recommendations were followed in developing this plan. The development of an IP is a requirement of Virginia's 1997 Water Quality Monitoring, Information, and Restoration Act (§62.1-44.19:4 through 19:8 of the Code of Virginia), or WQMIRA. WQMIRA directs the State Water Control Board (SWCB) to "develop and implement a plan to achieve fully supporting status for impaired waters."

In order for IPs to be approved by the Commonwealth of Virginia they must meet the following requirements of WQMIRA:

- date of expected achievement of water quality objectives,
- measurable goals,
- necessary corrective actions, and
- associated costs, benefits, and environmental impact of addressing the impairment

EPA regulations (40 CFR 130.33(b)(10)) require the inclusion of an implementation plan as an element of TMDL submittal. The EPA minimum elements of an approvable IP are described in EPA's 1999 Guidance for Water Quality-Based Decisions: The TMDL Process, and include:

- a description of the implementation actions and management measures,
- a time line for implementing these measures,
- legal or regulatory controls,
- the time required to attain water quality standards, and
- a monitoring plan and milestones for attaining water quality standards.

The IP for the Mountain Run, Muddy Run and Lower Hazel River watersheds fully addresses both the EPA and Virginia requirements and recommendations for TMDL implementation plans.

2.2 Requirements for Section 319 Funding Eligibility

The EPA has issued guidelines that describe the process and criteria used to award CWA Section 319 nonpoint source grants to States. The "Nonpoint Source Program and Grants Guidelines for State and Territories" (April, 2013) continues long-standing emphasis on the following nine elements for meeting Section 319 program requirements:

1. Identify the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan;
2. Estimate the load reductions expected to achieve water quality standards;
3. Describe the nonpoint source (NPS) management measures that will need to be implemented to achieve the identified load reductions;
4. Estimate the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement the watershed-based plan.

5. Provide an information/education component that will be used to enhance public understanding of the project and encourage the public's participation in selecting, designing, and implementing NPS management measures;
6. Provide a schedule for implementing the NPS management measures identified in the watershed-based plan;
7. Describe interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented;
8. Identify a set of criteria for determining if loading reductions are being achieved and if progress is being made towards attaining water quality standards; if not, identify the criteria for determining if the watershed-based plan needs to be revised; and
9. Establish a monitoring component to evaluate the effectiveness of implementation efforts.

Once complete, DEQ presents IPs to the SWCB for delegated approval to guide efforts to implement pollutant allocations and reductions contained in the TMDL. DEQ also requests inclusion of new IPs in the appropriate Water Quality Management Plan (WQMP), in accordance with CWA Sec. 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

2.3 State and Local Water Quality Planning Initiatives

Historically DEQ has focused its greatest attention on development of Bacteria TMDLs and IPs, however in recent years the Agency has given top priority to addressing benthic impairments, and reduced the priority of Bacteria TMDLs/IPs. The adjoining Mountain Run, Muddy Run and Lower Hazel River watersheds presented DEQ with the opportunity to take a comprehensive watershed management approach that gives attention to both the bacteria and benthic impairments in a single IP.

Each of the IP watersheds have long had bacteria impaired water segments listed in the bi-annual IR. In addition, beginning with the 2006 IR, several water segments within the Mountain Run watershed have been designated as impaired for benthic community health. Since many of the control measures that address bacteria pollutants are also effective in reducing pollutants that cause harm to benthic life (especially sediments and nutrients), this planning effort presented an opportunity to frame a plan that can comprehensively address both the bacteria and benthic impairments in the project area.

The IP project area was proposed to DEQ as a priority for IP development by the Culpeper Soil and Water Conservation District (C-SWCD), after consultation with its Board of Directors and local leaders. In addition, both regional environmental organizations that are active in the area (Friends of the Rappahannock, FOR; and the Piedmont Environmental Council, PEC) have identified the IP watersheds as priority areas for their organizations ongoing work and new initiatives. There are significant opportunities for synergy with local stakeholders' interests and efforts in the project area.

The IP watersheds are all a part of the Chesapeake Bay watershed, and this plan can guide both the needed efforts to achieve local water quality management goals and those called for in the Bay Watershed Implementation Plan, Phase III (WIP-III). As the pollutants addressed in the 2010 Chesapeake Bay Watershed TMDL included sediments, phosphorus and nitrogen, all common stressors of benthic life, the control measures that are included in the local area component of the WIP III are also relevant to addressing the benthic life impairments in Mountain Run. Accordingly, in selecting control measures to include in this IP, DEQ gave attention to those included in the WIP III that have the most relevance to achieving the IP's water quality goals.

3.0 Applicable TMDLs and Comparative Analysis Methodology

The watersheds included in the Mountain Run, Muddy Run and Lower Hazel River IP project area were addressed in three separate bacteria TMDL projects, which identified pollutant reductions needed to achieve the water quality standard for the recreational use in waters listed as impaired due to high bacteria levels. The TMDLs were developed to address the water quality criteria in effect at the time, which originally was fecal coliform and later, *E.coli*. The first TMDL project was the "Fecal Coliform TMDL: Mountain Run Watershed, Culpeper, Virginia", completed in 2001. It was one of the first TMDLs completed within the Commonwealth, and addressed all three VA HU6 watersheds of Mountain Run (RA-19, RA-20, and RA-21). The 2004 "Bacteria TMDL for Muddy Run, Culpeper County, Virginia" project covered the entire RA-15 watershed. Finally, in 2008 the "Bacteria TMDL Development for the Rappahannock River Basin" project was completed. The 2008 TMDL encompassed an extremely large area of more than 1.2 million acres, with the Lower Hazel River IP watershed (RA-16) addressed herein a very small part of one of the two Hazel River TMDL watersheds.

The initial bacteria impairments were listed based upon data from four DEQ monitoring stations, and they were used to establish the TMDL watersheds. Additional water quality sampling was conducted in support of TMDL development, and further monitoring in the IP watersheds has occurred since that time:

- Mountain Run: at DEQ monitoring station 3-MTN000.59, 12 of 48 fecal coliform samples collected from 7/1/1992 to 6/30/1997 exceeded the water quality criterion, a 25% exceedance level.
- Muddy Run: at DEQ monitoring station 3-MUU000.82, 33% of the samples collected 7/1/1992 to 6/30/1997 exceeded the water quality criterion. At an upstream station, 3-MUU010.72, 18% of the samples collected from 1/1/1996 to 12/31/2000 exceeded the criterion.
- Lower Hazel River: while this area of the watershed was part of the 2008 TMDL that encompasses the TMDL equation for Hazel River Watershed 60076, water quality data was not available in that stream segment to support its inclusion at the time of planning for TMDL development. The segment was first listed as impaired for the recreational use due exceedances of the water quality criterion for bacteria in the 2006 305(b)/303(d) Integrated Report.

3.1 Approved TMDLs

Based on water quality data and analysis performed at the time of TMDL completion, these separate TMDLs quantified the amount of bacteria the IP area waters can receive, without exceeding the WQS in place when the TMDLs were developed, and the associated reductions necessary to attain the standard. The TMDL reports do not include a description of how, specifically and practically, the necessary bacteria reductions can be achieved.

Implementation plan development aims to create a stakeholder-driven, practical plan to meet WQS. The Mountain Run and Muddy Run TMDLs identified bacteria reductions that apply to the entire watersheds included in this IP. For the Lower Hazel River, the TMDL reductions applied to a significantly larger watershed, and cannot be readily translated into a bacteria reduction value specific to the IP watershed. The TMDL equations applicable to the project area watersheds are shown in

Table 3-1 below, with bacteria expressed as fecal coliform translated to *E.coli* units so all values are expressed in a comparable manner.

Table 3-1. TMDL Equations and Bacteria (E.coli) reductions needed for IP Watersheds

Watershed	VA-HU6	WLA	LA	TMDL	Reduction from Baseline
Mountain Run	RA-19,20,21	1.36E+13	5.49E+14	5.91E+14	96.8%
Upper Muddy Run	RA-15	0	1.02E+13	1.02E+13	96.6%
Lower Muddy Run	RA-15	2.09E+10	3.76E+13	3.76E+13	96.6%
Hazel River	RA-11,12,13, 14,16	7.48E+11	9.15E+13	9.22E+13	93.3%

Each of the three approved TMDL reports within the IP project area are addressed briefly below.

- ***2001 Mountain Run TMDL*:** This TMDL report addressed the lowest 7.58 mile stream segment (VAN-E09R_MTN01A00), which was listed as impaired in 1996 due to exceedances of fecal coliform from the water quality criterion for the recreational water use. The fecal coliform bacteria TMDL for the Mountain Run watershed was approved by the EPA on 04/27/2001, the SWCB approved it on 06/17/2004, and it was subsequently modified in 2009. The TMDL identified the sources of fecal coliform bacteria requiring reductions as livestock and wildlife waste delivered directly to the stream, runoff from pastureland, manure storage areas, urban stormwater, and human contributions from sewage straight pipes. Water quality monitoring of bacteria levels completed since TMDL development identified additional stream segments impaired for recreation, as well as the Mountain Run Reservoir. These impairments are individually listed in in Table 5.1 later in this report.

- ***2004 Muddy Run TMDL*:** This TMDL report addressed two segments of Muddy Run that were listed as impaired in 1996 and 2002 relative to the water quality criteria for fecal coliform in place at that time. The 1996 listing covered the lowest section of Muddy Run (VAN-E07R_MUU01A00) to its confluence with the Hazel River, which now is reported as 6.09 miles in length. In 2002 an upstream segment of Muddy Run was listed as impaired due to exceedances of fecal coliform (VAN-E07R_MUU02A02), and this has subsequently been expanded to an 8.25 mile segment extending to its headwaters. The entirety of Muddy Run is now designated as impaired.

  The Muddy Run bacteria TMDL consists of two TMDL equations, one for each of the two sub-watersheds; Upper and Lower Muddy Run. EPA approved the TMDL report on 07/06/2004 and the SWCB approved the TMDL on 12/02/2004. The Muddy Run TMDL identified the sources of bacteria requiring reductions as pet and livestock waste delivered directly to the stream and via pastureland, and human contributions from developed land runoff, straight pipes and failing septic systems.

- **2008 *Rappahannock River TMDL*:** This TMDL report addressed multiple impaired segments of the Rappahannock, Hughes, Hazel and Rush Rivers, as well as several smaller streams within the large TMDL project area. For the Lower Hazel River watershed (RA-16) included in this IP, a 3.36 mile segment (E07R_HAZ01A04) from the confluence of Indian Run downstream to where Muddy Run joins the Hazel River was listed as impaired due to exceedances of the *E.coli* bacteria standard in 2006. Additional bacteria impairments were identified within the watershed on Indian Run in 2006 (E07R-03-BAC) and Waterford Run in 2020 (E07R-04-BAC).

  The Rappahannock River TMDL was approved by EPA on 01/23/2008, and the SWCB approved the TMDL on 07/31/2008. The sources of *E. coli* bacteria requiring reductions were identified as livestock and wildlife waste delivered directly to the stream, and indirect loads from pet, and human sources. The human source contributions were identified as failing septic systems and straight pipes.

A plan for the successful implementation to address the load allocation portion of the TMDLs requires an evaluation of current watershed conditions to identify whether land use changes since TMDL development suggest any significant differences in the bacteria sources and reductions needed to achieve water quality standards. This information will be presented and discussed in Section 4.0, followed by a discussion of water quality conditions and the most recent water quality assessment for project area in Section 5.0.

3.2 Comparative Analysis Methodology: Conceptual Discussion

Since 2001, DEQ (and the Virginia Department of Conservation and Recreation, DCR, prior to 2013) have completed and EPA has approved 75 bacteria IPs (53 for *E.coli*, 22 for Fecal Coliform), establishing eligibility to expend Clean Water Act Section 319 Nonpoint Source grant funds to support voluntary implementation efforts. These previously completed IPs used a variety of water quality modeling techniques to determine precise levels of bacteria reductions needed in each watershed, as quantified in the load allocation of the TMDLs. BMP recommendations were guided by both modeling and stakeholder consultations, and final recommendations were prepared that achieved the bacteria reductions assigned to each source sector identified as comprising the load allocation part of the TMDL. With this rich set of completed technical analysis to draw upon, the Mountain Run, Muddy Run and Lower Hazel River IP comparative analysis benefits from a wealth of prior modeling results, without requiring additional modeling specifically for the new IP itself. Streamlining IP development in this way allows water quality management efforts to focus sooner on getting BMPs on the ground, while avoiding the cost of contractor technical support.

A comparative analysis methodology was used to develop a "strawman" of which BMP practices and the number of each that are likely needed to reduce bacteria from the identified pollutant sources to meet the water quality criteria. This approach bases new IP recommendations on those contained in previously approved plans developed for watersheds with similar characteristics and pollutant sources. DEQ identified 13 bacteria IP watersheds[1] in four EPA-approved plans that were similar in character to one or more of the five Mountain Run, Muddy Run and Lower Hazel River IP watersheds. The selected

[1] The comparison watersheds include Blue, Marsh, Poplar, and Rippin Run, Rapidan #2 (2015 Upper Rapidan IP), Hawksbill and Mill Creek (2008 IP), Craig, Brown and Marsh Run (2010 IP), and Cromwells Run and Upper Goose Creek (2018 IP).

watersheds share similar characteristics, such as in distribution of land uses and bacteria sources and are located within the Piedmont ecoregion.

In reviewing these approved bacteria IPs, several "core" practices were found to be most commonly recommended to achieve the bacteria reductions called for in the TMDLs. The core bacteria BMPs include livestock exclusion fencing, pasture management, and residential septic practices. Data tables were compiled with the IP's recommendations for these core bacteria BMPs, along with watershed size and land use data, for each of the selected (comparison) watersheds. Core BMP recommendations from the comparison watersheds were adjusted to account for differences in watershed size and land uses, thereby scaling the comparison watersheds recommendations to this IP's watershed characteristics.

Based on input during the initial workgroup meeting, DEQ then compiled data on core BMPs that have already been completed in the IP watersheds, and are still within their effective life span. The initial comparative analysis BMP recommendations were reduced by the amount of BMPs already completed and still in effect.

DEQ next conducted data analysis to identify the potential "opportunities" for each of the core bacteria BMP types. For livestock exclusion fencing, this entailed developing an estimate of the length of streams that flow through or are adjacent to pasture land. For pasture management measures, the opportunities are lands currently in pasture. For septic system BMPs, the opportunities are the estimated number of residences located in each of the IP watersheds that utilize on-site septic systems for their wastewater treatment. This data was used to reallocate the initial BMP recommendations across the five IP watersheds.

Finally, to avoid a conveying a false sense of precision in the final results, all BMP recommendations were rounded to an appropriate level (closest 50, 10, etc. depending on the scale of the specific BMP recommendation). Precision in BMP recommendations is not a goal of this plan, since in the end the number and type of BMPs installed are ultimately reliant upon voluntary implementation. Additionally, progress toward achieving the water quality criteria must be determined through water quality monitoring and assessment. Instead of precise IP recommendations, this plan aims to identify the general type and amount of BMPs needed, and calls for ongoing water quality monitoring to gage progress over time and inform adaptive management of the initial plan, as needed.

After developing the Core bacteria BMP recommendations in the manner discussed, a more streamlined comparative analysis approach was used for additional agricultural BMPs and stormwater management (urban) BMPs. For these measures, DEQ extracted the BMP recommendations for all Sediment IPs (since this plan aims to address not only the bacteria impairments in all IP watersheds, but also the benthic impairments in Mountain Run). BMP recommendations for the Sediment IP watersheds were adjusted to account for the difference in size with the new IP watersheds, and after removing outliers, average values for these BMPs were calculated to provide a comprehensive suite of BMP recommendations. The approach used to prepare BMP recommendations is discussed in more detail in Section 8.0.

4.0 Watershed Characterization

This section provides a summary of the most up-to-date data used to characterize the IP project area for purposes of plan development

4.1 Climate and Soils

The Mountain Run, Muddy Run, and Lower Hazel River watersheds are located within the Rappahannock River basin, in the Piedmont geologic zone. The area has a mixed-humid climate, with average annual precipitation of 41 inches (NOAA). Average July low and high temperatures are 64 and 87 degrees Fahrenheit, and average January low and high temperatures are 23 and 43 degrees Fahrenheit (NOAA).

The IP project area is almost entirely located in Culpeper County (a very small part of the Lower Hazel River watershed is in Rappahannock County), which is exclusively within the Piedmont Plateau physiographic province. Many soils found within the County are suitable for agricultural and residential purposes. Soil limitations exist in some locations, including areas of steep slopes, susceptibility to wind and water erosion, shallow soil depths, unfavorable soil structure and workability, and permanent wetness problems that hinders farming and septic disposal. All soils require careful management and conservation practices to prevent deterioration in water quality and to maintain and improve soil quality. (Culpeper County Comprehensive Plan, 2015). Figure 4-1**Error! Reference source not found.** below presents the generalized soils groups for Culpeper County, the light blue-shaded areas (Jackland-Waxpool-Haymarket-Montalto) to the south and east of the Town of Culpeper are referred to as “Shrink/Swell” soils in the County’s Natural Resources section of the Comprehensive Plan, and are generally unsuitable for conventional septic systems. In relation to this project, these soils are primarily found in RA-21, the Mountain Run – Flat Run watershed in the southeastern section of the project area.

The geographic area of the IP is slightly over 100,000 acres in size, and includes the entirety of both the Mountain and Muddy Run watersheds, and the lowest portion of the Hazel River watershed. As noted, with the exception of some 30 acres of the Lower Hazel River watershed that falls within Rappahannock County, the IP project area is located within Culpeper County, in the north-central portion of Virginia.

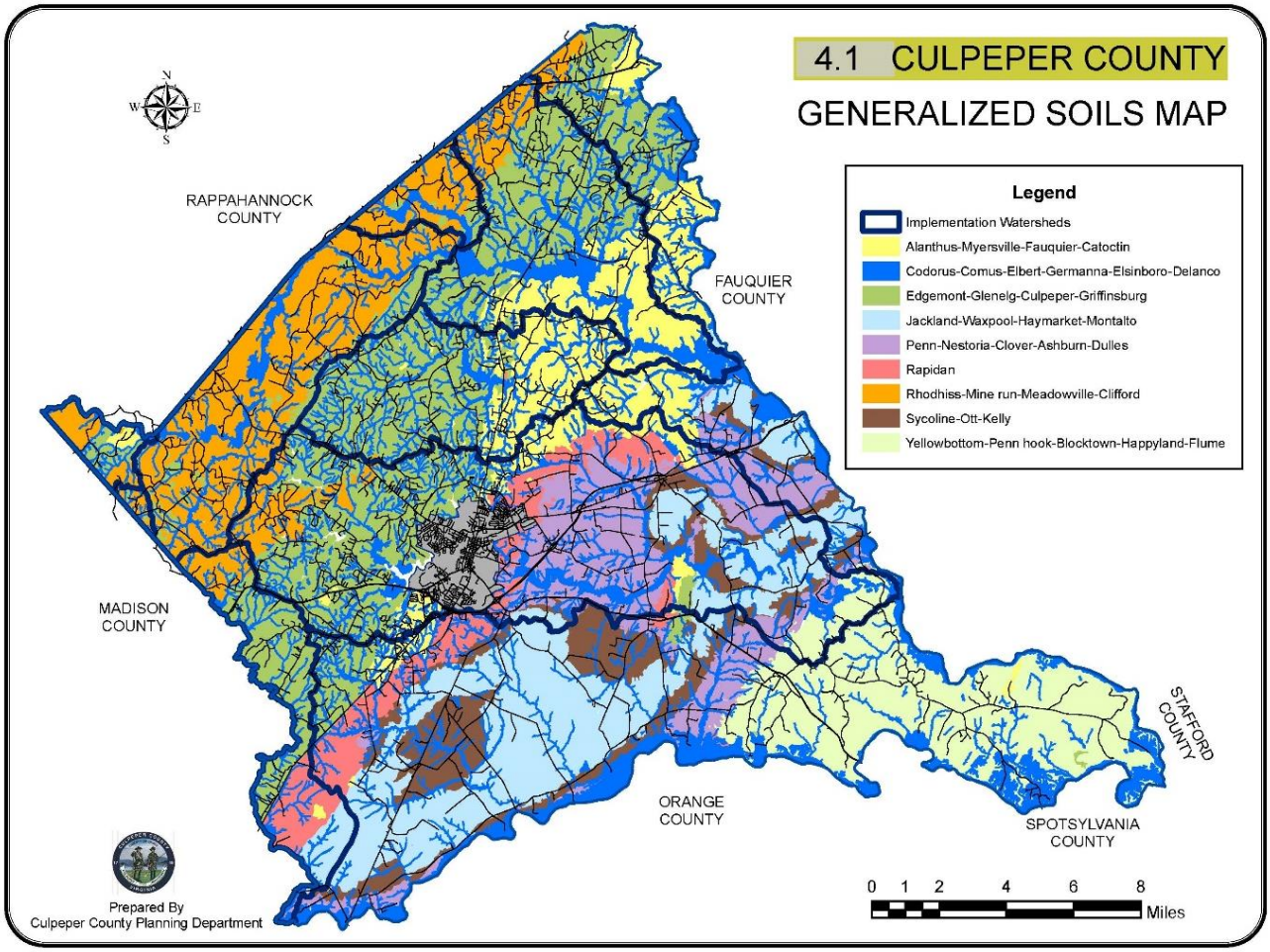


Figure 4-1. Culpeper County Generalized Soils Map

4.2 Land Use

The bacteria TMDLs for the IP watersheds utilized the most recent land cover/land use data at the time the TMDL project was initiated. The land use distribution contained in the TMDL reports is compared to current land use analysis to identify changes that may have impacted the sources of bacteria that need to be addressed to achieve water quality standards. Table 4-1 below presents the land use summary information from the TMDL reports for the combined Mountain Run IP watersheds, Muddy Run, and for the Hazel River TMDL watershed that the Lower Hazel River IP watershed lies within. Note that the Lower Hazel River IP watershed is a very small part of the Hazel River TMDL watershed, and the land use distribution for the larger TMDL watershed may not have accurately reflected land use in the smaller IP watershed.

Table 4-1. IP Watersheds Land Use Summary from TMDL Reports

Land Use Class	Lower Hazel River Watershed (%)	Muddy Run Watershed (%)	Mountain Run Watershed (%)
Forest	67	57	25
Pasture	32*	25	31
Cropland	*	16	30
Developed	1	3	14
Total	**100**	**100**	**100**

* Hazel River TMDL watershed showed Pasture/Cropland combined

During IP development, DEQ performed GIS analysis of time series land use data from the National Land Cover Dataset (NLCD) from imagery taken in 2001, 2010, and 2016. These data are at the 30 meter level of spatial precision. In addition, 2016 VLCD, at the 1 meter level of spatial precision, was also analyzed. The NLCD data is used for purposes of assessing land use changes over time because it is the only aerial imagery data extending over the time period from TMDL development (2001, 2004, and 2008) to the current IP development. However, the 2016 VLCD is used in the Comparative Analysis methodology discussed in Chapter 3.2 and Chapter 8.1, since its higher resolution allows the most accurate assessment of current land use conditions.

Table 4-2. Analysis of Land Use Changes from 2001-2016 from NLCD Imagery

Land Type	Land Class	2001 NLCD (%)	2011 NLCD (%)	2016 NLCD (%)	Change in NLCD Land Use (2001-2006) (%)	2016 VLCD (Ac)	2016 VLCD (%)
Pervious	**Forest**	41.5	40.9	41.0	-0.5	51,503	50.9
	Cropland	8.1	8.6	8.9	0.8	10,745	10.6
	Pasture	39.8	38.4	38.0	-1.8	25,102	24.8
	Developed	8.3	9.1	9.1	0.8	9,377	9.3
Impervious	**Developed**	2.3	2.8	2.9	0.6	4,198	4.2
	Barren	0.1	0.1	0.1	0.0	192	0.2
	Total	**100.0**	**100.0**	**100.0**		**101,117**	**100.0**

Current land use values for use in the comparative analysis were derived from GIS analysis of the high resolution 2016 VLCD aerial imagery, shown in the IP project area map presented as Figure 4-2. Summary analysis of this imagery is shown in

Table 4-3 below. Data was extracted for each hydrologic unit in the watershed and then the classification scheme was summarized to match the classifications used in other IPs to allow for comparison.

Forest land ranges from 28-60% of total acreage across the IP watersheds, while developed land varies from 7-23% of total acreage. For the IP project area as a whole, 51% of land is forested, 25% pasture, 13% developed, and 11% cropland. The highest level of developed land is within Mountain Run #1, where the Town of Culpeper is located. The highest amount of agricultural land (57%) is within Mountain Run #2 (Jonas Run) IP watershed.

Mountain Run, Muddy Run, Lower Hazel Rivers IP Watersheds 2016 Virginia Land Cover Data

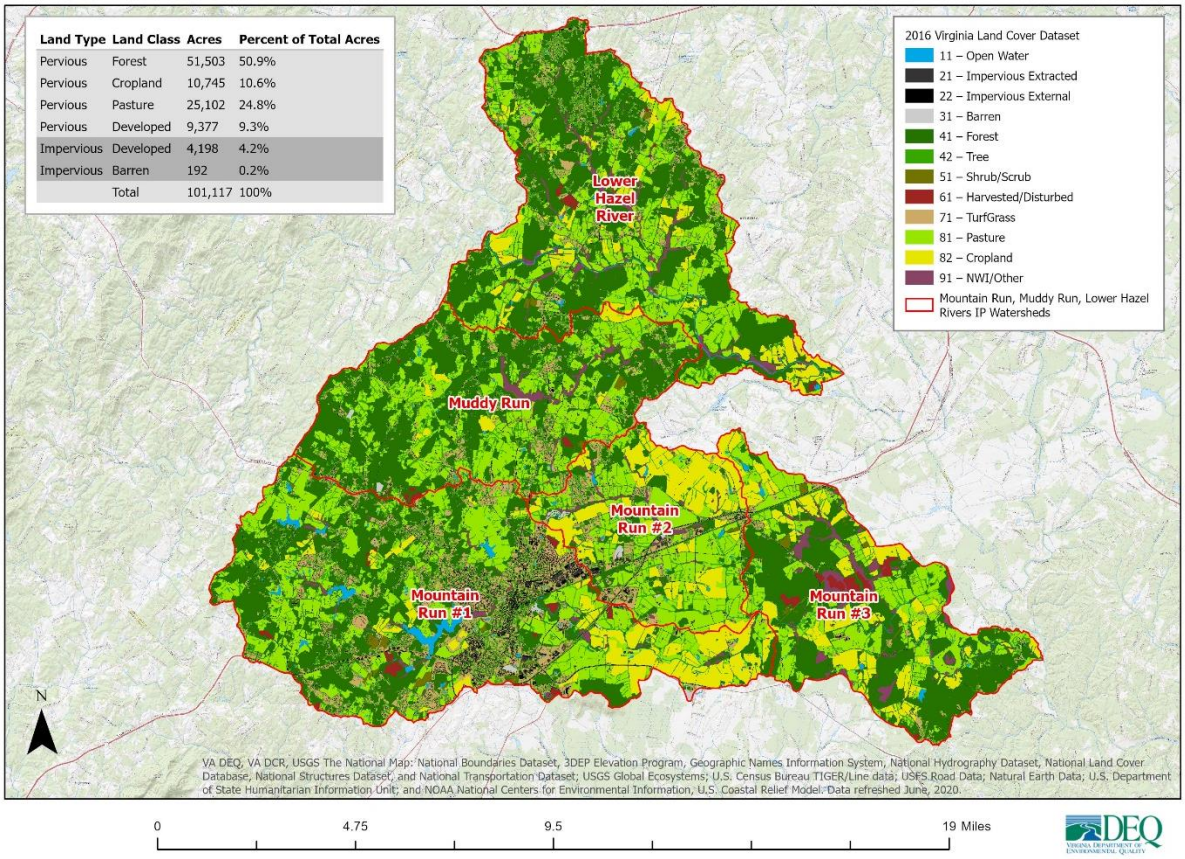


Figure 4-2. Aerial Imagery of land use in the IP watersheds

Table 4-3. Distribution of land use acreage and percent of total area by IP watershed (2016 VLCD)

Land Type	Land Class	L. Hazel River		Muddy Run		Mountain Run #1		Mountain Run #2 Acres		Mountain Run #2 Acres		Total IP Watershed	
		(Ac)	(%)	(Ac)	(%)	(Ac)	(%)	(Ac)	(%)	(Ac)	(%)	(Ac)	(%)
Pervious	Forest	11,342	60	14,737	59	13,466	44	3,169	28	8,790	56	51,505	51
	Cropland	365	2	1,986	8	2,869	9	2,982	26	2,544	16	10,746	11
	Pasture	5,251	2	5,761	23	7,064	23	3,500	31	3,527	22	25,103	25
	Developed	1,270	7	1,772	7	4,524	15	1,084	10	728	5	9,377	9
Impervious	Developed	560	3	581	2	2,312	8	501	4	243	2	4,198	4
	Barren	38	0	0	0	84	0	70	1	-	0	192	0
	Total	**18,826**	**100**	**24,837**	**100**	**30,320**	**100**	**11,306**	**100**	**15,833**	**100**	**101,121**	**100**

The current land use zoning shows that for all but Mountain Run #1, the most common zoning of the IP project area is Agricultural, followed by Rural (low density residential). Figure 4-3 presents current zoning by IP watershed, from analysis prepared by the Rappahannock-Rapidan Regional Commission (RRRC).

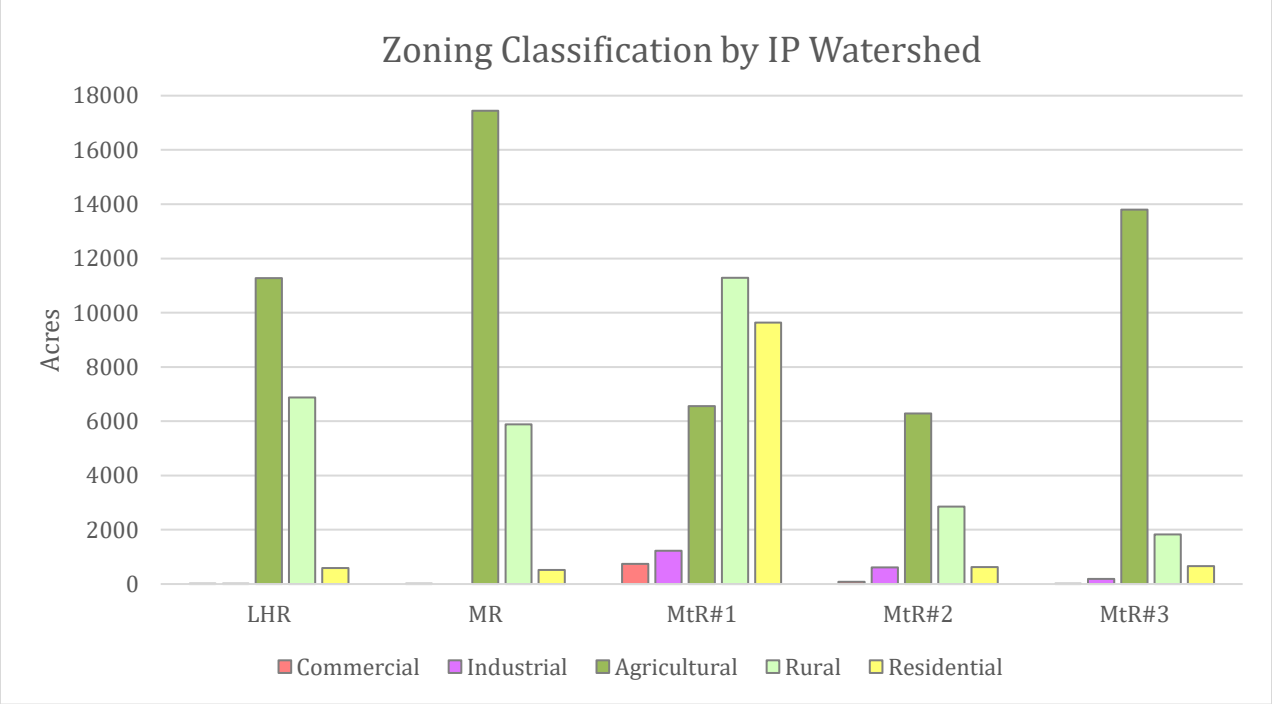


Figure 4-3. Land Use Zoning by IP Watershed (RRRC analysis)

5.0 Water Quality Sampling and Analysis

Since the time of TMDL development, additional information on bacteria levels within the IP project area has been collected by DEQ. This data has resulted in a number of additional impairment determinations. Data specific to the recreational use impairment due to exceedances of the water quality criteria for bacteria will be discussed first, followed by a summary of recent analysis of data on benthic macroinvertebrate community health, associated with aquatic life use impairments in Mountain Run.

5.1 DEQ Monitoring and Assessment

Two DEQ trend monitoring stations are located within the IP project area, station 3-HAZ005.98 in the Lower Hazel River watershed, and station 3-MTN000.59 in the lowest section of Mountain Run. Trend stations are sampled for core water quality parameters, including bacteria, bi-monthly on an annual basis to identify long-term water quality trends. DEQ also has watershed stations sited within the IP project area, and the sampling at these sites is rotated on a continual basis to enable monitoring to occur in all of Virginia's watersheds. These stations are sampled monthly for a period of one year during a rotation. Additional sampling occurred in the project area in support of various efforts, such as for DEQ's Freshwater Probabilistic Monitoring program and in support of TMDL development. On a biennial basis, DEQ assesses water quality monitoring data collected within a defined assessment cycle and reports the results in the 305(b)/303(d) IR (DEQ, 2020) which informs EPA and the public of its most current water quality assessment determinations for surface waters within the Commonwealth.

The current bacteria and benthic impairments within the IP watersheds are shown in Figure 5-1 and listed Figure 5-1 below. In the map, the waters impaired for bacteria only are shown in red, those with both bacteria and benthic impairments appear orange in color, and the segment in the Mountain Run #3 watershed shown in green is impaired for aquatic life (benthic macroinvertebrate bioassessment), but not bacteria.

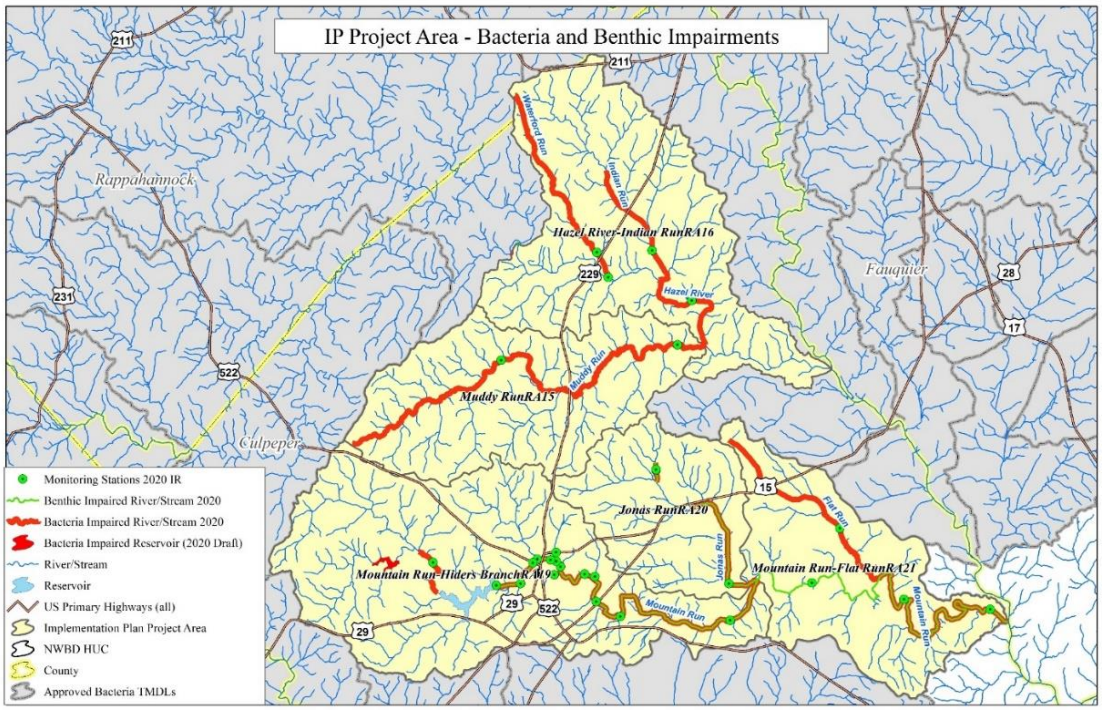


Figure 5-1. Map of Bacteria and Benthic Impairments in the IP Watersheds

A listing of the specific waterbody segments that have been assessed as impaired for either the recreational use due to excursions from the water quality criteria for bacteria, the aquatic life use due to an impaired benthic community, or both are presented in Table 5-1below. In total, 58.8 stream miles and 72.75 lake acres are currently reported in the 2020 Virginia IR (DEQ, 2020) as impaired under the recreational use WQS due to elevated bacteria levels. A total of 28.8 stream miles within the three Mountain Run watersheds are impaired under the aquatic life WQS due to benthic life impacts. There are additional water quality impairments within the Mountain Run watersheds due to Polychlorinated Biphenyls (PCBs) that exceed the Fish Consumption WQS which are being addressed through development of a TMDL that is currently underway.

Table 5-1. Water Quality Impairments (Bacteria and Benthic) in the IP Watersheds

Stream Name	VA HUC 6	Impairment Length (miles)	Impaired Use	Impairment Cause[a]	Assessment Unit	Cause Code Group	Year First Listed	Listing Station
Hazel River	RA-16	3.36 miles	Recreation	E.coli*	VAN-E07R_HAZ01A04	E07R-02-BAC	2006	3-HAZ005.98
Indian Run	RA-16	3.84 miles	Recreation	E.coli*	VAN-E07R_IND01A04	E07R-03-BAC	2006[b]	3-IND001.14
Waterford Run	RA-16	6.23 miles	Recreation	E.coli	VAN-E07R_WAF01A10	E07R-04-BAC	2020	3-WAF000.82
Muddy Run	RA-15	6.09 miles	Recreation	E.coli*	VAN-E07R_MUU01A00	E07R-01-BAC	1996	3-MUU000.82
Muddy Run	RA-15	8.25 miles	Recreation	E.coli*	VAN-E07R_MUU02A02	E07R-01-BAC	2002	3-MUU008.52
Mountain Run	RA-21	7.58 miles	Recreation	E.coli*	VAN-E09R_MTN01A00	E09R-01-BAC	1996	3-MTN000.59, 3-MTN005.79
Mountain Run	RA-21	7.58 miles	Aquatic Life	Benthic Macro-invertebrates	VAN-E09R_MTN01A00	E09R-01-BEN	2008	3-MTN005.79
Mountain Run	RA-20	5.67 miles	Aquatic Life	Benthic Macro-invertebrates	VAN-E09R_MTN02A04	E09R-01-BEN	2008	3-MTN005.79, 3-MTN014.88
Mountain Run	RA-20	6.65 miles	Recreation	E.coli	VAN-E09R_MTN03A00	E09R-02-BAC	2010	3-MTN014.88

Stream Name	VA HUC 6	Impairment Length (miles)	Impaired Use	Impairment Cause[a]	Assessment Unit	Cause Code Group	Year First Listed	Listing Station
Mountain Run	RA-20	6.65 miles	Aquatic Life	Benthic Macro-invertebrates	VAN-E09R_MTN03A00	E09R-01-BEN	2008	3-MTN014.88
Mountain Run	RA-19	4.63 miles	Recreation	E.coli	VAN-E09R_MTN04A04	E09R-02-BAC	2004[c]	3-MTN021.11, 3-MTN022.01
Mountain Run	RA-19	4.63 miles	Aquatic Life	Benthic Macro-invertebrates	VAN-E09R_MTN04A04	E09R-01-BEN	2020	3-MTN021.11
Mountain Run	RA-19	1.63 miles	Recreation	E.coli*	VAN-E09R_MTN05A04	E09R-03-BAC	2006	3-MTN027.08
Mountain Run Reservoir	RA-19	72.75 acres	Recreation	E.coli	VAN-E09L_MTN02A02	E09L-01-BAC	2020	3-MTN028.68
Jonas Run	RA-20	3.78 miles	Recreation	E.coli	VAN-E09R_JOA01A06	E09R-04-BAC	2008	3-JOA000.80
Jonas Run	RA-20	3.78 miles	Aquatic Life	Benthic Macroinvertebrates	VAN-E09R_JOA01A06	E09R-02-BEN	2012	3-JOA001.60
Jonas Run, Unnamed Tributary	RA-20	0.53 miles	Recreation	E.coli	VAN-E09R_XMO01A20	E09R-06-BAC	2020	3-XMO000.44
Jonas Run, Unnamed Tributary	RA-20	0.53 miles	Aquatic Life	Benthic Macroinvertebrates	VAN-E09R_XMO01A20	E09R-03-BEN	2020	3-XMO000.44

Stream Name	VA HUC 6	Impairment Length (miles)	Impaired Use	Impairment Cause[a]	Assessment Unit	Cause Code Group	Year First Listed	Listing Station
Flat Run	RA-21	6.23 miles	Recreation	E.coli	VAN-E09R_FLA01A08	E09R-05-BAC	2014	3-FLA001.93

[a] Impairment Cause "E.coli*" indicates the impairment was initially based on the Fecal Coliform criterion used for the original listing.
[b] VAN-E07R_IND01A04 originally was listed for Fecal Coliform in 2006. This segment was delisted in 2010, and then relisted for E.coli in 2020.
[c] VAN-E09R_MTN04A04 originally was listed for Fecal Coliform in 2004. This segment was delisted in 2008, and then relisted for E.coli in 2016.

5.2 Bacteria Data Summary

Periodically, EPA reviews all of its recommended water quality criteria so that they reflect the best available science. In 2019 the Virginia State Water Control Board adopted nationally recommended bacteria criteria (for E.coli) published by the EPA. The new criterion of 410 counts/100mL is a Statistical Threshold Value (STV) that is used in combination with the geometric mean value, which requires data collected at a higher frequency (e.g. weekly over a 90 day period to collect a minimum of 10 samples) than previously collected to assess the water quality of freshwater surface waters for the recreational use. While assessing bacteria (E.coli) under the new criteria to identify impairment status and/or potential for delisting now requires high frequency data, data collected at lower frequencies (e.g. monthly) can help to guide implementation planning and indicate where levels of bacteria may be improving.

DEQ reviewed bacteria data collected from sampling conducted from 2002-2020 (the years with E.coli data) at DEQ monitoring stations within the IP watersheds. The focus of this data review was stations with E.coli data that had a minimum of 10 samples for both the 2002-10 and 2011-20 timeframes. The purpose of this review was to use as an indicator of whether there appears to be improvement in the levels of bacteria in the selected waterbodies. Identifying changes in the trajectory of bacterial levels can be complicated as the amount of bacteria in surface waterbodies is highly influenced by runoff from storm events. Looking at longer timeframes helps to reduce short term influences related to the timing of monitoring relative to rainfall events.

Table 5-2. Bacteria data from selected stations in the IP Watersheds (2002-2020)

IP Watershed	DEQ Monitoring Station	2002-2010			2011-2020		
		No. Samples	> 235 cfu[1]	Exceedance (%)	No. Samples	> 235 cfu[1]	Exceedance (%)
Lower Hazel	3-HAZ005.98	49	14	29%	55	18	33%
Lower Hazel	3-IND001.14	16	1	6%	12	7	58%
Muddy Run	3-MUU008.52	13	9	69%	11	7	64%
Muddy Run	3-MUU000.82	16	9	56%	23	10	43%
Mt Run #1	3-MTN027.08	20	11	55%	24	6	25%
Mt Run #1	3-MTN014.88	23	6	26%	20	14	70%
Mt Run #2	3-JOA000.80	22	9	41%	15	5	33%
Mt Run #3	3-MTN000.59	41	12	29%	65	21	32%
	Total	**200**	**71**	**36%**	**225**	**88**	**39%**

[1] The retired single sample maximum bacteria criterion of 235 cfu/100mL is used in this comparison as a guide to understand bacteria data collected at low frequency and not the high frequency necessary to conduct an assessment of the data under the current bacteria water quality criteria.

Looking at stations with at least 10 samples during each of the multi-year two time periods chosen, some stations show percent increases over time above the 235 cfu/100 mL value while other stations show decreases. When the stations are reviewed together for each time period, there is a nominal increase from 36% (2002-10) to 39% (2011-20).

Data collected from stations with at least 20 samples collected in the last 10 years, 2011-2020, is the focus of the following graph. It was prepared to help view more recent patterns in bacteria levels. The values, as shown in Figure 5.2, appear to indicate a modest increase in bacteria levels over time. Due to the correlation between precipitation (due to stormwater runoff) and bacteria elevated levels in surface water, precipitation data for each year is also provided. The influence of precipitation levels is discernable from the bar chart, as 2015-17 were years with lower than average rainfall, and 2018-20 had above average rainfall (with 2018 the highest precipitation on record for the project area).

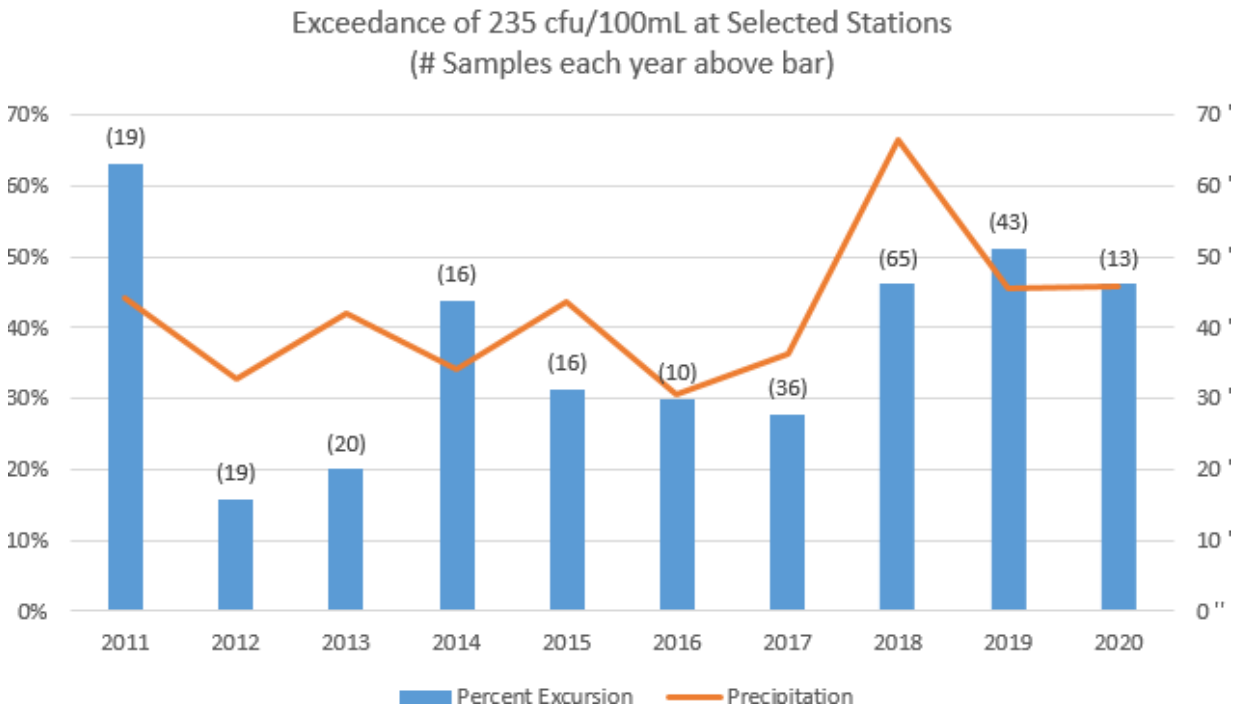


Figure 5-2. Annual Bacteria Criterion Exceedances and Precipitation for the 2011-20 timeframe

While it is difficult to identify trends from low frequency data, this data indicates there are still elevated levels of bacteria which are likely above the current water quality criteria due the percentage of data above the value of 235 cfu/100 mL. Therefore, there is need for additional management measures in the IP project area to address ongoing sources of bacteria and reduce those pollutant loads to meet the load allocation of the applicable TMDLs.

5.3 Benthic Data Analysis

Mountain Run, Jonas Run and an unnamed tributary Jonas Run are listed as impaired for aquatic life designated use based upon assessment of the benthic macroinvertebrates, meaning there is not a healthy and diverse community. Based on recent data, Flat Run, which is also in the watershed, will likely also be listed as impaired for aquatic life designated use in the 2022 IR.

A Benthic Stressor Analysis (BSA) is conducted to identify probable cause(s) of stress to the impaired benthic community. A stressor analysis is an investigation of available information, such as DEQ

monitoring data and scientific literature, to identify stressors that result in an unhealthy benthic macroinvertebrate community. Once probable stressors are known, approaches to address those, such as TMDL development or one that favors “straight to implementation”, can be considered.

DEQ completed a BSA for the Mountain Run watershed in conjunction with development of this IP, to support an approach aimed to achieve co-benefits through implementing BMPs that address more than one pollutant. Based on the stressors the BSA identified, there appears to be the potential for implementation efforts to effectively resolve both the bacteria impairments that had been addressed by TMDLs, as well as the benthic impairments that have not. The BSA report is presented in its entirety under Appendix D.

For this watershed, based upon preliminary review of existing land uses and DEQ experience from approximately 20 years of TMDL development, it was anticipated during project planning phase that the probable stressors identified as contributing to an unhealthy benthic community would be ones which also can be managed by BMPs typically selected to address bacteria impairments. Because DEQ is taking an approach that aims to leverage and utilize BMPs that provide co-benefits, DEQ is not pursuing TMDL development for the pollutants identified as probable stressors to the impaired benthic community in the Mountain Run watershed.

5.3.1 Benthic Community Health

A multi-metric macroinvertebrate index, the Virginia Stream Condition Index (VSCI), is used to assess the aquatic life use status for wadeable freshwater streams and rivers in non-coastal areas of the state. VSCI scores range from 0 to 100, with higher scores indicating relatively better ecological health. DEQ has set a score of 60 as the threshold for impairment. Scores below 60 indicate an impaired benthic community, while scores above 60 indicate a healthy benthic community.

5.3.2 DEQ Benthic Monitoring and Assessment

The mainstem of Mountain Run below the Lake Pelham dam was first monitored for macroinvertebrate health on September 15, 1994 and since that time there have been 40 sampling events at 6 monitoring stations. The median and average VSCI scores in the watershed have been below the impairment threshold with a median value of 59.09 and an average value of 55.65 (Figure 5-3).

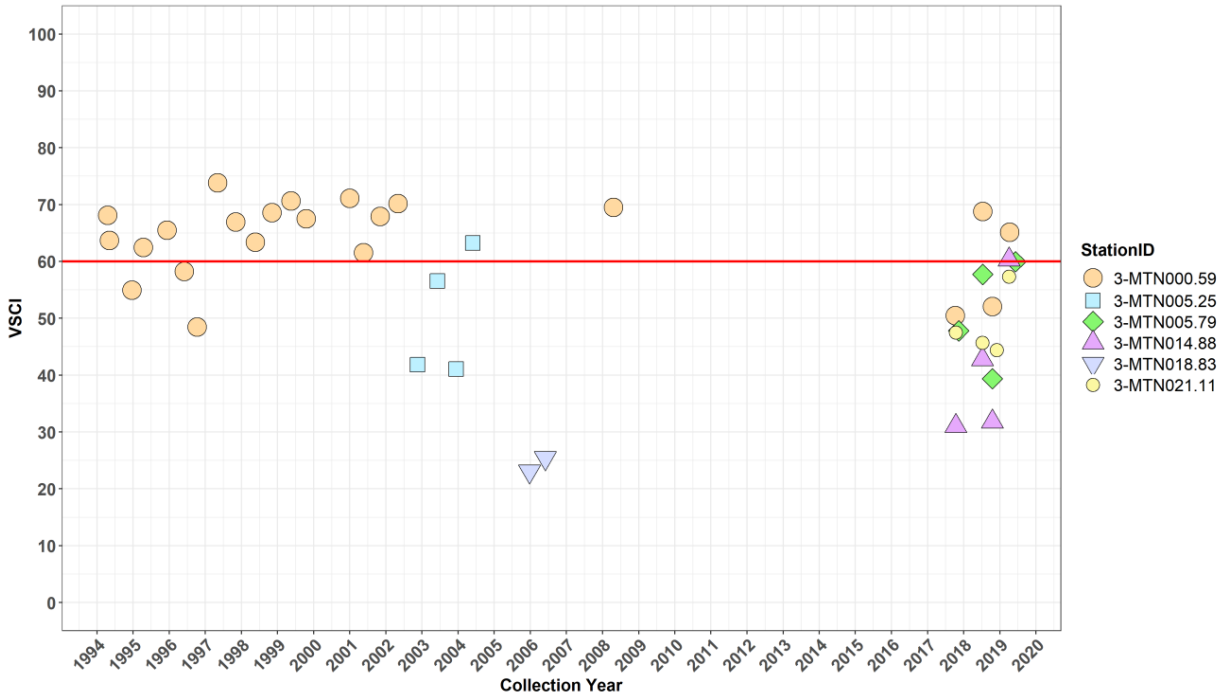


Figure 5-3. Historic Virginia Stream Condition Index (VSCI) Data for the Mountain Run Watershed

The Jonas Run watershed was first monitored for macroinvertebrate health on April 16, 2003 and since that time there have been 10 sampling events at 4 monitoring stations. The VSCI scores in the watershed have been below the impairment threshold with a median value of 39.02 and an average value of 42.77 (Figure 5-4).

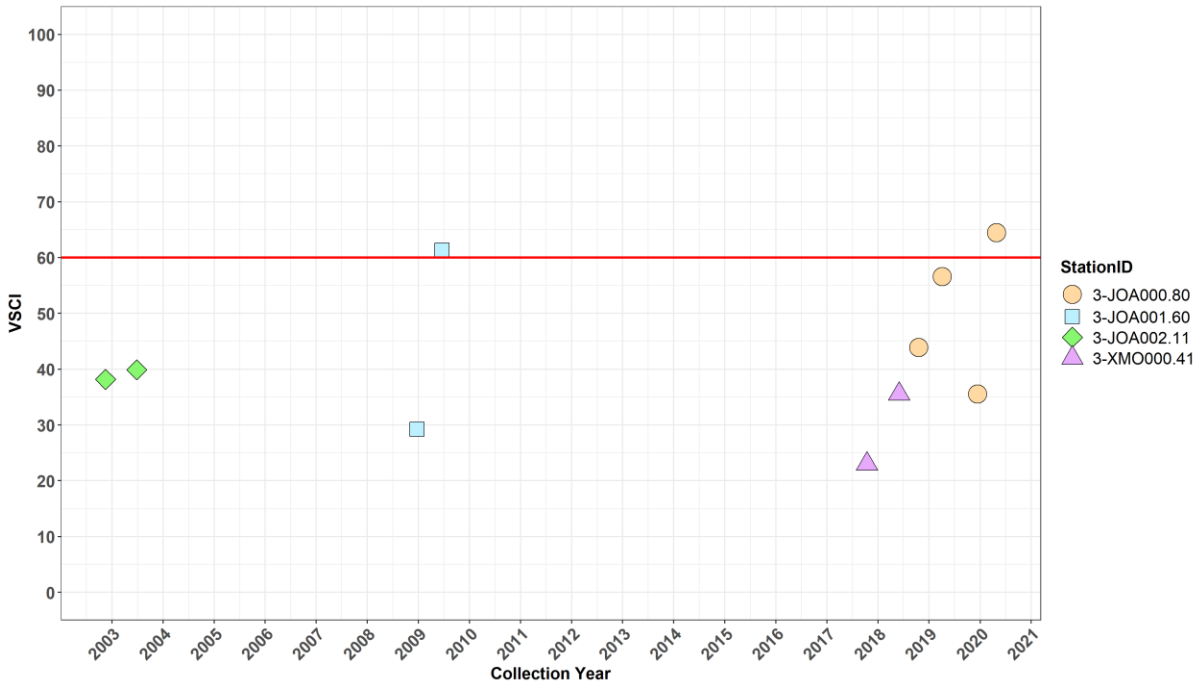


Figure 5-4. Historic Virginia Stream Condition Index (VSCI) Data for the Jonas Run Watershed

The current benthic impairments in the Mountain Run watershed are defined by six assessment units (AU) based on the 2020 IR. The mainstem of Mountain Run, from the confluence with the Rappahannock River upstream to the outlet from Lake Pelham to the, is covered by four AUs.

Jonas Run, from the confluence with an unnamed tributary at approximately river mile 3.74 downstream to the confluence with Mountain Run, is covered by AU VAN-E09R_JOA01A06. Above this Jonas Run AU an unnamed tributary to Jonas Run, from its confluence with an unnamed tributary (below Swan Dam) downstream to the confluence with Jonas Run, is covered by AU VAN-E09R_XMO01A20. Note that the upper most section of Jonas Run has not been assessed for macroinvertebrate health.

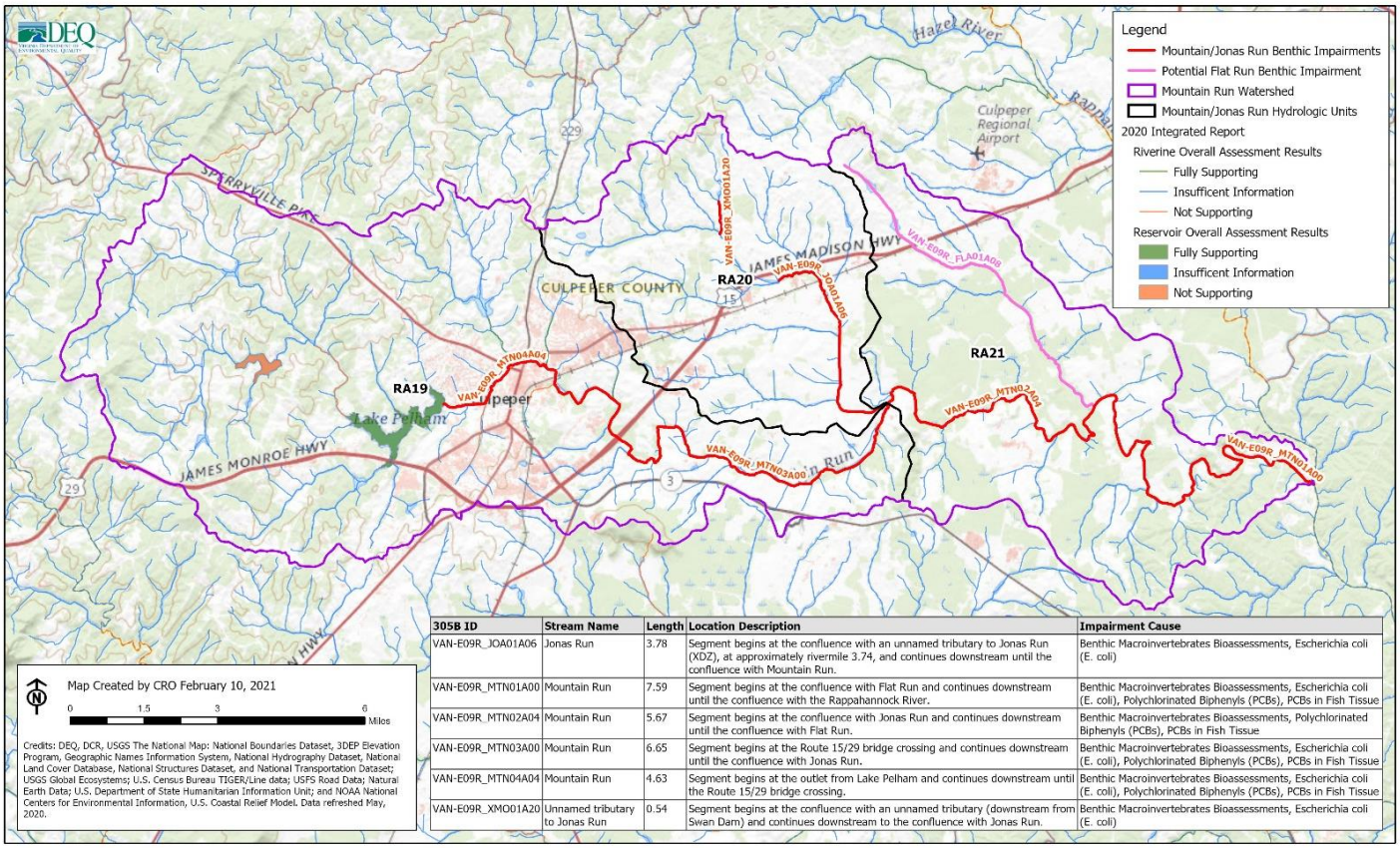
Table 5-3. Impairments in the Mountain Run Watershed

305B ID	Stream Name	Length (miles)	Location Description	Impairment Cause	Year First Listed for Benthics
VAN-E09R_JOA01A06	Jonas Run	3.78	Segment begins at the confluence with an unnamed tributary to Jonas Run (XDZ), at approximately rivermile 3.74, and continues downstream until the confluence with Mountain Run.	Benthic Macroinvertebrates, E. coli	2012
VAN-E09R_MTN01A00	Mountain Run	7.59	Segment begins at the confluence with Flat Run and continues downstream until the confluence with the Rappahannock River.	Benthic Macroinvertebrates, E. coli, Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue	2008
VAN-E09R_MTN02A04	Mountain Run	5.67	Segment begins at the confluence with Jonas Run and continues downstream until the confluence with Flat Run.	Benthic Macroinvertebrates , PCBs, PCBs in Fish Tissue	2008
VAN-E09R_MTN03A00	Mountain Run	6.65	Segment begins at the Route 15/29 bridge crossing and continues downstream until the confluence with Jonas Run.	Benthic Macroinvertebrates, E. coli, PCBs, PCBs in Fish Tissue	2008

305B ID	Stream Name	Length (miles)	Location Description	Impairment Cause	Year First Listed for Benthics
VAN-E09R_MTN04A04	Mountain Run	4.63	Segment begins at the outlet from Lake Pelham and continues downstream until the Route 15/29 bridge crossing.	Benthic Macroinvertebrates, E. coli, PCBs, PCBs in Fish Tissue	2020
VAN-E09R_XMO01A20	Jonas Run, Unnamed tributary	0.54	Segment begins at the confluence with an unnamed tributary (downstream from Swan Dam) and continues downstream to the confluence with Jonas Run.	Benthic Macroinvertebrates, E. coli	2020

In addition to these six AUs, the BSA includes the AU for Flat Run (VAN-E09R_FLA01A08), which begins at the headwaters of Flat Run and continues downstream until the confluence with Mountain Run. This AU was not assessed nor listed as impaired for benthics in the 2020 IR but all or a portion is expected to be listed in the 2022 IR based on the assessment period of 2015-2020 and data collected during 2019 and 2020. Note that while the entire reach of Flat Run is shown as potentially impaired in Figure 5.5 below, the actual length and placement of the impairment will be determined by DEQ staff during the assessment effort for the 2022 IR.

Mountain Run Watershed 2020 IR Benthic Assessment Results



305B ID	Stream Name	Length	Location Description	Impairment Cause
VAN-E09R_JOA01A06	Jonas Run	3.78	Segment begins at the confluence with an unnamed tributary to Jonas Run (XDZ), at approximately rivermile 3.74, and continues downstream until the confluence with Mountain Run.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli)
VAN-E09R_MTN01A00	Mountain Run	7.59	Segment begins at the confluence with Flat Run and continues downstream until the confluence with the Rappahannock River.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_MTN02A04	Mountain Run	5.67	Segment begins at the confluence with Jonas Run and continues downstream until the confluence with Flat Run.	Benthic Macroinvertebrates Bioassessments, Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_MTN03A00	Mountain Run	6.65	Segment begins at the Route 15/29 bridge crossing and continues downstream until the confluence with Jonas Run.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_MTN04A04	Mountain Run	4.63	Segment begins at the outlet from Lake Pelham and continues downstream until the Route 15/29 bridge crossing.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_XMO01A20	Unnamed tributary to Jonas Run	0.54	Segment begins at the confluence with an unnamed tributary (downstream from Swan Dam) and continues downstream to the confluence with Jonas Run.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli)

Figure 5-5. Impairment Listing for the Mountain Run Watershed

5.3.3 Results of Benthic Analysis

The suite of candidate stressors typically analyzed in the benthic stressor analysis are those known to have effects on benthic macroinvertebrates and are considered to be widespread and common stressors in Virginia. The candidate stressors were identified by DEQ based upon freshwater probabilistic monitoring data collected since 2005 throughout Virginia and supported by scientific literature.

Water quality data collected for the candidate stressors considered for this study were analyzed to identify if one or more of those parameters may be causing stress to the aquatic community. Candidate stressors were compared to numeric water quality criteria and threshold stressor values, as applicable. The threshold stressor values were developed and published by DEQ (2017) in the "Stressor Analysis in Virginia: Data Collection and Stressor Thresholds" document. The candidate stressors considered in the benthic stressor analysis are shown in Table 5.5 and are identified as having water quality criteria and/or a stressor threshold. The results of the stressor analysis were used to identify the potential of each candidate stressor to cause stress and lead to an impaired benthic community.

The BSA resulted in identifying Potassium, Total Habitat, and Total Nitrogen as the probable stressors of benthic health in impaired waters within the Mountain Run watershed. A summary of the rationale for these findings follows:

Potassium: Median potassium values fell into the medium probability of stress to aquatic life at all stations in the watershed except at station 3-XMO000.41 where only a single value was recorded. In mainstem Mountain Run, the measurements trended higher at the further downstream stations. While

potassium is not a specific stressor considered in the BCG, macroinvertebrates with high tolerance to specific conductance (a measure of how well water can conduct an electrical current based on the amount of ions in water) are present indicating stress due to ions such as potassium.

Total Habitat: Habitat conditions were found to be marginal based on the median values at all of the stations in the watershed except at station 3-FLA001.93 (Flat Run), where conditions were poor for all four measurements taken. The individual components that make up the total habitat metric provide more detail on the specific stressors; bank stability, bank vegetation, embeddedness, riparian vegetation and sediment components were often in the marginal range when a visual habitat assessment was performed. Total habitat scores generally indicate that the riparian corridor is highly impacted, provides conditions that favor bank erosion, stream channel instability, and the presence of deposited sediment.

Total Nitrogen: Median total nitrogen values into the medium probability of stress to aquatic life at all station in the watershed. The median values for all stations are also above the USEPA published recommended total nitrogen criteria based on ecoregion (USEPA, 2000a) of 0.69 mg/L.

These probable stressors include pollutants that can be reduced through application of BMPs that restrict livestock access to streams, improve pasture and cropland to reduce pollutant runoff to, reduce stormwater runoff from developed lands, and address septic system failures. In light of the conclusions from the BSA as to the probable stressors to the impaired benthic macroinvertebrate community, selecting BMPs that can achieve reductions of nutrients and sediment in addition to bacteria is a sound and cost effective approach that maximizes those BMPs to address both the bacteria and benthic impairments within the IP project area.

6.0 Source Assessment

The TMDL reports included a source assessment to identify potential human, agricultural, and wildlife sources of bacteria in the IP watersheds. The source assessments were derived from water quality modeling methods, as opposed to direct measurement of bacteria sources. The true contribution of bacteria from each source category is not known with precision. A summary of contribution made by the primary sources of bacteria, as estimated in the TMDL reports, is shown in Table 6-1.

Table 6-1. Estimated Existing Bacteria Loads by Source (from TMDL reports)

IP Watershed	Percent Contribution of the Total Estimated Bacteria Loads from each Bacteria Source				
	Cropland	Pasture	Cattle in Streams	Residential[1]	Forest and Wildlife
Lower Hazel River[2]	0.48%	97.1%	0.10%	2.36%	0.81%
Muddy Run	0.11%	94.7%	0.04%	4.31%	1.38%
Mountain Run[3]	--	91.3%	--	5.93%	2.70%

[1] Residential bacteria sources includes those from stormwater runoff, septic systems and straight pipes.
[2] The bacteria load source data is for the large Hazel River watershed.
[3] The bacteria load source data is combined for the subwatersheds identified as RA-19, 20, 21.

This section provides updated information on project area watershed populations, permitted discharges, updated estimates of the number of septic systems for use in residential septic BMP determinations, and household canine pet estimates for use in pet waste management BMP determinations.

6.1 Population and Number of Households

The County population for each of the IP watersheds was estimated by using a combination of geographic analysis of 2010 U.S. Census analysis and 2019 population Census Bureau data at a larger (block group) scale. The 2010 housing unit and population data were derived from GIS analysis of the 2010 census counts using the most detailed level of census data mapped to the IP watersheds. The estimated 2019 population was derived by adjusting the 2010 population upward based on the increased number of project area housing units identified by RRRC's GIS analysis of 2019 address records for the project area, which is described in Section 6.3 below.

Table 6-2. Project Area Watershed Household and Population Estimates

Watershed	Number of 2010 Census Block Groups	2010 Census Housing Units	2010 Census Population	Est. 2019 Housing Units	Estimated 2019 Population
Muddy Run	78	1,317	3,471	1,669	4,399
Lower Hazel River	129	1,333	3,595	1,510	4,072

Watershed	Number of 2010 Census Block Groups	2010 Census Housing Units	2010 Census Population	Est. 2019 Housing Units	Estimated 2019 Population
Mountain Run #1	618	9,107	23,253	9,890	25,252
Mountain Run #2	101	589	1,597	708	1,920
Mountain Run #3	76	288	678	315	742
Totals	**1,002**	**12,634**	**32,594**	**14,092**	**36,385**

Comparing the 2010 census to 2019 analysis shows that the IP project area increased in population by 11.6 percent during this timeframe, similar to the figure (12.7%) the U.S. Census Bureau shows for Culpeper County as a whole (noted in Section 1). As shown in Table 6.2 above, the IP watersheds are now estimated to have a population of approximately 35,400 people, residing in just over 14,000 residences.

6.2 Point Sources

As documented in the TMDL reports, nearly all bacteria in the project area comes from nonpoint sources. Point sources are estimated to contribute less than 1% of existing bacteria loads, and the individual permitted and general domestic permitted facilities that are within the IP area are discussed below.

The discharge of pollutants from facilities is permitted through Virginia's Pollutant Discharge Elimination System (VPDES). There are currently just four facilities with active individual permits that are expected to discharge bacteria within the project area. The Town of Culpeper operates a 6 million gallon per day (mgd) publicly-owned wastewater treatment works serving the entire population of the Town (shown in purple outline in Figure 6.2 below) and some adjacent areas of the County that border it (shown in orange shading). There are three small “package plants” that provide wastewater treatment in the IP project area to the Emerald Hill Elementary School, Culpeper Wood Preservers, and Camp Red Arrow; the remainder of the project area is served by individual on-site septic systems. All permitted facilities are required to meet water quality criteria for bacteria at their discharge point(s). Table 6-3 outlines the permit discharge limits and some pertinent information for the applicable permits within the IP watersheds.

Table 6-3. VPDES Individual Permits that discharge within IP watersheds

IP Watershed	Receiving Stream	Permit Number	Facility	Design Flow (mgd)
Mountain Run-Flat Run	Mountain Run, UT	VA0089354	Emerald Hill Elementary School	0.01
	Flat Run	VA0061590	Culpeper Wastewater Treatment Plant	6
	Mountain Run, UT	VA0059145	Culpeper Wood Preservers - Culpeper	0
	Flat Run, UT	VA0092452	Camp Red Arrow WWTP	0.0055

In Virginia, any owner of a domestic sewage treatment system with a design flow of less than or equal to 1,000 gallons per day on a monthly average basis must register for the VPDES domestic sewage discharge general permits for single-family homes. Ten systems are currently authorized within the project area to discharge under this general permit and were incorporated in the TMDLs. There are a total of 39 domestic sewage discharge general permits within the IP watersheds, which in aggregate discharge less than 0.039 mgd of effluent. These domestic sewage permit locations are shown in Figure 6-1, which also locates the four individual VPDES permits discussed and listed above.

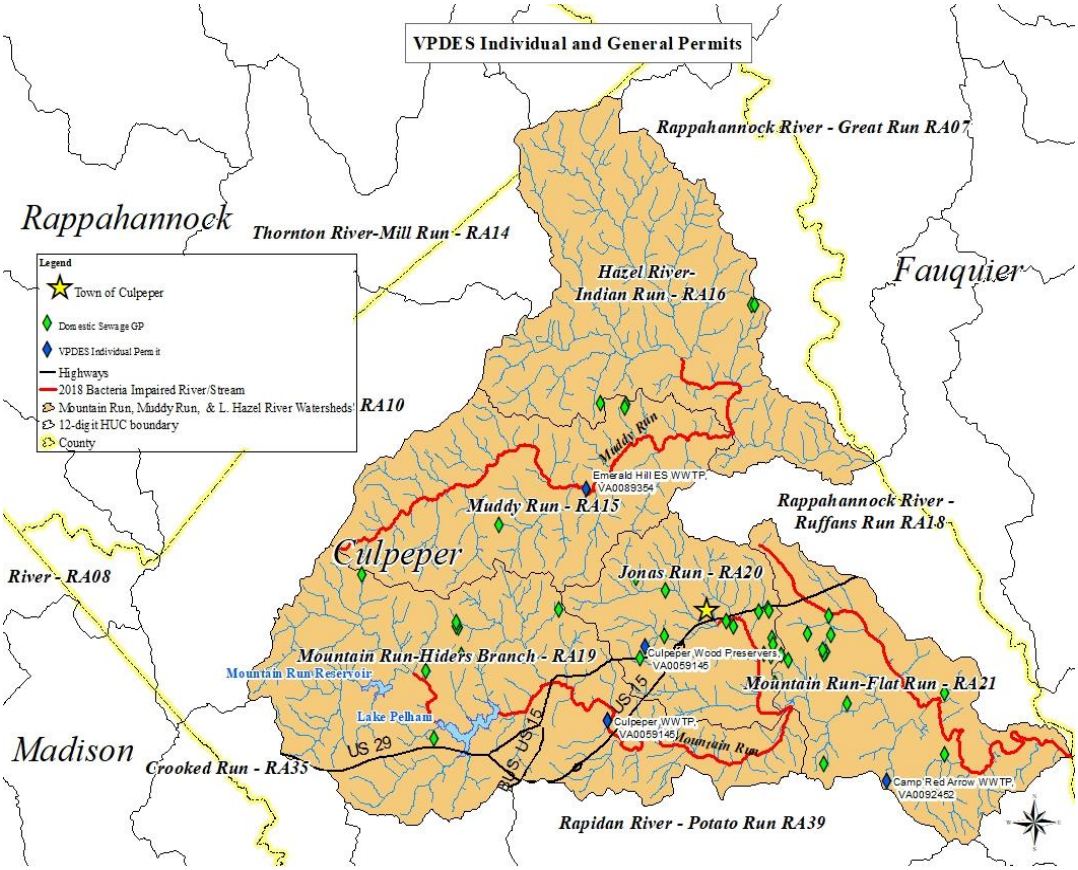


Figure 6-1. Individual VPDES permit and General Domestic Sewage permits in the IP Watersheds

6.3 Septic Systems

A detailed inventory of on-site septic systems was not directly available for the IP project area. For newly installed septic systems and septic repairs that required permits, the Virginia Department of Health has a geographically referenced inventory of systems dating back to about 2000. For the project area as a whole, this equated to approximately 2,500 septic systems. The septic systems that have had VDH permits issues for new installations or repairs since the year 2000 are shown as dots on the map in Figure 6-2 below.

To develop a more complete estimate of the number of residential septic systems in the IP project area, RRRC prepared new analysis at the request of DEQ. This entailed conducting geographic analysis of the number of street addresses found within each of the IP watersheds that were located within land zoned for other than commercial or industrial uses. These were then classified as falling either within or outside the Culpeper wastewater treatment facility's sewer service area. It resulted in an estimate of approximately 6,600 residential septic systems for the IP project area, as shown in Table 6-4 below. This is likely to be somewhat conservative, given some residences within sewer service areas may still use on-site septic systems, but it much more closely captures the full universe of septic systems than VDH permit records. Nonetheless, the dot pattern shown in Figure 6-2 below provides a good sense of the spatial distribution and relative density of septic systems within the project area.

Table 6-4. Addresses in Areas Not Zoned Commercial or Industrial

IP Watersheds	Addresses	Inside Sewer Service Areas	Outside Sewer Service Areas	Inside Sewer Service Areas (%)
Muddy Run	1,659	0	1,659	0
Lower Hazel River	1,510	0	1,510	0
Mountain Run #1	9,890	7,315	2,575	74.0
Mountain Run #2	708	168	540	23.7
Mountain Run #3	315	0	315	0
Total	**14,082**	**7,483**	**6,599**	**53.1**

The estimated number of septic BMPs that will be presented in Septic Systems 8.5.1 of this report are developed using the estimated number of residences in each IP watershed. As is shown in Table 6-5 below, with the exception of the Mountain Run #3 watershed (the lowest section of Mountain Run), the distribution of housing stock age by IP watershed is relatively similar. Mountain Run #3 has considerably older housing (67 percent is over 60 years old or of unknown age), and this combined with the presence of poorly drained soils in the watershed, serves as a rationale to increase the share of septic system replacements in the septic BMP recommendations for Mountain Run #3.

Table 6-5. The Age Distribution of the IP Area Housing Stock

Age in 2021	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total IP Project Area
0 to 20 years	19.0%	17.8%	38.9%	26.2%	9.5%	31.8%
21 to 40 years	30.3%	39.3%	19.4%	25.4%	12.4%	23.4%
41 to 60 years	17.2%	11.1%	13.6%	8.7%	10.8%	13.4%
> 60 years	9.8%	8.2%	14.0%	14.4%	18.1%	12.9%
Unknown	23.7%	23.6%	14.1%	25.3%	49.2%	18.5%

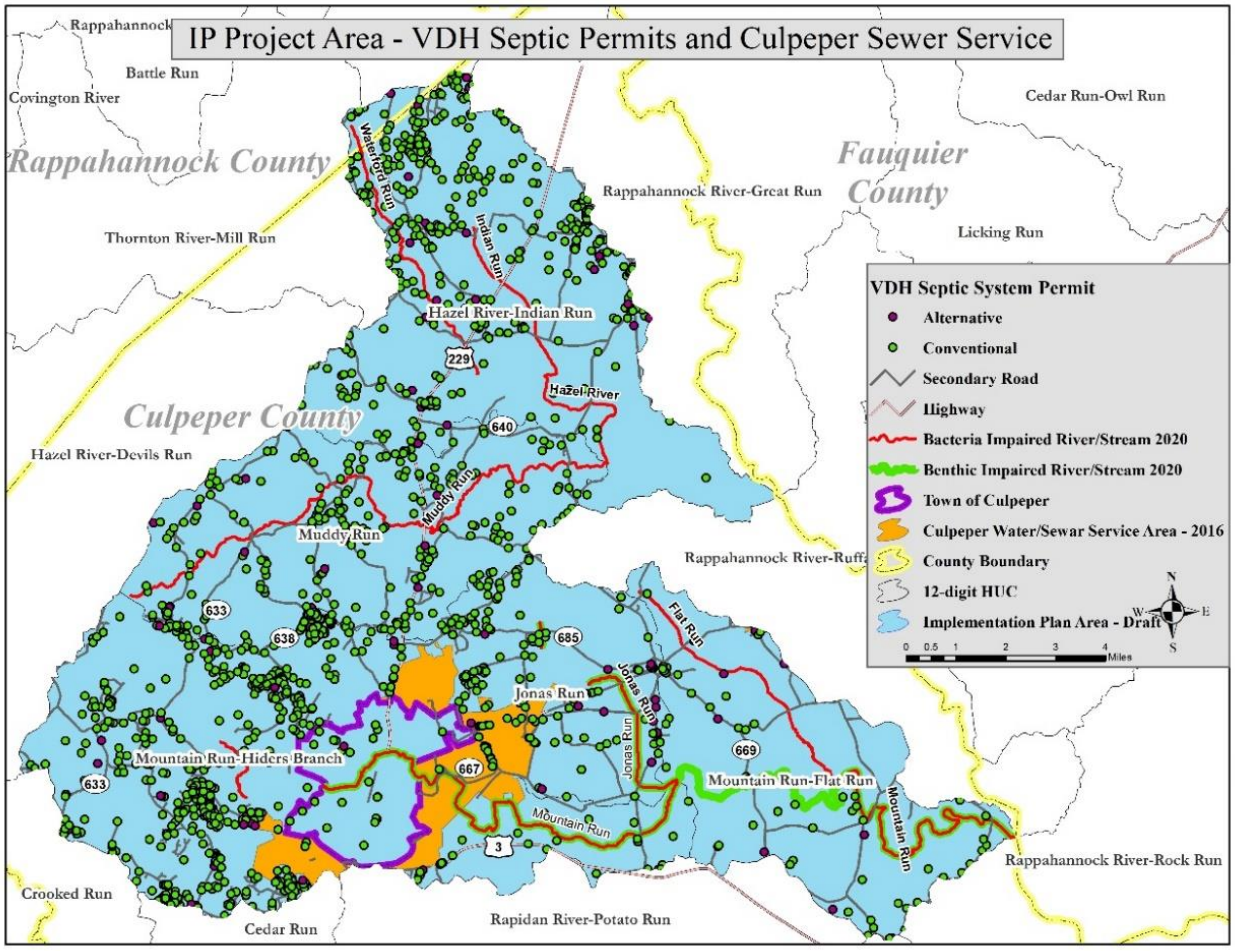


Figure 6-2. Permitted Residential Septic Systems and the Culpeper Wastewater Treatment Facility Sewer Service Area

6.4 Livestock

Current livestock animal counts by VA HUC6 watershed are compiled annually by DCR. Table 6-6 presents this data for the project area watersheds, with beef and dairy cattle divided between those maintained in confined buildings and those unconfined.

Table 6-6. Current Cattle and Horse populations in the IP watersheds (DCR Animal Census, 2020a)

Watershed Name	Confined Milk Cows*	Unconfined Milk Cows*	Total Milk Cows*	Confined Beef**	Unconfined Beef	Total Beef Cows	Horses
Muddy Run	-	92	92	43	1,798	1,841	317
Lower Hazel River	-	74	74	64	1,478	1,542	287
Mountain Run #1	217	65	282	386	1,272	1,658	304
Mountain Run #2	82	15	97	25	290	315	39
Mountain Run #3	245	30	275	78	595	673	55
Total IP Watersheds	**544**	**276**	**820**	**596**	**5,433**	**6,029**	**1,002**

* C-SWCD noted in 11-22-21 communications that no dairy cows are currently found in any of the IP watersheds

** C-SWCD also noted that confined beef cattle are approximately five times the reported number shown in this table

Beef and dairy cattle estimates were included in the TMDL reports; however, since the Lower Hazel River IP watershed was part of the much larger Hazel #2 TMDL watershed, no livestock estimates for RA-16 are available from the time of the 2008 TMDL. For Mountain Run and Muddy Run, comparing the TMDL report estimates with the 2020 livestock estimates by VA HUC6 watersheds gives a sense of the change in cattle populations over time in the project area.

As is evident in Table 6-7, for Mountain Run and Muddy Run, beef cattle populations have declined somewhat (0.3 – 17.1%), while dairy cow populations have declined significantly (68.5 – 69.8%). Nonetheless, a substantial cattle population of approximately 6,850 is currently found in the IP watersheds, and some 1,000 horses are also within the project area.

Table 6-7. Livestock Populations within the IP Watersheds

Watershed Name	No. of Beef Cattle			No. of Dairy Cows			No. of Horses
	TMDL	Current (2020)	% Change	TMDL	2020	% Change	2020
Muddy Run	1,846	1,841	-0.3%	305	92	-69.8%	317

Watershed Name	No. of Beef Cattle			No. of Dairy Cows			No. of Horses
	TMDL	Current (2020)	% Change	TMDL	2020	% Change	2020
Lower Hazel River		1,542	N/A		74	N/A	287
Mountain Run (#1-3)	3,192	2,646	-17.1%	2,073	654	-68.5%	398
Total IP Project Area	**N/A**	**6,029**	**N/A**	**N/A**	**820**	**N/A**	**1,002**

6.5 Wildlife

Each of the TMDL reports included analysis of the estimated contribution of total existing bacteria levels that were attributed to wildlife. The TMDLs did not assign a reduction allocation to wildlife/forest however, as the focus of TMDLs is to allocate pollutant reductions to anthropomorphic sources, which are more readily controlled through management measures. The total estimated amount of bacteria in the applicable TMDL watersheds and the amount associated with wildlife (both direct deposition to streams and runoff from forest lands) is shown in Table 6-8. The share of total existing bacteria levels that were associated with wildlife ranged from 1.2% in Upper Muddy Run to 11.9% in the large Hazel River TMDL watershed that the Lower Hazel River IP watershed lies within.

Table 6-8. Wildlife Sources of Bacteria (Fecal Coliform in cfu/100mL) in the TMDL Watersheds

TMDL Watershed	VA HUC6	Wildlife (direct and forest)	Total Bacteria Load	Wildlife % of Total
Mountain Run	RA-19,20,21	7.9E+14	2.62E+16	3.0%
Upper Muddy Run	RA-15	9.46E+13	7.61E+15	1.2%
Lower Muddy Run	RA-15	3.81E+14	2.76E+16	1.4%
Hazel River	RA-11,12,13, 14,16	8.53E+14	7.15E+15	11.9%

While no specific management measures are prescribed to address bacteria from wildlife, in response to concerns about increased wildlife populations raised during the February 2021 residential workgroup meeting summarized in Appendix A-4, information on current Virginia Department of Wildlife Resources (DWR) policies to address overpopulation of wildlife are briefly discussed herein. These policies have been developed in light of growing nuisance concerns associated with increased human/wildlife contact in recent years; they provide general information and techniques for Virginia property owners to utilize that are specific to 20 types of wildlife.

The policies that address geese and deer are most relevant to the concerns expressed in the workgroup meeting. For Canadian Geese, the policy is associated with environmental impact studies conducted by the U.S. Fish and Wildlife Service, and provides in specific circumstances for the destruction of nests and eggs to control over population. For deer, if non-lethal practices to control deer are unsuccessful, there are five programs (all requiring advance consultation) that may be available to landowners. These and other nuisance wildlife management policies can be found in the DWR reference included at the end of this report.

6.6 Canine Pets

An estimate of current canine (dog) pet populations was developed using the 2019 estimated number of residential households in the project area which was presented above in Section 6.1. While wastes from all pets can be a source of excess bacteria, the IP focuses on dogs since they are commonly walked by their owners, presenting an opportunity to pick up their waste. Dog population estimates were derived by multiplying the average number of dogs per household (0.584) obtained from the American Veterinary Medical Association (AVMA, 2012) by the number of households in each IP watershed. This resulted in an estimated total of 8,230 dogs, as shown in Table 6.9 below. Since estimated dog populations track to the number of households, the vast majority of dogs are found within RA-19, Mountain Run – Hiders Branch, in and around the Town of Culpeper. Pet waste education and dog waste disposal stations targeted to the public parks and residential areas with the greatest number of households can help reduce the amount of bacteria that reaches local waterways from improperly managed dog waste.

Table 6-9. Estimated Dog Populations in the IP Watersheds

IP Watershed	Housing Units (2019 Estimate)	Estimated Number of Dogs
Lower Hazel River	1,669	975
Muddy Run	1,510	882
Mountain Run #1	9,890	5,776
Mountain Run #2	708	413
Mountain Run #3	315	184
Total IP Watersheds	**14,092**	**8,230**

There are several Culpeper County licensed kennels in the IP watersheds that may benefit from installation of a waste management system to prevent bacteria from running offsite and contaminating local waters. Culpeper County provided a listing of all kennels licensed to operate in 2021 and DEQ geo-located the business addresses to identify the watershed in which they were located. Six of these facilities are located within the IP project area, in the watersheds noted in Table 6-10. DEQ has recently developed a demonstration BMP specification for “Confined Canine Facilities” that entails design of a septic system with the ability to manage the special challenges of treating dog waste matter (high hair content, etc.).

Table 6-10. Culpeper County Licensed Kennels in IP Watersheds

VA HUC6	Watershed Name	# Licensed Kennels
RA-15	Lower Hazel River	1
RA-19	Mountain Run #1	4
RA-20	Mountain Run #2	1
Total IP Watersheds		**6**

7.0 Public Participation

Collecting public input on conservation and outreach strategies to include in the IP is a critical step in the planning process. Local stakeholder support is a primary factor for success in carrying out the IP's recommended actions, since plans are implemented primarily by watershed stakeholders on a voluntary basis (often with financial incentives). There was good participation and valuable contributions by local stakeholders throughout the IP development process. A unique challenge for this IP was that it was developed at the height of the Covid-19 pandemic in 2020-21 during social gathering restrictions. The initial public and workgroup meetings were all conducted virtually, in accordance with policies in place for such meetings as established by the Commonwealth of Virginia. A summary of the public and stakeholder meetings held as part of the development of this IP are identified in Table 7-1.

7.1 Initial Public Meeting

The initial public meeting served as an opportunity for local residents to learn more about the condition of local streams and the process used by Virginia DEQ to develop plans to restore water quality of impaired waterways.

The October 2020 initial public meeting formally began IP development, however it was preceded by an informal virtual meeting in March 2020 to engage local stakeholders early and inform them of DEQ's preliminary plans, anticipated timeframe, and process for formal public engagement in plan development. In the months leading up to the initial public meeting, Virginia developed its policies for holding entirely virtual public meetings, enabling stakeholder engagement in IP development during the time when in-person meetings were not possible.

The initial public meeting was held virtually the evening of October 28, 2020 using GoToWebinar. This meeting was publicized through the *Virginia Register*, an article in the weekly Culpeper Star Exponent newspaper, county websites, and additional stakeholder electronic communications. There were 33 participants in the October 28th meeting, counting eight DEQ staff. Participants included local citizens and landowners, state and local government agency representatives, soil and water conservation district staff, and representatives of regional non-governmental environmental organizations. Participants shared their input and ideas relative to a series of questions posed by DEQ, following the opening presentation. In response to polls conducted during the meeting, DEQ learned that 78% of meeting participants either lived or worked within the project area, and that participants' greatest interests were in stormwater (43%), agricultural (35%) and septic system (22%) aspects of the pending implementation plan. DEQ prepared and shared a summary of the meeting discussions with participants for their review, along with a link to an audio-video recording of the meeting (a new requirement for entirely virtual meetings). A thirty-day public comment period followed these meetings, but no comment letters were received. The final summary of this meeting is included as Appendix A.1.

The first workgroup meeting discussions were held the following morning, as a consolidated initial meeting for those interested to discuss in more detail the agricultural and residential/developed lands aspects of the implementation plan. A similar number of individuals (32) participated in the October 29, 2021 consolidated workgroup meeting. DEQ explained the role of workgroups in IP development, shared information about plan development methodology, and received many valuable insights and perspectives to factor into its project planning at this meeting; a summary of the October 29 meeting is found in Appendix A.2. This meeting included brief remarks by representatives of the C-SWCD, RRRC, FOR, and the Piedmont Environmental Council (PEC) about work they are leading that is relevant to this IP.

Table 7-1. Meetings held during the IP development process

Date	Meeting Type	Location	Attendance
10/28/20	First Public Meeting	Virtual, using GoToWebinar	33
10/29/20	First Meetings of the Agricultural & Residential Workgroups	Virtual, using GoToMeeting	32
01/28/21	2nd Agricultural Working Group Meeting	Virtual, using GoToMeeting	19
02/17/21	2nd Residential Working Group Meeting	Virtual, using GoToMeeting	20
5/11/21	3rd Residential Working Group Meeting	Virtual, using GoToMeeting	17
10/15/21	Steering Committee	Lenn Park, Culpeper, VA	12
TBD	Final Public Meeting		TBD

7.2 Agricultural Workgroup Meeting

In a January 28, 2021 Agricultural Workgroup meeting, participants shared their knowledge of local agricultural activities, existing conservation practices, and other perspectives relevant to the IP. DEQ began the meeting with a summary presentation that included results of its comparative analysis of approved IPs that was used to develop a preliminary amount of livestock exclusion fencing and pasture management BMPs that are appropriate for the IP watersheds. A representative of C-SWCD summarized the range of Agricultural BMPs that it commonly implements within its district. There was discussion of the large wildlife populations in the area, both birds and mammals, and some participants expressed the view that wildlife may be a significant source of bacteria in IP area streams. Participants also shared their input relative to a series of questions prepared for the meeting by DEQ.

Workgroup discussions included expressions of interest to have a more detailed understanding of the sources of bacteria, and opportunities for use of portable fencing (a pending new Virginia Agricultural Cost Share program BMP) and tree planting to complement pasture management and permanent stream exclusion fencing measures that will be important components of the IP. The FOR representative noted that they have received a DEQ voluntary monitoring grant that may enable targeted sampling to try to answer questions some participants have about water quality conditions and sources of bacteria. A more complete summary of the Agricultural Workgroup meeting is found in Appendix A.3.

7.3 Residential Workgroup Meetings

In a February 17, 2021 Residential Workgroup meeting, DEQ shared a summary presentation that included results of its comparative analysis of approved IPs that was used to develop a preliminary amount of septic system BMPs that are appropriate for the IP watersheds. A representative of RRRC then summarized the type of stormwater management BMPs that are included in the regional component of

Virginia's 2019 Chesapeake Bay WIP III. Brief remarks were also offered by C-SWCD, FOR, and the Town of Culpeper on work they are leading that is relevant to IP development.

DEQ also presented its preliminary findings and plans to conduct more detailed stressor analysis associated with the benthic impairments in each of the three Mountain Run watersheds. Workgroup discussions included additional questions about bacteria impairments and sources, concerns for the severity of stormwater runoff from developed lands and high resident geese populations, and ideas to improve pet waste management. Meeting participants support inclusion of residential septic, pet waste management, and stormwater management practices in the implementation plan. A complete summary of the second Residential Workgroup meeting is found in Appendix A.4.

A third Residential Workgroup meeting was held virtually on May 11, 2021. This meeting opened with DEQ presenting its refined analysis of septic system BMP preliminary recommendations, initial recommendations for pet waste and kennel BMPs, and an update on the ongoing benthic stressor analysis work in the Mountain Run watersheds. Participants asked whether sewer system connections would be a part of the IP, and DEQ confirmed they will in the Mountain Run #1 and #2 watersheds, parts of which are included in the Town of Culpeper's WWTF sewer service area. Participants also shared their knowledge of existing pet waste management stations within the IP project area, thoughts on where additional stations would be most valuable, and cost information the Town has compiled for purchasing additional stations.

Meeting discussions then shifted to seeking participants' input on opportunities and suggestions for developed land (urban) stormwater BMPs to include in the IP. The C-SWCD manager suggested that, given this IP is primarily focused on bacteria, that stormwater BMPs be located in areas where runoff has elevated bacteria levels. DEQ indicated that existing water quality monitoring is limited in the developed area in and around the Town of Culpeper, and the FOR representative indicated they will look for opportunities to sample in and around the Town to enhance existing knowledge of bacteria hot-spots. RRRC noted that they have grant funds to support stormwater BMP planning, and work is underway to develop a geographically-based stormwater BMP planning tool for their jurisdiction. Other participant comments suggested the plan include:

- Low cost measures like "live-staking" of stream bank to improve streambank stability, wetland restoration
- Conversion of existing dry detention ponds to higher (water quality) functioning wet ponds or wetlands
- Inclusion of street sweeping BMPs to foster more extensive and higher frequency sweeping than is currently conducted
- A prominent education and outreach component, to address negative perceptions many project area residents currently have of wetlands and stormwater BMPs.

A complete summary of the second Residential Workgroup meeting is found in Appendix A.5.

7.4 Steering Committee Meeting

A Steering Committee that included nine representatives from the two workgroups and three DEQ staff met on October 15, 2021 at the Lenn Park Pavilion in Culpeper. The purpose of this meeting was to seek early feedback on the preliminary IP report recommendations from a small group who had participated in earlier public and workgroup meetings. The meeting entailed DEQ presenting an overview of the plan's development and a summary of initial BMP and other recommendations included in the draft IP report, and encouraging questions and input from the Steering Committee throughout the presentation

Most discussion focused on the agricultural BMP recommendations, and participants had several specific suggestions for DEQ consideration that are noted below. There was also good input on the residential septic recommendations, a few specific suggestions for refining stormwater BMP recommendations, and comments to increase technical assistance and agricultural outreach.

A full summary of the meeting is found in Appendix A.6; some key points made during discussions were:

- Livestock Exclusion Fencing: participants encouraged DEQ to reduce the amount of portable fencing recommended, and shift the reduction to SL-6 LEF systems. Limitations of the new portable fencing BMP, including no provision for alternative water supplies or portable shade, were noted for acknowledgement in the IP report.
- Pasture and Cropland BMPs: participants offered many comments on this suite of BMP recommendations. Among them were to move the WP-1 (Water Control/Sediment Retention) practice from pasture to cropland BMPs, and to shift Sod Waterways (WP-3) and Animal Waste Control (WP-4) practices to a new "Other Agricultural BMP" category, which would also include WP-2A (Streambank Stabilization);. An increase for the SL-1 Permanent Vegetative Cover practice from 200 to 1,000 acres was also suggested.
- Residential Septic BMPs: participants discussed the high cost of sewer connections and alternative on-site septic systems, and suggested report language to acknowledge the Town of Culpeper's $5,000 subsidy for new sewer connections for septic system properties, and the importance of supplemental assistance for low income homeowners who need new alternative septic systems.
- Stormwater BMPs: participants suggested a significant reduction in the BMP recommendation for Rain Gardens, with an increase to Bioretention. Additionally, there was a question posed for DEQ follow up on whether the bacteria reductions that are associated with practices required to control nutrient and sediment runoff could be counted toward IP goals.
- Education and Technical Assistance: participants noted that agricultural education and outreach was not identified in the draft IP report, and should be added, and that technical assistance needs were underestimated at 0.5 FTE/yr., and should be increased to 1.0 FTE/yr.

DEQ concluded the meeting with a summary of the final steps and timetable for IP completion, which will include a Final Public Meeting and 30 day public comment period early in 2022. DEQ welcomed participants to submit additional written input if they wished, and later received such input from the C-SWCD.

7.5 Final Public Meeting

_____ people attended the final public meeting (to be) held on February 3, 2022 in Culpeper. The primary purpose of this meeting was to present highlights of the draft IP, provide opportunities to answer questions from participants and initiate the 30-day public comment period. The public comment period extended from _____ to _____; DEQ did/did not …..

The meeting began with DEQ presenting a short slide show summary of relevant background and the recommendations contained in the draft Mountain Run, Muddy Run and Lower Hazel River IP report and discussions occurred during and following the presentation. Initial questions and comments pertained to _____

There was significant discussion of _____

Participants were interested and supportive of recommendations to address _____

At the end of the meeting, there was discussion of plans for _____. A full summary of the Final Public Meeting is found in Appendix A.7.

8.0 Implementation Actions

Implementation actions (a.k.a. BMPs or management measures) are the heart of the Mountain Run, Muddy Run and Lower Hazel River IP. Individual actions will incrementally improve water quality and, in sufficient quantities and combinations, will restore the water quality of the streams in the plan area sufficiently to be delisted from the impaired waters list.

In coordination with residents, government agencies, and other community groups, DEQ conducted an assessment of the IP area to identify and quantify bacteria reduction measures. The measures discussed below are of the type and amount that the comparative analysis of EPA-approved bacteria IPs suggests will be sufficient to restore the water quality of the impaired stream segments at the end of the 15-year implementation period (see Section 10 for a description of the implementation timeline). The proposed management measures are voluntary and designed to be adaptive through iterative implementation over the course of the 15-year implementation period. This section describes the amount and type of management measures recommended to improve the quality of the impaired waters within the IP project area, and the methodology used in preparing BMP recommendations.

Table 8-1 summarizes the source sector bacteria reductions for the selected allocation scenarios of the 2001, 2004 and 2008 TMDLs. Although achieving the water quality criterion for bacteria in place at the time of the 2001 Mountain Run TMDL did not require pasture and cropland load reductions, measures directed at reductions from those land uses will be necessary to meet the current water quality criteria for bacteria. The comprehensive suite of BMPs recommended in this section are framed with the goal of achieving current water quality criteria for bacteria.

Table 8-1. Reductions Required to Meet Delisting Goals by Bacteria Source (from TMDL Reports)

IP Watershed	Load Reductions (%) for each Bacteria Source				
	Cropland	Pasture	Developed Land	Failing Septic Systems	Direct Cattle Deposition
Lower Hazel River	94%	94%	94%	100%	94%
Muddy Run	71%	99%	78%	100%	98%
Mountain Run (RA-19, 20, 21 combined)	*	*	95%	100%	94%

* The 2001 Mountain Run TMDL did not specify reductions for pasture or cropland bacteria sources.

Recommendations for the “core” bacteria reduction BMPs, livestock exclusion fencing (LEF), pasture management (PM), and septic systems, were developed using a comparative analysis methodology that drew upon a selected set of EPA-approved bacteria IPs. If DEQ had utilized its traditional approach for IP development, new water quality modeling work would have been required, given the differences in the technical approaches taken in the three TMDL reports, the passage of time since their completion, and the lack of a TMDL equation specific to the Lower Hazel River IP watershed. Use of the comparative analysis methodology enabled a more efficient approach to establish recommended levels for the BMP measures selected for the project area by drawing upon the analysis in EPA-approved IPs for comparable watersheds. This methodology benefits from experience DEQ has gained over the years in developing TMDL implementation plans that address water quality impairments due to bacteria, and indirectly draws on the water quality modeling conducted in support of EPA-approved IPs.

8.1 Comparative Analysis Methodology

Section 3.6 presented an initial discussion of the comparative analysis methodology used to develop preliminary BMP recommendations for core bacteria management measures, while this section provides a more in-depth overview of the methodology, including a providing a specific example in Section 8.1.1 to help outline the steps taken. Appendix B provides more details on the methodology, along with a presentation of the comparative analysis approach used to prepare initial recommendation for the core BMPs in each of the five IP watersheds.

The preliminary BMP levels for LEF, PM, and septic BMPs for each IP watershed were drawn from those recommended in approved IP reports and amount of each adjusted to account for differences in acreage and land use between the comparison watersheds and the IP project area watersheds, shown in Table 8-2 below. As will be described below, these preliminary values were revised based on input provided during workgroup discussions, data on the opportunities to install the core BMPs, and subsequent consultation with local stakeholders.

Table 8-2. Preliminary Comparative Analysis Derived BMP Recommendations by IP Watershed

Watershed	Watershed Size (Acres)	Livestock Exclusion Fencing (Miles)	Pasture Manage-ment (Acres)	Septic Pump Outs	Septic Repairs	New Conventional Septic Systems	New Alternative Septic Systems
Muddy Run	18,826	19.1	4,445	417	222	121	13
Lower Hazel River	24,837	26.0	6,060	496	264	144	15
Mountain Run #1	30,397	36.9	11,280	395	311	176	65
Mountain Run #2	11,378	17.2	3,781	549	71	34	9
Mountain Run #3	15,891	23.8	5,320	166	89	49	7
Total IP Watersheds	**101,329**	**123.0**	**30,886**	**2,023**	**958**	**524**	**108**

Next, the number of BMPs existing and still within their "life span", was compiled and summarized for each IP watershed. These completed, in life-span BMPs were subtracted from the initial IP watershed core BMP levels, resulting in the amount of each core bacteria BMP type still needed for each IP watershed.

Further adjustments to tailor BMPs within each specific watersheds entailed comparing the allocation of preliminary recommendations for each IP watersheds with the potential for each of the core bacteria BMP types to be implemented within each watershed based upon land use for that type of BMP. For instance, the opportunity to implement livestock exclusion fencing BMPs is based upon the estimated length of stream channels within each watershed that flow within or adjacent to pasture lands. For pasture management, it is based upon the actual amount of land currently in pasture land use, and for septic

systems, BMPs are tailored based upon the number of households utilizing septic systems for wastewater treatment.

An additional adjustment was made for BMP recommendations for septic installations (both conventional and alternative). Analysis of housing stock age and soil properties show that the Mountain Run #3 watershed has both significantly older housing and a greater share of poorly drained soils than the other four IP watersheds. In light of this, the amount of new conventional and alternative on-site septic systems were both increased for Mountain Run #3, with modest decreases to the other watersheds made to offset the Mountain Run #3 increases.

Finally, the result of these steps was rounded to avoid conveying a false sense of precision in the core bacteria BMPs recommendations. Table 8-3 shows the final BMP recommendations for each of the IP watersheds. An example of the step-wise approach of this methodology is outlined in Section 8.1.1 using the Muddy Run watershed.

Table 8-3. Final Core Bacteria BMP Recommendations by IP Watershed

IP Watershed	Watershed Size (Acres)	Livestock Exclusion Fencing (Miles)	Pasture Manage-ment (Acres)	Septic Pumpouts	Septic Repairs	New Conventional Septic Systems	New Alternative Septic Systems
Muddy Run	18,826	18.0	4,700	450	140	120	20
Lower Hazel River	24,837	19.0	4,300	400	130	110	20
Mountain Run #1	30,397	25.0	5,800	700	220	190	35
Mountain Run #2	11,378	11.0	2,800	150	50	40	10
Mountain Run #3	15,891	11.0	2,900	100	30	50	25
Final BMP Recommendations	**101,329**	**84.0**	**20,500**	**1,800**	**570**	**510**	**110**

8.1.1 Muddy Run Comparative Analysis Example

The comparison watersheds from EPA approved IPs selected for Muddy Run, based on similarities in watershed setting and land uses, were Blue Run and the combined Marsh and Rippin Run from the 2015 Upper Rapidan IP, and the Hawksbill and Mill Creek watersheds from the 2008 Mill Creek IP. Table 8-4 below shows how these watersheds compare in overall size and land use distribution to Muddy Run.

Table 8-4. Comparison IP watersheds for Muddy Run

Watershed	Approved Implementation Plan	WS Size (Acres)	Pasture/ Crop	Forest	Developed
Blue Run	2015 Upper Rapidan River IP	20,955	41%	52%	5%
Marsh/Rippin Run (Combined)	2015 Upper Rapidan River IP	18,187	32%	61%	5%
Hawksbill/Mill Creek (Combined)	2008 Hawksbill/Mill Creek IP	65,263	31%	56%	12%
Muddy Run	New IP	18,826	30%	60%	10%

With the comparison watersheds selected, the BMP recommendations for LEF, PM and Septic were extracted from the approved IP reports for analysis purposes. These values are shown in Table 8-5 below.

Table 8-5. Core Bacteria BMP Recommendations in Comparison IP watersheds

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Manage-ment (Acres)	Septic Pumpouts	Septic Repairs	New Conventional Septic Systems	New Alternative Septic Systems
Blue Run	45.0	8,006	252	150	94	8
Marsh/Rippin Run (Combined)	21.3	4,188	292	194	91	7
Hawksbill/Mill Creek (Combined)	26.3	14,749	936	57	63	41

Proportionate adjustments to the comparison watershed BMP recommendations were then made to account for the differences in land use and watershed size between the comparison watersheds and Muddy Run. For LEF and PM, the land use comparison was for the combined Pasture/Cropland acreage, as many of the approved IPs did not isolate pasture land, and the combined Pasture/Cropland was the commonly available reference value that could be used for analysis. For septic BMPs, adjustments were made based on the differences in developed land acreage.

The calculation to obtain the adjusted BMP recommendations for each of the comparison watersheds was to first multiply by the ratio of Muddy Run and the comparison watershed size in acres, and then by the ratio of the percentage of relevant land use available (pasture for LEF, pasture/cropland for PM, and developed land for Septic) in Muddy Run and the comparison watershed. Using Blue Run as an example, the math for LEF worked like this: 45 miles * (18,826 ac / 20,955 ac) * (0.30 / 0.41). Table 8-6 below presents the revised LEF, PM and Septic BMP levels for the comparison watersheds following the adjustments that accounted for differences in watershed size and land use. The Preliminary BMP recommendation values shown for Muddy Run are the average of the adjusted values for the comparison

watersheds. The completed BMPs (still in their life span) were then subtracted from the preliminary recommendations to derive the Initial BMP recommendations for Muddy Run.

Table 8-6. Adjusted BMP Recommendations for Comparison IP watersheds used to develop Muddy Run BMP Recommendations

IP Watersheds	BMP Recommendations					
	Livestock Exclusion Fencing (miles)	**Pasture Manage -ment (Acres)**	**Septic Pumpouts**	**Septic Repairs**	**New Conventional Septic Systems**	**New Alternative Septic Systems**
Blue Run	29.6	5,263	453	270	169	14
Marsh/Rippin Run (Combined)	20.4	4,007	578	384	180	14
Hawksbill/Mill Creek (Combined)	7.3	4,067	222	14	15	10
Muddy Run – Prelim BMPs	19.1	4,445	417	222	121	13
Muddy Run – Completed BMPs	2.3	144	35	69	-	-
Muddy Run – Initial BMP recommendations	**16.8**	**4,301**	**382**	**153**	**121**	**13**

Adjustments to the allocation of core bacteria BMPs across the IP watersheds were then made to align with the opportunities for each type BMP within the IP project area, resulted in the second line in the Table 8-7 below, the Adjusted BMP recommendation. Final BMP recommendations included rounding to whole miles for LEF, the closest 100 acres for PM, and to the nearest 50 for septic pump outs, and the nearest 10 for septic repairs and installations (5 for alternative systems).

Table 8-7. Final Core Bacteria BMP Recommendations for Muddy Run

BMP Recommendations for Muddy Run	Livestock Exclusion Fencing (miles)	Pasture Management (Acres)	Septic Pumpouts	Septic Repairs	New Conventional Septic Systems	New Alternative Septic Systems
Initial	16.8	4,301	382	153	121	13
Adjusted	18.1	4,705	460	142	123	22
Final	**18.0**	**4,700**	**450**	**140**	**120**	**20**

8.2 Agricultural Implementation Needs

Based upon the TMDLs completed for the IP project area, the largest share of the bacteria in each of the IP watersheds was from pasture lands (ranged from 91.3 – 97.1%, see Table 6-1). Accordingly, the greatest reductions needed to meet water quality standards will need to come from the agricultural sector, with the majority of bacteria reductions being needed from pasture lands. Agricultural sources and recommended BMPs are presented for livestock exclusion fencing, pasture and cropland, and equine.

8.2.1 Livestock Exclusion Fencing

Removing livestock from riparian corridors and limiting access to surface waterbodies is a top priority management measure (Figure 8.1). Although the relative amount of total bacteria from direct deposition by cattle is minimal (0.04 and 0.11% for Muddy Run and Lower Hazel River, respectively), direct deposition has highly adverse impacts on water quality during periods of low flow, and unless dramatically reduced, will preclude achieving recreational water quality standards. The three TMDL reports called for between a 94 and 98% reduction in bacteria directly deposited by cattle into streams. In 2020, the Commonwealth of Virginia enacted legislation calling for exclusion of cattle from all perennial streams. The Virginia General Assembly passed a bill that was signed into law in April 2020 that states: "*Any person who owns property in the Chesapeake Bay watershed on which 20 or more bovines are pastured shall install and maintain stream exclusion practices sufficient to exclude all such bovines from any perennial stream in the watershed."* The bill further provided that this provision *"….shall not become effective unless, on or after July 1, 2026, the Secretary of Agriculture and Forestry and the Secretary of Natural Resources jointly determine that the Commonwealth's commitments in the Chesapeake Bay Total Maximum Daily Load Phase III Watershed Implementation Plan have not been satisfied…."* (Code of Virginia, 2020).

While not yet a requirement, the Commonwealth has clearly communicated a policy goal of excluding cattle access to all perennial streams. Accordingly, this IP report supports the elimination of cattle from perennial streams *(excepting designed stream crossings and limited water access points)*, and the LEF BMP recommendations are framed around that goal. Flexibility in achieving this goal is important, as farmers will need access to surface water if there is a long-term power outage or other event that would interrupt in-field water supplies. Designed stream crossings or access points are a common way to meet this need.

Figure 8-1. Livestock exclusion fencing in Upper Rapidan River (Culpeper SWCD

Based upon the comparative analysis methodology, an estimated 123 miles of livestock exclusion fencing is needed in the IP project area. According to the Virginia DCR database of agricultural practices (DCR 2020b), C-SWCD has worked with landowners to install over 39 miles of livestock exclusion fencing that remains within its BMP practice life span. After taking into consideration the completed fencing completed thus far, approximately 84 additional miles of LEF is needed, as shown in Table 8.5 above.

8.2.1.1 *Exclusion Fencing Opportunity Assessment*

With pasture identified as the greatest single source of bacteria within the IP watersheds, it is critical to assess the potential opportunities to reduce the amount of bacteria entering area streams from pasture lands. Information obtained from high resolution VLCD imagery identified that in 2016, 24.8 percent (25,103 acres) of the IP watersheds was in pasture. Based upon a review of prior aerial imagery (using lower resolution NLCD), pasture land decreased by approximately 1.8% (about 500 acres) from 2002-2016. Although the decrease in pasture lands since TMDL development has been minimal, an accurate estimate of the extent of streams that flow through or are adjacent to pasture lands is an important foundation for agricultural BMP recommendations to reduce bacteria entering local streams.

As a part of Virginia's WIP III development, DEQ conducted a Land Cover Stream Assessment (LCSA) to identify the acreage of various land uses (crop, developed, pasture, natural and roads) in the areas extending out to 150' from National Hydrography Dataset (NHD+) streams for all counties and cities. Figure 5.2 shows an example of these buffers around streams adjacent to or that intersected pasture land.

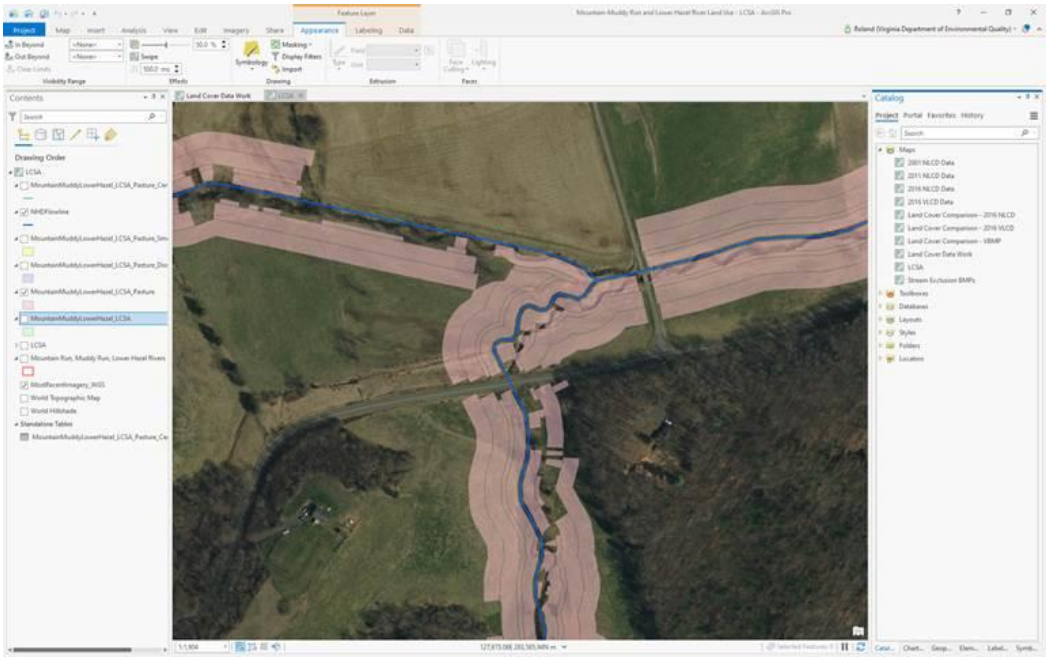


Figure 8-2. Buffer Area where Pasture Land exists within 150’ of a Stream/Water Feature

The data derived from this buffer analysis were compiled for each IP watershed and used to reallocate the LEF recommendations based on the fencing opportunities within the IP project area. Table 8.8 shows the number of pasture parcels adjacent to streams in each IP watershed and the estimated stream bank miles associated with these parcels. In total, the 2,728 parcels have approximately 264 miles of streambank that potentially could be fenced, in some cases a single side of the stream, and in other cases both sides as was explained above. The total LEF recommendation for the project area (83.3 miles) was then allocated across the IP watersheds based on the share each had of the 264 miles of LEF opportunities. Following rounding, the final LEF recommendations are between 11 and 25 miles of fencing for each of the IP watersheds, the least for Mountain Run #2 and #3, and the greatest need being for Mountain Run #1.

Table 8-8. Final LEF Recommendations based on Livestock Exclusion Fencing Opportunities

IP Watershed	No. Pasture Parcels Adjacent to Streams	Pasture Stream Bank (Miles)	Initial Estimated LEF Needs (Miles)	Final LEF BMP Recommendation (Miles)
Muddy Run	723	57.5	16.8	18
Lower Hazel River	639	59.2	16.5	19
Mountain Run #1	719	78.8	20.1	25
Mountain Run #2	303	34.4	14.8	11
Mountain Run #3	344	34.3	15.1	11
Total IP Watersheds	**2,728**	**264.0**	**83.3**	**84**

Table 8-9 shows a summary of the in life-span LEF projects in the project area. When added to the final LEF recommendation, the total matches the 123 miles estimate initially derived from the comparative analysis. While the final LEF recommendation represents approximately 50% coverage for the potential LEF opportunities identified through the analysis discussed above, area agricultural professionals do not believe there are practical opportunities to implement more than the recommended levels.

Table 8-9. In-Life Span Livestock Exclusion Fencing BMPs Installed in IP Watersheds, as of Aug. 20, 2020

Practice Code	Livestock Exclusion Fencing (LEF) BMPs	No. BMPs	Total BMP Cost	Average Cost of BMP	Extent Benefitted (Acres)	Extent Installed (linear ft.)
CRLF-1	CREP Linear Foot of Streambank Protected	1				4,588
CRSL-6	CREP Stream Exclusion with Grazing Land Management	1	$21,838	$21,838	13.6	6,500
LE-2	Livestock Exclusion with Reduced Setback	1	$12,112	$12,112	1.0	3,340
SL-6	Stream Exclusion With Grazing Land Management	34	$1,157,756	$34,052	2,191.9	191,371
SL-6W	Stream Exclusion with Wide Width Buffer and Grazing Land Management	5	$48,341	$9,668	69.8	4,632
WP-2	Streambank protection (fencing)	1	$3,120	$3,120	1.0	2,600
Total Livestock Exclusion Fencing BMPs		**43**	**$1,243,166**		**2,277**	**213,031**

8.2.1.2 *LEF BMPs*

Multiple cost-share programs are available through DCR and USDA to help off-set the capital costs of installing livestock exclusion fencing in the IP project area. Many of these measures are bundled with pasture improvement practices and referenced to as livestock exclusion fencing "systems". The recommended management measures to achieve the necessary load reductions from direct deposition from cattle are presented in Table 8-10. Livestock exclusion practices historically have most commonly included a 35' riparian buffer. Recent program changes in Virginia have made 50' buffers more common, as the VACS program measure SL-6W provides a 100% cost share for exclusion fencing with at least a 50' buffer, as well as an annual buffer zone payment to offset lost income from land taken out of agricultural production.

While it has been common for IPs to include an exhaustive listing of exclusion fencing BMPs, in order to simplify the presentation of BMP recommendations in this report, the SL-6W VACS BMP is used to represent all State and Federal exclusion fencing BMPs that employ a wide buffer, and SL-6N is used to represent all State and Federal exclusion fencing BMPs that employ a narrow buffer. Both of these BMPs include pasture management practices in a "system". Consistent with advice from C-SWCD and Virginia Cooperative Extension (VCE) representatives, the majority (65% total, 45% SL-6W and 20% SL-6N) of LEF needs were recommended to be met with these SL-6 practices.

Table 8-10. Recommended livestock exclusion management measures by IP Watershed (# LEF Systems)

BMP Name	BMP Code	Average System Size (linear ft)	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
Stream Exclusion, w/ Grazing Land Mgmt - Wide Buffer	SL-6W	4,500	12	13	16	7	7	55
Stream Exclusion, w/ Grazing Land Mgmt - Narrow Buffer	SL-6N	3,500	6	7	9	3	3	28
Portable Fencing BMP	SL-6P	1,000	12	12	16	8	8	56
Small Farm Grazing Systems	SL-6AT	1,500	8	8	8	3	3	30

The VACS measures WP-2W and WP-2N are the corresponding exclusion fencing BMPs that do not including grazing land management components. Where these stand-alone fencing measures are preferred by agricultural producers, they may be substituted for the SL-6 practices to enable agricultural producers to elect the type of stream exclusion fencing of greatest interest. There are similar LEF practice variations available through USDA conservation programs, and these measures similarly may be substituted for the recommended SL-6W and SL-6N practices.

A new measure, WP-2P (Portable Fencing) was added to the VACS program for 2022. This BMP provides for low-cost fencing with a five year life-span that does not require any specific set-back distance. Due to its lower cost and shorter life-span, it is also expected to be a more attractive option than the more expensive SL-6/WP-2 practices for some producers who operate on leased agricultural lands. A member of the Steering Committee asked that this report note that the new practice does not provide for alternative water and portable shade. These limitations may constrain use of portable fencing, and future changes to the VACS WP-2P specification should be considered to address this concern.

Portable fencing may be especially relevant to the smallest/ephemeral stream channels located within farm lands, and around the perimeter of wetlands or flood prone areas within agricultural lands. In the Agricultural workgroup meeting discussions it was noted that at the lowest portion of each watershed, near their confluence with the larger waterbody they join, there are significant areas of wetlands and land subject to "back-water" flooding following heavy precipitation events. The areas near the confluence of Flat Run and Jonas Run with Mountain Run also remain very wet following heavy precipitation events. Agricultural areas in all of these confluence areas may be especially suitable for use of the new portable fencing BMP. Of the total LEF needs, 25 percent were recommended to be satisfied with the new WP-2P practice.

There was limited discussion of horse and other non-traditional animal farms within the IP project area, but as shown in Table 3.12, the 2020 DCR animal census documented over 1,000 horses within the IP watersheds. While some of these farms meet the agricultural income thresholds to qualify the VACS cost-share funding, many do not and the DEQ measure SL-6AT is designed to serve the needs of small farms for stream exclusion and grazing land improvements. Ten percent of the total LEF needs are met with the SL-6AT practice, which along with equine manure composting BMPs, are discussed in Section 8.4 below.

Figure 8-3. Mature forested riparian buffer, Mountain Run (Culpeper County Parks and Recreation, 2020)

Improvements to riparian buffers are not a requirement of livestock exclusion systems, but they are encouraged through planting of native plant species and tree planting (Figure 8-3). An improved riparian buffer will increase bacteria, sediment, and nutrient removal efficiencies and provide additional water quality and habitat benefits. There are many publicly funded programs available that support riparian tree planting available from DOF, NRCS, FSA, C-SWCD and more; preeminent among these programs is the Conservation Reserve Enhancement Program (CREP).

In addition, landowners can partner with local watershed organizations or schools to help improve the newly established riparian buffers. Since 2015, FOR has directly planted or funded some 235 acres of

trees in the Upper Rappahannock and Rapidan River watersheds. FOR and the PEC are partners in the Rappahannock Headwaters Stream Initiative and these local environmental organizations are poised to step up their level of tree planting activities to support WIP III and local watershed restoration goals.

8.3 Pasture and Cropland

The TMDL reports identify pasture lands as being the largest bacteria source in the project area watersheds; they ranged from 91.3% of total estimated bacteria load for Mountain Run (#1, #2, and #3 combined) to 97.1% of the load for the Hazel River watershed that the Lower Hazel River IP watershed falls within. The 2001 Mountain Run TMDL did not specify a bacteria reduction target for pasture and cropland, but both the Muddy Run and Upper Rappahannock TMDLs did; calling for 99% (pasture) and 71% (cropland) bacteria reductions in the Muddy Run TMDL, and a 94% reduction of load from both pasture and cropland in the Hazel River TMDL watershed.

The primary ways to reduce bacteria runoff from pasture or cropland are to improve agricultural land management or convert these lands to an alternate uses, such as through afforestation, land use development, or creation of sedimentation basins to capture bacteria runoff. This IP prioritizes improved pasture and cropland management practices, to retain existing agricultural land uses consistent with the project area's history and local area planning goals. The importance of agriculture to Culpeper County is stated clearly in the County's 2015 Comprehensive Plan: *"As a major industry, agriculture is an integral component of the County's economy. Maintaining the continued vitality of agriculture is necessary to achieve and preserve a balanced tax base and a diverse, healthy economy benefiting all of the citizens of the County. Agriculture is also an important part of the County's cultural heritage, having existed, and flourished, in Culpeper for more than three centuries."*

The 2016 VLCD identified 25,103 acres of pasture and 10,745 acres of cropland in the IP project area watersheds. A total of 3,001 acres of pasture lands have been improved by BMPs still within their practice life-span, and more than 2,000 acres of cropland are planted in cover crops. These practices reduce stormwater runoff from agricultural lands, and the load of bacteria, nutrients and sediment transported to area streams. Through these agricultural BMP installations, progress to reduce pollutant loads in the watershed has already occurred, however, significant work remains to achieve water quality goals.

The additional pasture and cropland management BMPs recommended in this plan are designed to reduce bacteria levels sufficiently to achieve water quality criteria for the recreational use. In addition, these same measures that reduce bacteria runoff from fields also produce other valuable environmental and productivity benefits, including nutrient and sediment runoff reductions that will help to address the benthic community impairments in Mountain Run, and contribute toward achieving Chesapeake Bay cleanup goals. In selecting the pasture and cropland management BMPs included in this plan, increased attention was given to those that reduce nutrient and sediment pollutant loads, in addition to bacteria loads.

8.3.1 Methodology

Taking the approach explained for Muddy Run in Section 8.1.1, after subtracting the completed in life-span PM practices shown in Table 8-11 below, an initial estimate of over 28,000 additional acres of PM were identified for the IP project area. This exceeded the total acres in pasture within the IP project area and needed to be adjusted to account for the actual opportunities to implement pasture management improvements.

Table 8-11. In-Life Span Pasture and Cropland BMPs Installed in IP Watersheds as of Aug. 20, 2020

Practice Code	BMP Name	No. BMPs	Total BMP Cost	Average Cost of BMP	Extent Installed (Acres)
SL-10	Prescribed Grazing Land Management	1	$2,400.00	$2,400.00	32.0
SL-7	Extension of Watering Systems	2	$33,845.43	$16,922.72	165.0
SL-9	Grazing Land Management	1	$7,509.25	$7,509.25	23.0
FR-1	Afforestation of Crop, Hay and Pasture Land	1	$1,417.64	$1,417.64	20.0
Total Pasture Management BMPs		**4**	**$45,172.32**		**240.0**
CCI-FRB-1	Forested Riparian Buffer - Maintenance Practice	2	$11,220.00	$5,610.00	74.8
CP-22	CREP Riparian Forest Buffer	5	$2,584.50	$516.90	55.7
CP-22B	CREP Riparian 100' Wide and Wider Buffer Bonus	1	$1,160.00	$1,160.00	11.6
CRFR-3	CREP Woodland Buffer Filter Area	4	$11,319.50	$2,829.88	44.1
Total Buffer BMPs		**12**	**$26,284.00**		**186.3**
CCI-CNT	Long Term Continuous No-Till Planting Systems	4	$31,845.25	$7,961.31	1,628.3
SL-1	Long Term Vegetative Cover on Cropland	11	$95,100.83	$8,645.53	441.0
SL-15A	Continuous High Residue Minimal Soil Disturbance Tillage System	1	$4,200.00	$4,200.00	60.0
Total Cropland BMPs		**16**	**$131,146.08**		**2,129.3**

In consultation with members of the agricultural workgroup, a total additional level of 20,500 acres of PM BMPs was agreed to be a more appropriate target for inclusion in the IP. Together with the completed BMPs, this would equate to just over 90% of all pasture in the IP watersheds having conservation practices in place. These consultations also resulted in a decision that the majority of new pasture management BMP recommendations should be the VACS SL-10 practice (Prescribed Grazing Land Management), while other pasture and cropland BMPs should be included to allow maximum flexibility to support individual producer's needs and preferences during plan implementation. The SL-6N and SL-6W practices recommended above for LEF will benefit approximately 4,000 acres of adjoining pasture,

based on analysis of data from the DCR's BMP Tracking program for completed SL-6 practices, and this then lowers the additional PM BMPs needed from 20,500 to 16,500 acres.

A simplified form of the comparative analysis methodology used for the core bacteria IP measures was employed to derive recommended levels for additional pasture and cropland management BMPs. This methodology involved summarizing the pasture management and cropland BMPs included in 28 EPA-approved IPs that had sediment reduction goals, to support the project goal of selecting "supplemental" BMPs (beyond the core bacteria IP measures) that would produce the greatest co-benefits of nutrient and sediment load reductions to address the benthic impairments in Mountain Run. The BMP goals for the approved IP watersheds were adjusted to account for the differences in their size with that of the IP project area, and the average value for each BMP was computed as a preliminary BMP goal for the IP project area. These values were then rounded, consistent with the approach taken for the core IP measures, and allocated across the IP watersheds based on watershed size.

8.3.2 Implementation Actions

Table 8-12 below presents the pasture and cropland BMPs by IP watershed that are recommended to meet the bacteria reduction needs allocated to runoff from agricultural lands. As explained above, approximately 4,000 acres of pasture improvements are linked to the creation of stream buffers associated with LEF. The majority of the remaining need is recommended in the form of the SL-10 Grazing Land Management practice at the advice of local agricultural professionals. Other practices are included in the approximate amounts suggested by the results of comparative analysis, combined with local agricultural professionals' best judgment.

Most of the improved pasture measures have bacteria reduction efficiencies of 50 percent; therefore, the specific pasture improvement measure used on individual parcels can be adapted to meet parcel specific constraints and opportunities while achieving bacteria reduction goals. The recommended management measure that achieves the greatest bacteria reduction, at 88 percent, is considered a land use conversion practice. The VACS practice WP-1 converts erodible agricultural land to a sediment retention/water control structure, and can be prioritized in the latter stage of implementation if other measures should prove insufficient to achieve the needed bacteria reductions. Initially the 2,430 acres treated with this practice were included in the pasture category, but during the Steering Committee meeting participants said this would be most applicable to cropland, and the WP-1 practice is now included there. For this reason, the total of pasture management BMPs (13,425 acres) is less than the goal of 16,500 acres noted above.

The individual measures may be mixed and matched depending on the individual circumstances of each landowner and the resources available. Working together, the C-SWCD and project area producers can find the optimal, site-specific combination of practices for each farm.

Table 8-12. Management Measures Recommended for Pasture and Cropland

BMP Name/Code	Units	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total IP
Pasture Management BMPs							
Grazing Land Management (SL-10)	/acre	2,092	2,295	2,814	1,394	1,405	**10,000**
Extend Watering Systems (SL-7)	/system	5	6	7	3	4	**25**

BMP Name/Code	Units	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total IP
Woodland Filter Buffer Area (FR-3)	acres	42	46	56	28	28	**200**
Afforestation (FR-1)	acres	110	151	194	127	118	**700**
Total for "Acreage" BMPs		2,249	2,498	3,071	1,552	1,555	**10,925**
Implied Acres for Alt Water Systems (SL-7)		500	600	700	300	400	**2,500**
Total Pasture Management BMPs (acres)		**2,749**	**3,098**	**3,771**	**1,852**	**1,955**	**13,425**
Cropland BMPs							
Cover Crops (SL-8)	acres	51	277	401	416	355	**1,500**
Permanent Vegetative Cover on Critical Areas (SL-11)	acres	10	55	80	83	72	**300**
Sediment Retention/Water Control Structure (WP-1)	acres treated	381	525	673	439	412	**2,430**
Grass Filter Strips (WQ-1)	acres	2	9	13	14	12	**50**
Conservation Tillage (SL-15A)	acres	34	185	267	277	237	**1,000**
Permanent Vegetative Cover on Cropland (SL-1)	acres	35	185	265	275	240	**1,000**
Total Cropland BMPs (acres)		**513**	**1,236**	**1,699**	**1,504**	**1,328**	**6,280**
Other Agricultural BMPs							
Sod Waterway (WP-3)	acres	3	4	6	4	3	**20**
Animal Waste Control Facilities (WP-4), f(Total Cattle)	systems	1	1	3	1	1	**7**
Streambank Stabilization (WP-2A)	linear feet	1,332	1,837	2,355	1,537	1,439	**8,500**

[1]There is a total of 3,200 acres of pasture management associated with the watering system extensions and animal waste facilities that are not shown separately in the table, but are reflected in the totals.

Spatial analysis, shown in Figure 8-4 below, identified the location of pasture land on slopes greater than ten percent. Lands meeting these criteria are located primarily in the Lower Hazel River, Muddy Run and Mountain Run #1 IP watersheds. Permanent vegetative cover on critical areas (SL-11) and Afforestation

(FR-1) should be prioritized to stabilize any steep slope areas to reduce land erosion and sedimentation of adjacent streams.

Mountain Run and Lower Hazel River Watershed Pasture/Dominant Slope

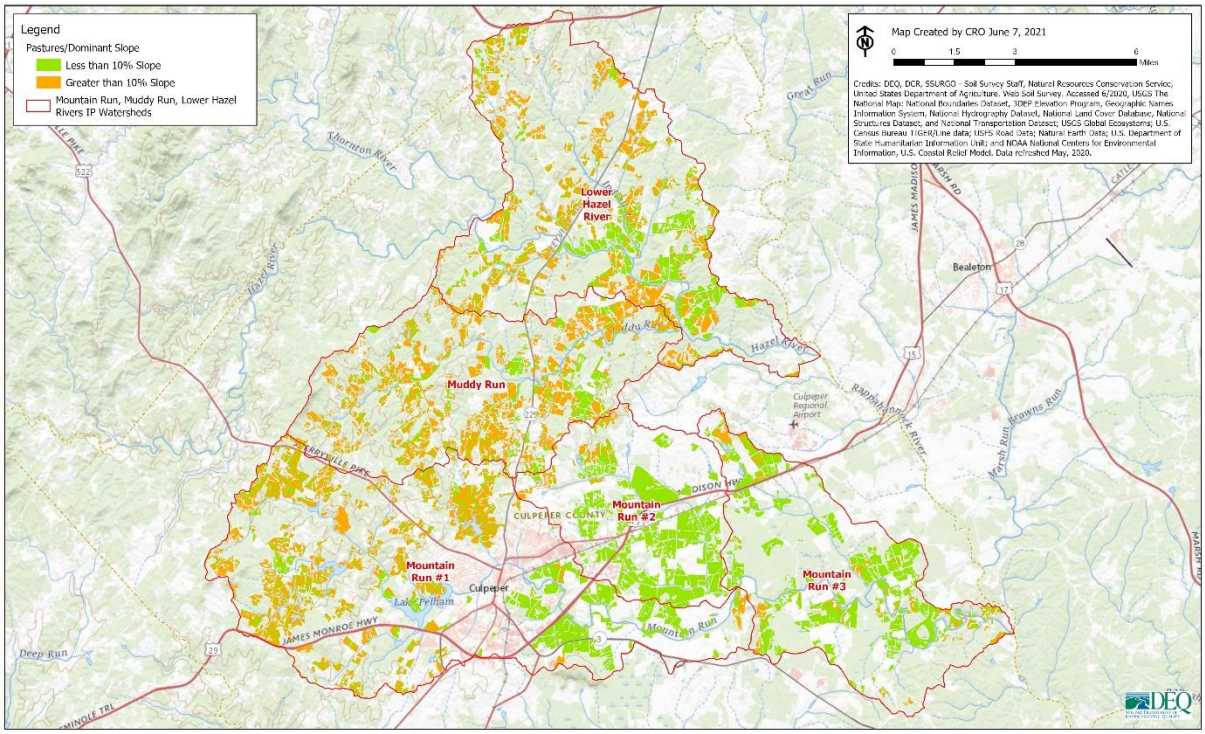


Figure 8-4. Location of pasture land on greater than and less than ten percent slope in the IP project area

Conservation tillage (SL-15A) and cover crops (SL-8) are effective ways to address bacteria runoff from cropland, given the rotational nature of crop production. The integrity of riparian corridors should also be maintained, and the FR-3 and WQ-1 are designed for this purpose. Steering Committee members requested that this report note that current VACS funding and cost-share rates for the Grass Filter Strip (WQ-1) practice are insufficient to encourage its full utilization. Mowing or plowing along swales should be minimized and vegetation should be allowed to return to improve of bacteria reduction effectiveness (Figure 8-5).

Agricultural stormwater management infrastructure (WP-1) can be applied to help manage runoff and prevent bacteria from entering local streams. Most bacteria IPs have a significant amount of this practice in their recommended BMPs, as it often has been difficult to achieve TMDL bacteria reductions without its inclusion. While stormwater infrastructure to manage runoff from agricultural lands has an estimated 88% bacteria removal efficiency, because this BMP results in significant loss of agricultural land to productive use agricultural producers generally are interested to put in place, and no instances of this practice have been reported in DCR's BMP database for the IP project area. However an examination of aerial photo imagery for the area shows dozens of small impoundments along the upper reaches of Mountain Run and its tributaries, including Jonas Run, and these impoundments reduce downstream transport of bacteria. Because the WP-1 practice has generally not been implemented in other IPs, it is primarily a Phase II measure to consider should other BMPs prove to be insufficient to achieve water quality goals.

Figure 8-5. Grass buffer along a stream

8.4 Equine Management

There are approximately 1,000 horses within the IP project area, as was noted in Chapter 6 (see Table 6-7). Although the TMDLs that this IP project addresses do not allocate reductions to equine sources of bacteria, during the Agricultural Workgroup and Steering Committee meetings participants recommended including equine management measures in this IP due to the sizeable horse population in the project area.

Recent VACS program modifications have increased the rate of eligibility of small horse farms. Effective for 2021, the VACS program farm related income threshold of $1,000 per year was modified to apply to the most recent three years (versus the previous five year requirement) and a clarifying definition explicitly states that horse boarding, training and breeding facilities that meet program requirements are VACS eligible. In 2018, DEQ added demonstration BMP practices to address equine manure sources that are eligible for Section 319 grant funding. Together, these DCR and DEQ program changes increase the Commonwealth's ability to provide cost-share assistance for equine operation conservation measures. Proactively working with owners and boarding operations to properly manage horse manure will help ensure bacteria are kept out of area streams. Proposed equine management measures were separated from the other agriculture BMPs to assist in identifying opportunities for implementation and obtaining funding assistance.

8.4.1 Methodology

For both the small farm grazing systems practice (assigned 10 percent of the overall LEF need, see Section 8.2.1.2) and the equine manure composting practices, the allocation of the recommended number of practices for the entire project area was proportionate to the share of the horse population located in each IP watershed. The number of horses in each watershed were derived from data available in the DCR Annual Nonpoint Source assessment survey.

8.4.2 Implementation Actions

Table 8-13 provides a list of management measures to address bacteria runoff attributed to horse farms that were identified at the agricultural workgroup meeting and in discussions with C-SWCD. The Small Acreage Grazing System practice (SL-6AT) is designed to prevent manure and sediment runoff from heavy use areas and pastures from entering watercourses and to capture a portion of the manure as a resource for other use as fertilizer. This is accomplished by dividing the pasture into grazing paddocks. Livestock are rotated among paddocks as is necessary to maintain a permanent vegetative cover. One lot is stabilized and designated as a heavy-use area for use in periods of wet weather and when grass in the grazing paddocks needs to rest and re-grow to the appropriate grazing height. These systems also include exclusion fencing to prevent access of horses to streams adjoining the farm.

Figure 8-6. Horse manure composting structure (Washington State University Cooperative Extension 2016)

Composting manure, in combination with improved pasture management, can effectively address bacteria loads from equine operations. Composting facilities can vary in size and capital costs depending on the number of horses present at an individual farm. DEQ currently has two “Demonstration” BMPs (EM-1T and EM-1AT) available to address equine manure composting needs, with eligible cost-share amounts of $3,000 and $5,000, respectively at 75% cost-share). Small composting systems, micro-bins designed to handle manure from three to five horses, may be less costly to construct while constructing composting for more horses will require larger systems at greater expense. Figure 8.6 provides an example of a composting system for a large farm or boarding operations.

Barnyard runoff controls are structures which collect and divert runoff from barnyard or associated buildings into areas of low environmental impact. These structures are similar to stormwater management practices commonly used to address runoff from industrial, commercial or residential areas but are applied in a barnyard setting (Figure 8-7. Small acreage grazing system with heavy use area and diversion ditch in Great Run watershed, Fauquier County (photo by Claire Hilsen, John Marshall SWCD, 2015)). The purpose is to store and filter nonpoint source pollution related to equine or other livestock. In some cases, it is possible to effectively collect, treat, and/or divert stormwater runoff concerns around barnyard areas with relatively inexpensive regrading of the surface to minimize erosion and runoff.

A common improvement may include appropriately sized gutters for barns and walk-in sheds that carry water from downspouts to outlets in a “safe” area away from any manure. High use area pads for feeding, watering and gateway areas, modified French drains for drip lines, infiltration trenches, and conservation landscaping (vegetated buffers) are also inexpensive and practical improvements. In other cases, simple grading and re-seeding (consistent with the SL-11 VACS practice to stabilize critical areas) may reduce bacteria runoff from horse farms.

Figure 8-7. Small acreage grazing system with heavy use area and diversion ditch in Great Run watershed, Fauquier County (photo by Claire Hilsen, John Marshall SWCD, 2015)

Table 8-13. Management Measures to address Bacteria Runoff from Equine Operations

BMP Name	BMP Code	Average System Size	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
Small Acreage Grazing System	(SL-6AT)	1,500 Linear Ft	8	8	8	3	3	30
Small Scale Equine Manure Composting – Static Systems	(EM-1T)	3 bins	5	5	5	2	2	19
Small Scale Equine Manure Composting – Aerated Systems	(EM-1AT)	3 bins	3	3	3	1	1	11

8.5 Residential Implementation Needs

Non-agriculture sources of bacteria are considered residential in nature and include sources from septic systems, "straight pipes" (untreated sewage released directly to streams), pet wastes, and stormwater runoff from developed lands. Each of the three TMDL reports called for 100% reduction of bacteria from "straight pipes" and failed septic systems, as both of these conditions are considered illegal discharges. The three TMDL reports also called for load reductions of bacteria in stormwater runoff from developed land ("urban"), ranging from 78% for Muddy Run to 94% and 95% for the Hazel River and Mountain Run TMDL watersheds, respectively.

8.5.1 Septic Systems

As discussed in Section 6.3 and shown in Figure 8-8, the majority of the IP area is served by private septic systems, with sewer service existing in and around the Town of Culpeper. Nearly half (47%) of the IP project area homes are served by individual septic systems. Only portions of the Mountain Run #1 and #2 IP watersheds have areas within the Town of Culpeper's wastewater treatment facility; 100% of the residences in the Lower Hazel River, Muddy Run, and Mountain Run #3 IP watersheds are on individual septic systems. In light of this, proper design and maintenance of these systems is required to prevent bacteria from entering surface water and groundwater resources.

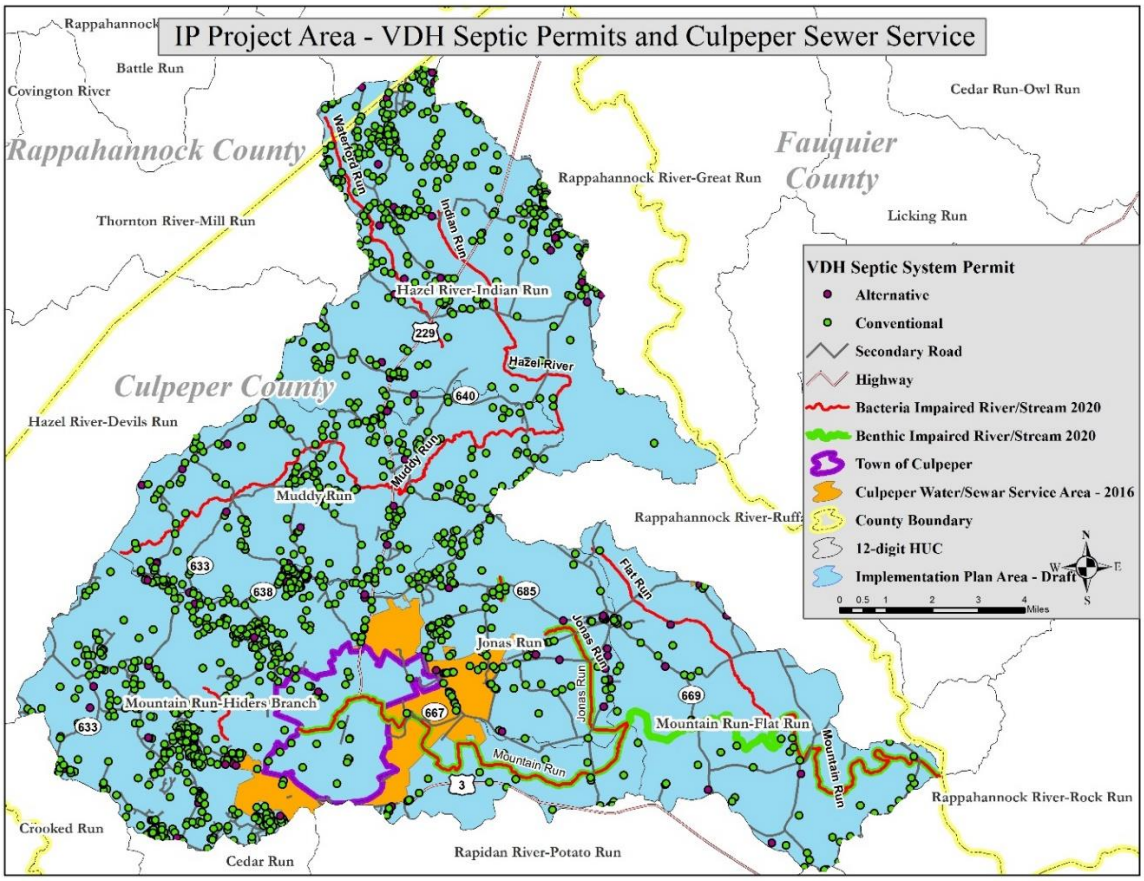


Figure 8-8. Septic System and Sewer Use Areas in the IP Project Area

Based on the analysis by RRRC discussed in Chapter 6, there are an estimated 6,599 septic systems in the IP area. The distribution of these septic systems across the IP watersheds is presented in Table 6.4, with the vast majority (87%) located within the Lower Hazel River, Muddy Run, and Mountain Run #1 watersheds. In addition to analyzing the number and distribution of septic systems, DEQ also worked with RRRC to estimate the age of these systems, so that adjustments to the septic system replacement BMP recommendations could be made, if the data suggested that was warranted.

8.5.1.1 *Methodology*

BMP recommendations for septic systems were prepared using the core bacteria BMP comparative analysis methodology discussed in Section 8.1 above. As was done for Agricultural BMPs, the initial BMP recommendations were adjusted to account for the septic BMPs already completed and still within their practice life-span in 2020 (see Table 8-14). Accounting for the completed BMPs resulted in the septic BMP recommendations of 1,861 septic pump outs, 566 septic repairs, 515 new conventional septic systems, and 106 new alternative on-site septic systems.

Table 8-14. In-Life Span Residential Septic BMPs Installed in IP Watersheds as of Aug. 20, 2020 (DCR BMP Database)

Practice Code	Septic System BMPs	No. BMPs	Total BMP Cost	Average Cost of BMP
RB-1	Septic System Pumpouts	192	$ 65,152.50	$ 339.34
RB-2	Connection to Public Sewer	2	$ 18,937.68	$ 9,468.84
RB-3	Conventional Onsite Sewage System Repair	30*	$ 100,870.22	$ 3,362.34
RB-3R	Conventional Onsite Sewage Systems Inspection and Non-permitted Repair	38*	$ 36,155.83	$ 951.47
RB-4	Conventional Onsite Sewage System Install/Replacement	7	$ 68,655.00	$ 9,807.86
RB-4P	Conventional System Install/Replacement with Pump	4	$ 63,776.51	$ 15,944.13
RB-5	Alternative Onsite Sewage System Installation	2	$ 57,092.00	$ 28,546.00
	Total Septic System BMPs		**$ 410,639.74**	

*VDH records show a total of 392 septic repair permits were issued in the project area from 2010-19, and this figure was used to adjust the initial BMP recommendation for RB-3 septic system repairs.

DEQ then compared the IP watershed allocation of the septic BMPs to the estimated number of houses served by septic systems in the IP watersheds, identified from analysis completed by RRRC. This comparison flagged a significant mismatch in that Jonas Run, with the second to the lowest number of septic system residences, had the highest number of initial septic pump outs recommended. As was done for LEF and PM, to better align the BMP recommendations with the opportunities to implement them, DEQ reallocated the Septic BMP totals across the IP watersheds as a function of the share each had of the total number of septic systems within the IP project area. A further adjustment was made to the distribution of new conventional and alternative septic system BMPs to increase the share located in Mountain Run #3, where both older housing stock and poorly drained soils are concentrated. Both of these factors suggest a greater share of existing septic systems may require replacement (vs. maintenance or repair) to effectively treat residential sewage.

8.5.1.2 *Recommended BMPs and Support for Implementation*

The suite of septic system BMPs recommended, shown in Table 8-15, will greatly reduce bacteria runoff to local streams. Their inclusion in this IP, once approved by EPA, will result in the eligibility of homeowners in the project area to receive cost-share assistance for the maintenance or replacement of their existing septic systems. Since 2007 the C-SWCD has administered residential septic cost share programs under both Section 319 and WQIF grants. The District is well prepared to administer a septic cost-share program in the IP project area following plan approval.

In 2018, DEQ modified its Residential Septic System BMP guidelines to allow for up to 80-90 percent cost-share assistance for septic system BMPs for residents earning less than 40 percent of the local (county) median income, with a sliding scale reduction of the maximum cost-share to 50 percent for homeowners who earn greater than 120% of the county median income. This assistance is provided as part of Section 319 grants, which may fund reimbursable cost-share assistance to homeowners who contract for the recommended septic system BMPs in the IP watersheds.

Table 8-15. Septic BMP Final Recommendations by IP Watershed

BMP Name	BMP Code	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
Septic Pump-out	RB-1	450	400	700	150	100	**1,800**
Sanitary Sewer Connection	RB-2	0	0	25	10	0	**35**
Septic System Repair	RB-3	140	130	220	50	30	**570**
New Conventional Septic System	RB-4	120	110	190	40	50	**510**
New Alternative On-site Septic System	RB-5	20	20	35	10	25	**110**

Over the course of the 15-year implementation planning timeline, there may be opportunities to connect residences within the Town of Culpeper's sewer service area (Mountain Run #1 and #2 only) that experience failing septic systems to the Town's 6 MGD wastewater treatment system. Management measure RB-2 (connection to a public sewer) can help offset the capital cost of a sewer connection. Since opportunities for connection to existing wastewater treatment facilities is highly watershed and location specific, the RB-2 recommendations of 35 sewer system connections were not derived from comparative analysis but instead from stakeholder consultations during IP development. Given the relatively high cost of sewer system connections. The Town of Culpeper offers a $5,000 reduction to the normal sewer connection fee as an incentive for new connections of current septic system homes. Additional low income assistance could be made available through other grant or micro-loan programs, such as the Southeast Rural Community Assistance Program (SER-CAP) or USDA's Water and Waste Disposal Loan and Grant Program, described in Section 13.

Financial assistance to complement that from future Section 319 grants would be even more valuable to low income homeowners who may be required to install a new alternative on-site wastewater treatment system, which are estimated to cost approximately $24,000 each. These costly systems may be most applicable to areas of the County that have poorly drained soil types. As seen in Figure 8.8 the Jackson-Waxpool-Haymarket-Montalto soil type extends across the eastern portion of the Mountain Run watershed, primarily within the Mountain Run #3 watershed. These soils are highlighted (in a tan color) in the Culpeper County Development Constraints map (Figure 8.9, Map 4.7 in the County's Comprehensive Plan), because their "shrink-swell" properties result in poor drainage that is often not suitable for conventional septic systems. These may be the most important areas to focus alternative on-site septic systems when existing conventional septic systems fail. Accordingly, in the Septic System BMP recommendations, there was a final adjustment to the allocation of Alternative On-Site Septic

Systems that slightly reduced the recommendations for all other IP watersheds to increase the number of alternative septic systems recommended for Mountain Run #3. A Steering Committee member observed that increased follow up by the local health department with homeowners whose septic systems are failing would promoted improved septic system maintenance

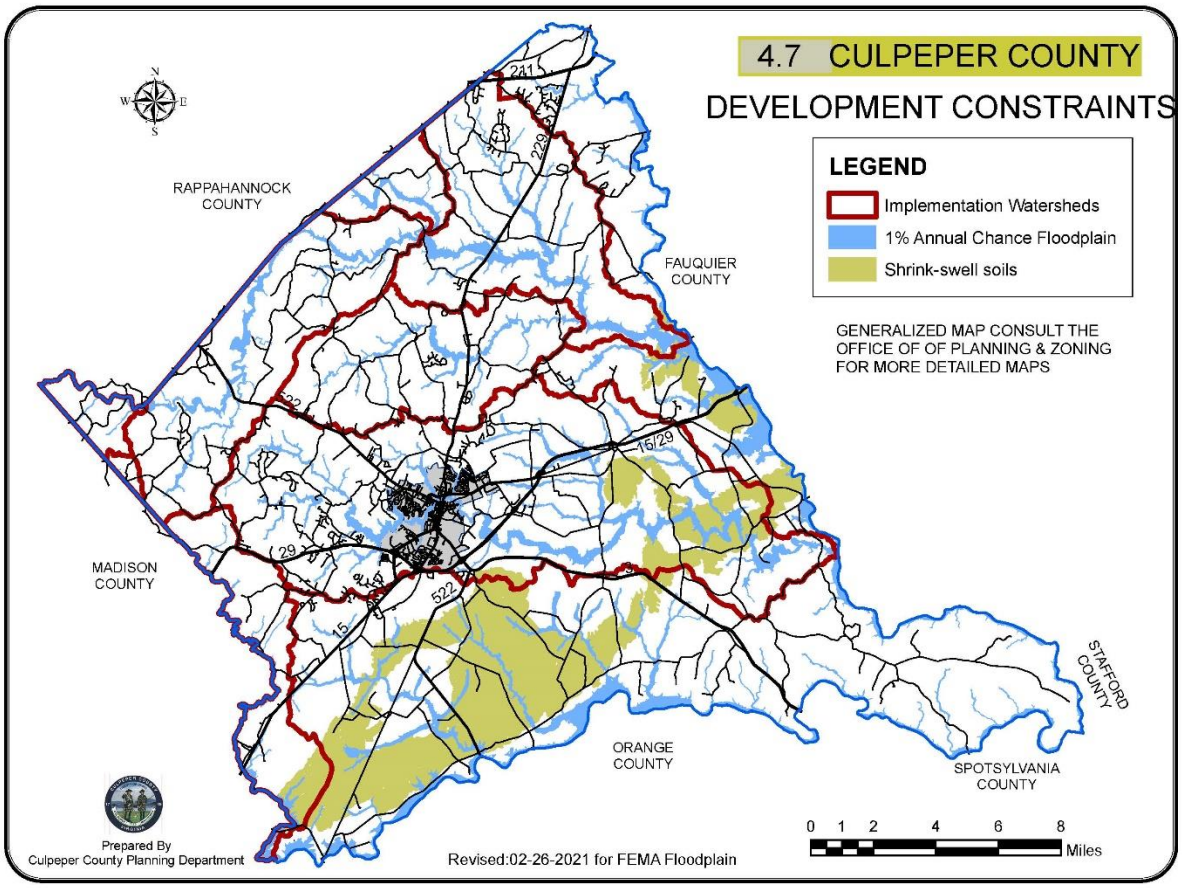


Figure 8-9. Development Constraints due to Soils and Floodplains in Culpeper County

8.5.2 Pet Waste

Pet waste is another source of bacteria entering local waterways from residential sources. Historically, many pet owners did not make the connection between pet waste and local water quality. During rain events, bacteria from pet waste can run off lawns into local streams. While it is more common for pet owners to pick up after their pets now, there remain opportunities to further reduce bacteria runoff from undisposed pet wastes. Proper disposal of these wastes will eliminate associated bacteria from reaching local waterways and keep public parks and gathering places clean.

Figure 8-10. Culpeper resident walking their dog in Yowell Meadow Park

8.5.2.1 *Methodology*

While wastes from all pets can be a source of excess bacteria, the IP focuses on dogs since they are commonly walked by their owners, presenting an opportunity to pick up their waste. The number of dogs living in the IP area was calculated using number of households multiplied by the average number of dogs per household according to the AVMA's 2012 survey (AVMA 2012), and the resulting distribution of the estimated 8,230 dogs across the IP watersheds was presented in Table 6-9.

8.5.2.2 *Implementation Actions*

DEQ has two established BMPs for pet waste management, pet waste disposal stations, and pet waste composters. From past experience implementing pet waste programs in adjoining watersheds, during the Residential Workgroup meeting the representative from RRRC explained that while pet waste stations were well accepted and used, there had never been interest to install pet waste compost units in the past. Accordingly, the only BMP recommended here are pet waste stations, and their distribution across the IP watersheds follows the estimated number of dogs presented in Section 6.6. In addition, pet waste management educational information should be shared and communicated with the public throughout implementation of this plan.

During the Residential Workgroup meeting, participants agreed that the IP should include pet waste station BMPs and an education and outreach program to address pet waste sources of bacteria. Culpeper County and the Town of Culpeper parks, the neighborhood access points to parks, and common grounds within neighborhoods, especially developments with homeowner/citizen associations were all identified as appropriate areas to install pet waste stations and provide associated educational information. Table 8-16 presents the recommended number of pet waste stations in the IP watersheds. Increased engagement with local veterinarians could help promote improved pet waste management, and should be a part of the education and outreach program discussed in Section 8.6.1.2.

Another type of BMP recommended to address canine wastes, the Confined Canine Facility BMP, has recently been added as a demonstration practice eligible for Section 319 funding by DEQ. This practice is a modified septic system designed to effectively treat wastes from kennel facilities that hold ten or more dogs. As was discussed in Section 3.4.6, DEQ learned from Culpeper County that there are currently six canine kennels licensed for operation in the IP project area, one each in the Lower Hazel River and Mountain Run #2 IP watersheds, and four in Mountain Run #1. Table 8-16 also shows the number of Confined Canine Facility BMPs recommended.

Table 8-16. Number and Cost of Confined Canine Facilities for IP Watersheds

BMP Name	BMP Code	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total IP Watersheds
Pet Waste Stations	PW-1	4	3	24	2	1	**34**
Confined Canine Facilities Waste Treatment	PW-3	1	0	2	1	0	**4**

8.5.3 Stormwater

Developed land stormwater runoff was identified as a bacteria source to be controlled in each of the three TMDL reports that addressed the IP project area. The TMDLs called for bacteria load reductions from developed lands that ranged from 78 to 95%. Accordingly, a number of "urban" BMPs are recommended to achieve bacteria reductions in stormwater runoff from developed lands in the IP project area. Given the presence of an impaired benthic macroinvertebrate community in the Mountain Run IP watersheds, BMPs that reduce loads of sediments and nutrients (primary sources of the benthic impairments), in addition to bacteria, are given priority in this plan.

8.5.3.1 *Methodology*

A more streamlined comparative analysis method than that employed for LEF, PM and septic BMPs was used to generate ballpark levels for stormwater management BMPs. While bacteria IPs are the most common in Virginia, DEQ has also completed 28 sediment IPs that have been approved by EPA. DEQ extracted the urban BMP recommendations from these IPs to analyze for possible inclusion in this IP. Several of these measures are often recommended in bacteria IPs, since they produce multiple pollutant reduction benefits. Those that have been commonly included in bacteria IPs were allocated across all IP watersheds, while those not typically found in bacteria IPs were allocated only to the Mountain Run watersheds, with the goal of having a suite of Mountain Run BMPs able to address both the bacteria and benthic impairments.

The specific approach taken to develop recommended values for urban stormwater BMPs entailed (1) extracting urban BMP goals for the 28 sediment IPs, (2) calculating watershed sizes to enable comparative adjustments to BMP goals, (3) averaging the adjusted BMP goals to create the new IP urban BMP goals, (4) identifying and removing outlier BMP goals, zero values and those greater than 10 times the average, and (5) computing final averages for the new IP's urban BMP goals. The BMP goals derived from this streamlined comparative analysis are shown in Table 8-17. (This same streamlined comparative analysis method was used for supplemental pasture and cropland measures discussed in Section 8.3.1.):

8.5.3.2 *Implementation Actions*

During stakeholder consultations in the residential workgroup meetings, participants expressed support for including stormwater management measures that DEQ identified as commonly a part of bacteria IPs. Stakeholders also identified a few additional BMPs as particularly applicable to the IP project area, such as regular street sweeping in the heavily developed area in and around the Town of Culpeper, wetlands creation/restoration, and adding filtering and infiltration features to existing dry detention ponds or converting dry detention to wet ponds to improve the water quality benefits of existing stormwater controls.

As shown in Table 8-17 below, stormwater BMPs that are commonly found in recent EPA-approved bacteria IPs are included in all of the IP watersheds, while those that are less commonly found are only included in the three Mountain Run watersheds that have benthic impairments. The type and number of each stormwater BMP recommendation was informed by the comparative analysis values (Table 8.17), the levels of similar BMPs included in the local area WIP III (Table 8-19), and stakeholder input. The allocation of these measures across the IP watersheds is a function of either the IP watershed size or the relative amount of developed land in each watershed. As shown in Figure 8.11 below, in addition to installing new stormwater BMPs, there also are opportunities to improve the water quality functions of existing BMPs. Adding infiltration and bioretention features to existing dry detention ponds can provide significant water quality improvements from stormwater management features already in place in the IP project area. There are currently some 1,500 acres that drain to dry detention ponds in the Mountain Run #1 and #2 watersheds, from analysis provided by C-SWCD.

Figure 8-11. Dry Pond (above) is a BMP that is very common in the local area, and Wet Pond with Wetland Cell BMP (below). Photo 2015 Redwood Lakes Subdivision (R. Jacobs)

Table 8-17. Urban BMP Preliminary Goals from Comparative Analysis of EPA Approved Sediment IPs

DEQ and (VCAP) BMP Type and Codes		BMP Units	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
WS Size (Acres)			18,826	24,837	30,320	11,306	15,833	**101,121**
Developed Land (Acres)			2,353	1,830	6,836	1,585	971	**13,575**
Bioretention	BR-1, 2, and 6 (BR)	Area Treated			1,820	422	258	**2,500**
Rain Gardens	BR-10 (RG)	Drainage Area	173	135	504	117	72	**1,000**
Infiltration Trench	IP-5, IP-6 (IF)	Drainage Area	156	121	453	105	64	**900**
Permeable Pavement	IP-4 (PP)	Area Treated	3	3	10	2	1	**20**
Manufactured BMP	MBMP-1	Area Treated			437	101	62	600
Street Sweeping	SS-1	Curb Miles Swept			1,700			**1,700**
Conservation Landscaping	UB-2, UB-4 (CL)	Buffer Area	61	47	176	41	25	**350**

DEQ and (VCAP) BMP Type and Codes		BMP Units	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
Converted Dry Detention Ponds	DP-1	Area Treated			291	68	41	**400**
Streambank Stabilization/ Restoration	U-5, USR-2	Stream Length (lin. Ft.)			9,462	2,194	1,344	**13,000**
Stream Restoration	USR-1	Stream Length (lin. Ft.)			16,013	3,713	2,274	**22,000**
Constructed Wetland	UW-2 (CW)	Area Treated	186	246	300	112	157	**1,000**

An important recommendation from the residential workgroup discussions on implementing the recommended stormwater BMPs is to conduct additional bacteria monitoring in areas in and around the Town of Culpeper, which has the highest levels of developed lands in the IP project area. Using this information, urban BMPs can be prioritized for location in areas where the greatest bacteria reductions can be achieved. FOR is preparing a monitoring plan that could accomplish this, under a citizen monitoring grant from DEQ. This will be discussed further in the Water Quality Monitoring section of this plan, as well as the discussion of priority areas for implementation in Section 10.0.

Figure 8-12. Parking lot filter strip. Photo 2021 Rockwater Park (R.Jacobs)

Local government facilities such as schools and parks may provide ideal locations for installation of stormwater BMPs, especially when capital improvements are planned. For example, rain gardens, wet

ponds, and riparian buffers can both reduce stormwater runoff transported downstream from developed areas, slow the velocity of stormwater runoff (which reduces erosion and pollutant mobilization), and reduce the transport of bacteria and other pollutants downstream. Through a NFWF grant, RRRC, FOR and the Chesapeake Conservancy are developing a desktop application to identify locations well suited to various BMP practices, and this can help to prioritize project outreach. They (RRRC and FOR) are also developing another application to enable homeowners to report their own BMP installations. Future stormwater outreach should promote this to more fully document stormwater BMP implementation in the area.

Creation or restoration of wetlands is included in the urban BMP recommendations. Wetlands are defined by having a wet hydrologic regime, wetlands tolerant plant life, and the presence of hydric soils. As noted earlier, there are many wetlands, former wetlands converted to agricultural and other uses, and areas prone to flooding in the lower sections of each IP watershed. These areas present the best opportunity for creation or restoration of wetlands, and locating them in areas known to have bacteria and excess nutrients in stormwater runoff will provide the greatest co-benefits.

Consistent with the participants' interests, the IP recommends a modest amount of wetland creation or restoration BMPs in all IP watersheds to allow interested landowners to seek funding support for wetlands they may wish to restore/create. For agricultural lands, the USDA has several conservation programs that include eligibility for wetlands restoration, and with an approved IP, Section 319 grant funds could provide funding for this work in developed land settings. Wetlands are estimated to have bacteria reduction efficiencies of 80 percent, causing these features to be even more effective than riparian buffers in reducing the amount of bacteria that reaches streams from stormwater runoff.

Streambank restoration and stream restoration are both a part of the urban BMP recommendations; however, these measures are recommended to be implemented to address streambanks found in both urban and agricultural landscapes, in amounts derived from comparative analysis. There are several opportunities to restore streambanks, which will primarily have the benefit of reducing bank erosion and the release of sediments into local waters. Residential workgroup members specifically noted the possibility of adding vegetation and root mass to protect these areas using the very low cost method of "live staking", or placing native shrubs that root directly from branch cuttings into the banks. Where existing banks are eroding due to the current structure of the stream channel/banks, erosion can be reduced by re-grading the banks to reduce the slope and improve the ability to vegetate the streambank. Stream restoration is a more costly measure that may be warranted in areas where more extensive modifications to highly degraded stream channels is needed to halt high erosion rates.

Figure 8-13. Bioretention with pea gravel flow spreader. Photo 2014: Farm Credit (R.Jacobs)

Bioretention (Figure 8.14) and manufactured BMPs are more expensive stormwater management practices that include engineering components that provide a level of treatment before water is infiltrated into the subsurface. These practices are included in the BMP recommendations for the Mountain Run watersheds, with manufactured BMPs limited to Mountain Run #1, as it is specifically intended to enable on-site stormwater capture and treatment in densely developed settings. As shown in Figure 8.14, Filterra® is a brand name product that is an example of a manufactured BMP, and is designed specifically to enable treatment of runoff at high flow rates that occur in heavily developed areas with high amounts of impervious surfaces (Contech, 2010).

Figure 8-14. Filterra® Bioscape manufactured BMP installed in Middleton, MD in 2015 (above) and in 2021 (below)

Final adjustments to the amount of the various stormwater management practices were made in consultation with stormwater management professionals with an eye toward improving the overall cost-effectiveness of this IP, the final urban BMP recommendations are presented in Table 8-18 below.

Table 8-18. Final Urban BMP Recommendations

BMP Name	BMP Codes	BMP Units	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
Bioretention	BR-1, 2, and 6 (BR)	Area Treated			109	25	16	**150**
Rain Gardens	BR-10 (RG)	Drainage Area	17	13	50	12	7	**100**
Infiltration Trench	IP-5, IP-6 (IF)	Drainage Area	35	27	101	23	14	**200**
Permeable Pavement	IP-4 (PP)	Area Treated	0.3	0.3	1.0	0.2	0.1	**2.0**
Manufactured BMP	MBMP -1	Area Treated	-	-	10			**10**
Street Sweeping	SS-1	Curb Miles Swept	-	-	100	-	-	**100**
Conservation Landscaping	UB-2, UB-4 (CL)	Buffer Area	61	47	176	41	25	**350**
Converted Dry Detention Ponds	DP-1	Area Treated	-	-	291	68	41	**400**
Streambank Stabilization / Restoration	U-5, USR-2	Linear Feet	-	-	9,462	2,194	1,344	**13,000**
Stream Restoration	USR-1	Linear Feet	-	-	7,279	1,688	1,034	**10,000**
Constructed Wetland	UW-2 (CW)	Area Treated	186	246	300	112	157	**1,000**

8.6 Education and Outreach

Education and outreach programs are important to the successful implementation of proposed management measures. Informing landowners and residents of the importance of protecting local water quality and increasing awareness of the programs available to help with capital costs to install management measures will assist in successful implementation and meeting bacteria reductions targets over the 15-year planning horizon. Education and outreach also provides an opportunity for residents and stakeholders to provide feedback with regard to what programs are working and whether plan adjustments are needed to meet reduction goals.

The C-SWCD has a long history in the IP watershed providing technical and educational services and assistance to landowners, land managers, private citizens and local governments over its 80+ years of existence. Historically these efforts have often been coupled with USDA conservation program opportunities and VCE educational programs. These baseline efforts are expected to continue for the duration of the IP. Many different outreach and education strategies have been time tested by C-SWCD for both agricultural and residential audiences in surrounding IP watersheds, and C-SWCD is well poised to apply additional situational efforts to support successful implementation this plan.

In addition, FOR has offered watershed education programs for over 30 years, and works with K-12, college, and adult audiences to deliver education programs across the Rappahannock River watershed. FOR currently has a 3 year Bay Watershed Education and Training (BWET) grant from the National Oceanographic and Atmospheric Administration (NOAA) that provides meaningful watershed educational experiences (MWEE) annually to one grade of all elementary and high schools in Culpeper County (and surrounding areas also). This includes professional development for teachers, school administrators, and partners. FOR also provides family/community outreach and education and summer camp programs in partnership with local Parks and Recreation.

The education and outreach activities recommended below are an important way to foster continued engagement of project area stakeholders during implementation of this plan. On a broader scale, DEQ provides funding for water basin "Roundtables", which promote awareness and stakeholder engagement in watershed management activities. The Mountain Run, Muddy Run and Lower Hazel River project area falls within the Rappahannock River Roundtable, and this forum, led by FOR, serves to enhance stakeholder understanding and support for watershed stewardship, including efforts to carry out the recommendations of this plan. FOR has river stewards located in each section of the Rappahannock River basin, and its headwaters river steward is located in Culpeper.

Current education and outreach activities by public organizations and environmental NGO's, SWCD area meetings, and programs by DEQ and other state natural resource agencies all serve to foster and maintain the engagement of stakeholders in water quality management. These broad efforts will complement the targeted education and outreach activities recommended below to promote participation in and support for the actions called for in this report.

The C-SWCD has led implementation efforts within four adjoining IP watersheds, and has found the most effective outreach to promote agricultural and residential septic BMP installations has been individual contacts, via mail, phone and in-person communications. These direct communications with landowners/homeowners are critically important and can be supported under Section 319 grants.

Water quality professionals who participated in the residential workgroup also stressed the importance of including an education and outreach component of the plan specific to stormwater management. Public education/outreach is needed to address a wide-spread belief that wetlands and other stormwater management practices increase undesirable insect growth and have high operational costs. Conservation Districts in Virginia developed and deliver the Virginia Conservation Assistance Program (VCAP) as a means to provide technical and financial assistance to property owners for installing retro fit stormwater BMPs as a means to lessen water quality pollutants in local waters. The VCAP Program is well suited for

this IP and the C-SWCD should undertake a strong marketing program focused on installing VCAP BMPs in the IP watershed. Local governments and NGOs also have much to offer to improve understanding and enhance adoption of improved stormwater management practices.

8.6.1 Implementation Actions

Local SWCDs are typically the primary leaders of local watershed restoration efforts in Virginia, and the C-SWCD has considerable experience administering Section 319 grants awarded to support implementation projects for EPA-approved IPs. In addition, Culpeper County, the Town of Culpeper, the RRRC, FOR and PEC are all eligible to apply for Section 319 grants to carry out the recommended BMPs included in this implementation plan. A consolidated application with multiple eligible partners playing specific roles in the overall grant management is possible, and could support the type of broad education and outreach discussed above.

The proposed education and outreach programs recommended to support implementation of this plan are briefly described below. Information can be distributed through a variety of communication mediums including social media, print media, newsletters, and radio advertisements. Local homeowner and civic associations, environmental and conservation organizations, county and town agencies, local veterinarians, and engaged individuals can all spread the message about cost-share programs and benefits of improved agricultural, residential septic, and developed land management practices.

8.6.1.1 *Agricultural BMP Education and Outreach*

With changes in land ownership and agricultural operations, there is a need throughout the implementation of this plan for outreach to agricultural producers. This will include both participation in agricultural sector meetings and events, as well as one-on-one engagement of individual producers.

8.6.1.2 *Septic System Owner Education and Outreach*

Information about proper septic system maintenance and obligations of septic system owners can be communicated in many ways, all of which are supported as part of a comprehensive septic systems outreach program. Some methods for communication include, but are not limited to, newspaper articles, newsletters, individual mailings, and as the C-SWCD has concluded, most effectively through direct communications; In addition, outreach to area realtors can help them inform prospective homeowners of their obligations and proper maintenance of septic systems when purchasing a home with a septic system. Information about cost-share programs to help offset capital costs should be distributed in a targeted manner to lower income households, and county social service offices may be able to help focus outreach to low-income area residents.

8.6.1.3 *Pet Waste Management Education Programs*

A robust education and outreach campaign is recommended to inform pet owners of the importance of picking up after their dogs. Distributing dog waste bag leash holders is an inexpensive and popular program to spread the message. Opportunities to distribute educational materials include a variety of local community events, farmers markets, and in public display areas in more heavily developed areas. Local homeowner and civic associations should be engaged to encourage them to share pet waste management information with their members, and explore opportunities to place new pet waste station BMPs in larger private developments. Engaging local veterinarians could be a valuable way to help promote improved pet waste management practices.

8.6.1.4 *Incorporate Water-Related Curriculum into Area Classrooms*

The Virginia Department of Education (DOE) requires watershed-related curriculum as part of 3rd through 6th grade science education (DOE 2016). As part of addressing water quality concerns in the IP area, local watershed organizations and the C-SWCD can continue to ensure students are receiving a "meaningful watershed experience" (CBF 2004). Expansion of existing programs and promotion of locale-specific efforts promotes a "sense of place" in children, engages parents in local water quality problems, and brings communities together to find solutions. For over 20 years, C-SWCD has developed and delivered age appropriate, hands-on environmental education addressing non-point source pollution and human impacts on natural resources. These activities include development of environmental literacy and meaningful watershed educational experiences. They also include professional development programs for instructors to strengthen their capacity to present these programs to their students. Currently the C-SWCD is delivering a 3 year BWET program targeted at all 6th graders in the project area (and beyond). This effort is supported by a grant from the National Oceanographic and Atmospheric Administration (NOAA).

8.6.1.5 *Stormwater Management Education and Outreach*

New or refined education and outreach materials should be developed to effectively communicate the benefits, and dispel unsupported myths, about the stormwater management practices that are recommended in this IP. Communicating the water quality, flood reduction and aesthetic benefits of stormwater BMPs, while addressing inaccurate perceptions that they foster undesirable insect growth and other problems, will enhance public interest and support for these practices. The stormwater education and outreach program can also serve to explore BMP siting opportunities, primarily at public and commercial buildings and facilities where they will be most visible to local residents. Stormwater outreach should effectively communicate the VCAP program, and also promote use of the application developed by RRRC/FOR to enable homeowner reporting of stormwater BMPs they install on their own.

8.7 Technical Assistance

A robust technical assistance program is important to successful implementation of the proposed management measures. With additional technical staff time focused on the IP area, local professionals can inform residents of the importance of protecting local water quality, increase awareness of the programs available to help with capital costs of installing management measures, and provide individual consultations with interested land, home and business owners, as well as public facility managers. These efforts will assist in successful implementation of the management measures recommended to meet bacteria reductions goals over the 15-year IP time horizon.

Education/outreach and technical assistance also provides an opportunity for residents and stakeholders to provide feedback for understanding what programs are working and whether adjustments will need to be made to meet reduction goals. As with education and outreach, technical assistance activities can be provided by future Section 319 grant recipients and other local environmental professionals throughout the project area.

Examples of the types of technical assistance that will be critical to successful implementation of the IP are meetings with individual agricultural producers to discuss conservation opportunities, with homeowners to discuss residential septic system maintenance needs, and with property owners and public organizations about improved stormwater management practices. From initial discussions, local environmental professionals can work directly with interested parties to explore specific BMPs opportunities and develop project plans.

8.8 WIP III Planning Relevant to the IP Watersheds

Significant portions of Chesapeake Bay and its tidal tributaries within Virginia and other Bay States do not meet water quality standards and are listed as impaired. The main pollutants causing these impairments are nitrogen, phosphorus and sediment. Despite significant and sustained efforts for many years, the water quality goals under the Clean Water Act have yet to be met. On December 29, 2010, EPA finalized the Chesapeake Bay TMDL.

The Chesapeake Bay TMDL addresses all segments of the Bay and its tidal tributaries that are on the impaired waters list. The Bay TMDL divided the maximum aggregate watershed pollutant loadings that can achieve the Chesapeake Bay's water quality standards among the Bay states by major tributary basins and source categories (wastewater, urban storm water, septic, agriculture, air deposition). EPA also set a phased implementation planning requirement for all Bay jurisdictions to focus attention on the actions needed to implement required pollutant reductions by 2025.

Virginia submitted its Phase I Watershed Implementation Plan (WIP) in November 2010, and a more refined Phase II plan was built upon local BMP planning targets, in 2012. Development of Virginia's Phase III WIP involved extensive engagement with the full array of Virginia's Chesapeake Bay watershed local jurisdictions, state agencies, and numerous other partners as well as the public. Virginia DEQ and DCR coordinated local engagement in partnership with the Commonwealth's PDCs and SWCD Areas. Implementation of the agricultural, forestry, septic, and urban BMP targets that are identified in Virginia's Phase III WIP, together with ongoing reductions from permitted sources, are sufficient to achieve the Commonwealth's Bay TMDL sediment and nutrient reduction goals. Virginia's WIP III was submitted to EPA on August 23, 2019.

The watersheds in this IP project area are all located in the Rappahannock River Basin within Virginia's Chesapeake Bay watershed. In the context of the Mountain Run, Muddy Run, and Lower Hazel River IP, the primary pollutant of concern is bacteria, and secondary attention is given to sediment and nutrient pollutants that are identified as probable stressors to the benthic community in Mountain Run as well as being pollutants addressed by the WIP. Implementing measures within the IP watersheds that are identified in either this IP or the Phase III WIP will have the co-benefit of improving local water quality while also supporting efforts to achieve Chesapeake Bay cleanup goals. For bacteria IPs, implementation of BMPs identified in the Phase III WIP will also address sediment and nutrients in local waters, even if no local impairment associated with these pollutants has been identified, as is the case for Muddy Run and the Lower Hazel River. Stakeholder outreach conducted in the IP project area watersheds as part of the local TMDL implementation project can be leveraged to emphasize additional BMP implementation needs identified in the Phase III WIP.

The types of BMPs identified as part of the Phase III WIP for the IP project area that are most applicable to this plan are presented below. The full suite of WIP III BMPs selected for the Rappahannock River Basin can be found in Table 3 in Chapter 8.2 of Virginia's Phase III WIP document.

Table 8-19 and Table 8-20 below show the type and amount of BMPs that are most relevant to this IP that are targeted for implementation by 2025 in the WIP III for the IP watersheds. The table shows the proportionate allocation to the IP watersheds of BMPs planned for the larger WIP III local planning units. Many of the BMPs included in WIP III have the ability to achieve bacteria in addition to nutrient/sediment reductions, the latter being especially relevant to addressing the benthic impairments in the Mountain Run watershed.

Table 8-19. Selected WIP III Agricultural BMP Practices for the 2020-2025 Goals for the IP Watersheds

WIP III BMP Recommendations (and Units)		Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
Commodity + Cover Crop (annual)	Acres	7	8	1,209	445	626	**2,295**
Pasture Alternative Watering	Acres	162	216	226	83	117	**804**
Prescribed Grazing	Acres	769	1,028	900	332	465	**3,495**
Horse Pasture Management	Acres	54	73	74	27	38	**266**
Forest Buffers on Fenced Pasture Corridor	Acres	119	160	162	60	84	**584**
Grass Buffers on Fenced Pasture Corridor	Acres	129	172	158	58	82	**599**
Forest Buffers	Acres	92	122	252	93	130	**689**
Wetland Restoration	Acres	44	59	81	30	42	**256**
Wetland Enhancement & Rehabilitation	Acres	1	1	2	1	1	**6**
Grass Buffers	Acres	82	109	190	70	98	**550**
Tree Planting	Acres	153	204	293	108	151	**909**
Non-Urban Stream Restoration	Linear Feet	380	502	706	260	365	**2,213**

Table 8-20. Selected Urban and Septic WIP III BMP Practices for the 2020-2025 Goals for the IP Watersheds

WIP III BMP Recommendations (and Units)		Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total
Wet Ponds & Wetlands	Acres Treated	164	228	409	151	212	**1,165**
Infiltration Practices	Acres Treated	13	18	35	13	18	**96**
Filtering Practices	Acres Treated	23	32	64	24	33	**176**
BioSwale	Acres Treated	23	31	53	20	28	**153**
Urban Tree Planting	Acres	48	65	119	44	62	**338**
Urban Forest Planting	Acres	3	5	8	3	4	**24**
Septic System Practices							
Septic Denitrification	Systems	9	12	6	2	3	**32**
Septic Secondary Treatment	Systems	22	30	18	7	9	**86**
Septic Effluent	Systems	1	1	(0)	(0)	(0)	**2**
Septic Pumping	Systems	230	310	206	76	107	**929**

It is important to reemphasize that the WIP III BMP targets for the IP watersheds <u>were not</u> developed to achieve bacteria reductions, instead they focus on achieving the nitrogen reduction target allocated to the area for its contribution to Chesapeake Bay restoration. So, in some cases the level of the WIP III BMP recommendation is significantly different than that for the same/similar BMP in this IP. The data is presented here primarily to illustrate the overall complementary nature of the local IP and WIP III BMP recommendations.

8.9 Summary of Recommended Implementation Actions

Restoring water quality to support the recreational use of waterbodies impaired by excess bacteria levels will require implementation of a full suite of BMPs throughout the IP project area. The greatest bacteria reductions are expected to come from livestock exclusion fencing, pasture management, and residential septic BMPs, which were developed with reference to the levels contained in similar EPA approved IPs. Supplemental agricultural measures to address equine waste management, addressing pet wastes, and more effectively managing stormwater runoff in the IP project area are all parts of the comprehensive suite of recommended BMPs. Many of these measures, and especially stormwater management BMPs (including those on agricultural lands) will also serve to reduce levels of nutrients and sediments that are primary stressors of the benthic life community in Mountain Run and its tributaries (Flat and Jonas Run), while supporting WIP III goals. The recommended education and outreach and technical assistance activities are critically important to successful implementation of this plan.

9.0 Costs and Benefits of Implementation

This section presents the costs and benefits of implementing the conservation practices explained in the preceding chapter. The costs and benefits of recommended BMPs are based on a variety of sources that represent the best available information from both state wide and local implementation experiences.

9.1 Costs to implement the plan

The total cost of the recommended conservation practices and associated education/outreach and technical assistance is estimated to be just over $35 million. This breaks out across major categories as $7.25 million for agricultural BMPs, $10.2 million for residential septic BMPs, and $16.2 million for stormwater management BMPs, including pet wastes. These totals and the breakdown by IP watershed are shown in Table 9-1. With the greatest development, population and also a significant remaining agricultural sector, the costs are far greater for Mountain Run #1 than the other four IP watersheds.

Table 9-1. Summary of the Cost of IP Recommendations

Type of BMP	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Livestock Exclusion Systems	486,600	536,600	668,800	274,400	274,400	**2,240,800**
Pasture and Cropland BMPs	753,425	1,008,451	1,545,592	862,636	840,146	**5,010,250**
Equine Operation BMPs	102,000	102,000	102,000	38,000	38,000	**382,000**
Residential Septic BMPs	2,207,500	2,065,000	3,840,000	937,500	1,190,000	**10,240,000**
Pet Waste/Kennel BMPs	13,200	900	31,200	12,600	300	**58,200**
Stormwater Management BMPs	1,152,427	1,190,011	10,218,601	2,083,581	1,501,381	**16,146,000**
Education/Outreach/Technical Assistance						**965,000**
Total Cost of IP Recommendations	**4,715,152**	**4,902,962**	**16,406,193**	**4,208,717**	**3,844,227**	**35,042,250**

9.2 Costs of Livestock Exclusion Fencing BMPs

The greatest costs are associated with the exclusion fencing with grazing land management system BMPs, which experience has shown to be the LEF practice of greatest interest to area producers. With wide (>50 feet) buffers, this practice provides the greatest bacteria reduction benefits, by converting an estimated 5 acres per BMP from pasture to riparian buffer. The companion practice using more narrow buffers creates an average of 3 acres of buffer with each system.

By far, the least expensive exclusion fencing measure is the new Portable Fencing BMP, which is considered a temporary (5 year life span) practice, and does not require any buffer zone. Nonetheless, by preventing livestock from accessing the small streams and wetlands that are fenced, it will eliminate the possibility of direct deposition into local waters where it is installed. The cost estimate for the LEF practices recommended is approximately $2.2 million. Costs for the small farm grazing system BMPs,

which are expected to be primarily installed at horse farms, are presented in the Equine Operations section (Section 9.4).

Table 9-2. Estimated Cost for Recommended LEF Systems

BMP Name	BMP Code	Average System Cost ($)	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Stream Exclusion, w/ Grazing Land Mgmt - Wide Buffer	SL-6W	30,000	360,000	390,000	480,000	210,000	210,000	**1,650,000**
Stream Exclusion, w/ Grazing Land Mgmt - Narrow Buffer	SL-6N	20,000	120,000	140,000	180,000	60,000	60,000	**560,000**
Portable Fencing BMP	WP-2P	550	6,600	6,600	8,800	4,400	4,400	**30,800**
Total LEF Systems Cost			**486,600**	**536,600**	**668,800**	**274,400**	**274,400**	**2,240,800**

9.3 Costs of Pasture, Cropland, and Other Agricultural BMPs

The total cost of recommended pasture management practices is approximately $1.6 million. The highest BMP costs are for the recommended grazing land management (SL-10) BMP, the practice that local agricultural professionals believe is the most widely applicable pasture improvement practice for the IP project area; a total of 10,000 acres is recommended. Costs to extend water systems in pasture are next in magnitude. The other PM BMPs are recommended at more modest levels, and have correspondingly lower costs.

Cropland BMPs are commonly a smaller component of bacteria IPs, as their contribution of bacteria is limited, and often associated with the rotational use of land for cropping and pasture. Inclusion of cropland BMPs is especially valuable in this IP, however, as their ability to control for sediment and nutrient runoff to local streams will help to address the benthic impairments in the Mountain Run watersheds. Permanent vegetative cover on critical areas (highly erodible cropland) will be the most valuable practice in terms of water quality improvements, and it bears the second highest cost. The highest cost is associated with the WP-1 practice, which converts agricultural land to a water retention basin, and is included at the level that comparative analysis shows is consistent with previously approved bacteria IPs. Because of its high cost and generally low interest from agricultural producers (because it removes land from production), the vast majority of this practice is placed in Phase II of the IP; the phased schedule for implementation will be discussed in Section 10.0.The total cost of recommended cropland BMPs is estimated to be approximately $1.1 million.

Streambank erosion is a significant concern that was discussed within the IP workgroups, and the streambank stabilization BMP (WP-2A) is aimed to address this concern. While occasionally included in bacteria IPs, this practice is a primary measure for sediment IPs, and it will contribute greatly toward the goal of reducing sediment loads in local streams that are a primary stressor of benthic health in the Mountain Run watersheds. The estimated cost of the recommended 8,500 linear feet of streambank

stabilization is a significant share of the total pasture and cropland cost estimate, at nearly $1.3 million. The cost of seven animal waste facilities (WP-4) that are recommended are also high, at just over $1 million. Sod waterways are also included in the other agricultural BMP category, and bring the total cost of this group of BMPs to nearly $2.4 million.

The costs of all the pasture, cropland, and other agricultural BMPs are shown in Table 9.3 below.

Table 9-3. Cost of Pasture, Cropland, and Other Agricultural BMP Recommendations

BMP Name	Average System Cost ($)	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Pasture Management BMPs							
Grazing Land Management (SL-10)	75	156,900	172,125	211,050	104,550	105,375	**750,000**
Extend Watering Systems (SL-7)	25,000	125,000	150,000	175,000	75,000	100,000	**625,000**
Woodland Filter Buffer Area (FR-3)	450	18,900	20,700	25,200	12,600	12,600	**90,000**
Afforestation (FR-1)	150	16,500	22,650	29,100	19,050	17,700	**105,000**
Total Cost Pasture Management BMPs		**317,300**	**365,475**	**440,350**	**211,200**	**235,675**	**1,570,000**
Cropland BMPs							
Cover Crops (SL-8)	50	2,550	13,850	20,050	20,800	17,750	**75,000**
Permanent Vegetative Cover on Critical Areas (SL-11)	1,200	12,000	66,000	96,000	99,600	86,400	**360,000**
Sediment Retention/Water Control Structure (WP-1)	150	57,150	78,750	100,950	65,850	61,800	**364,500**
Grass Filter Strips (WQ-1)	175	350	1,575	2,275	2,450	2,100	**8,750**
Conservation Tillage (SL-15A)	100	3,400	18,500	26,700	27,700	23,700	**100,000**

BMP Name	Average System Cost ($)	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Permanent Vegetative Cover on Cropland (SL-1)	175	6,125	32,375	46,375	48,125	42,000	**175,000**
Total Cost Cropland BMPs		**81,575**	**211,050**	**292,350**	**264,525**	**233,750**	**1,083,250**
Other Agricultural BMPs							
Sod Waterway (WP-3)	1,600	4,800	6,400	9,600	6,400	4,800	**32,000**
Animal Waste Control Facilities (WP-4)	150,000	150,000	150,000	450,000	150,000	150,000	**1,050,000**
Streambank Stabilization (WP-2A)	150	199,750	275,526	353,292	230,511	215,921	**1,275,000**
Total Cost Other Agri BMPs		**354,550**	**431,926**	**812,892**	**386,911**	**370,721**	**2,357,000**
Total Costs for Pasture, Crop, & Other Agri BMPs		**753,425**	**1,008,451**	**1,545,592**	**862,636**	**840,146**	**5,010,250**

9.4 Costs of Equine Operation BMPs

Addressing bacteria from the approximately 1,000 horses that are located within the IP watersheds will complement the core bacteria BMP measures of LEF, PM and Septic. The estimated total cost of the recommended practices is $382,000. As shown in Table 9-4 below, the recommended small farm grazing systems (SL-6AT) make up the greatest share of these costs, with smaller funding needs associated with the 30 equine manure composting practices that are also recommended.

Table 9-4. Cost of Equine Operation BMP Recommendations

BMP Type	BMP Code	Avg System Cost	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Small Acreage Grazing System	(SL-6AT)	9,000	72,000	72,000	72,000	27,000	27,000	**270,000**

BMP Type	BMP Code	Avg System Cost	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Small Scale Equine Manure Composting – Static Systems	(EM-1T)	3,000	15,000	15,000	15,000	6,000	6,000	**57,000**
Small Scale Equine Manure Composting – Aerated Systems	(EM-1AT)	5,000	15,000	15,000	15,000	5,000	5,000	**55,000**
Total Equine Operations BMP Costs			**102,000**	**102,000**	**102,000**	**38,000**	**38,000**	**382,000**

9.5 Costs of Residential Septic BMPs

The estimated costs for residential septic BMP recommendations, at $10.2 million, are the second largest cost category for the Mountain Run, Muddy Run and Lower Hazel River IP. With nearly 6,600 residences served by septic systems in the IP project area, this is a more heavily populated area than many of the other project areas for which DEQ has prepared IPs. With more intensive development in the area surrounding the Town of Culpeper, in comparison to other parts of the IP project area, the greatest costs are for BMPs recommended in the Mountain Run #1 watershed. In comparison to its share of the residential septic systems within the project area, the Mountain Run #3 watershed has relatively high septic BMP costs due to the increased number of new conventional and alternative on-site systems that are associated with the older housing stock and presence of poorly drained soils in this part of the project area.

By type of septic BMP, the highest costs are associated with septic system repairs and new septic systems, and these practices, along with sewer connections, provide the greatest bacteria reduction benefits. Sewer connection BMPs are only possible in the Mountain Run #1 and #2 watersheds, where some residences with septic systems lie within the Town of Culpeper's sewer service area. Septic pump outs alone have limited (5%) bacteria reduction benefits, but pump outs are often a step toward identifying more significant septic system issues that, when addressed, result in significant bacteria reductions.

Table 9-5. Cost of Residential Septic BMP Recommendations

BMP Name	Average System Cost ($)	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Septic Pumpout (RB-1)	350	157,500	140,000	245,000	52,500	35,000	**630,000**
Sanitary Sewer Connection (RB-2)	11,000	-	-	275,000	110,000	-	**385,000**

BMP Name	Average System Cost ($)	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Septic System Repair (RB-3)	3,500	490,000	455,000	770,000	175,000	105,000	**1,995,000**
New Conventional Septic System (RB-4)	9,000	1,080,000	990,000	1,710,000	360,000	450,000	**4,590,000**
New Alternative On-site Septic System (RB-5)	24,000	480,000	480,000	840,000	240,000	600,000	**2,640,000**
Total Septic Systems Cost		**2,207,500**	**2,065,000**	**3,840,000**	**937,500**	**1,190,000**	**10,240,000**

9.6 Costs of Pet Waste BMPs

Costs associated with the BMPs recommended to address pet waste bacteria sources are modest, at $58,200. The greatest shared of these costs are to address bacteria from confined canine facilities (aka, kennels), with installation of modified septic systems. Lesser costs are linked to the recommended installation of 34 pet waste stations though out the IP project area. The Mountain Run #1 watersheds estimated costs are highest, as the distribution of pet waste BMPs closely follows the level of development/population.

Table 9-6. Cost of Pet Waste BMP Recommendations

BMP Type	Average Cost	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Pet Waste Stations	300	1,200	900	7,200	600	300	**10,200**
Confined Canine Facilities Waste Treatment	12,000	12,000	-	24,000	12,000	-	**48,000**
Total Pet Waste BMP Costs		**13,200**	**900**	**31,200**	**12,600**	**300**	**58,200**

9.7 Costs of Stormwater Management BMPs

Bacteria linked to stormwater runoff from developed areas was included in the same category as residential septic in the TMDL analysis, as shown in Table 6-1, and together were less than 6 percent of total bacteria loads for the project area watersheds. Most approved bacteria IPs include modest levels of stormwater management BMPs, with the goal of reducing human-based sources of bacteria to the greatest extent possible. This IP recommends a broader suite of stormwater BMPs, and in some cases higher levels of BMP implementation akin to those found in approved sediment IPs; this is driven by the goal of achieving the maximum co-benefit of nutrient and sediment reductions with the goal of addressing the

benthic impairments in Mountain Run. Total costs for the recommended stormwater BMPs are approximately $16 million.

Table 9-7. Cost of Stormwater BMP Recommendations

BMP Name	Average BMP Cost ($)	Muddy Run ($)	Lower Hazel River ($)	Mountain Run #1 ($)	Mountain Run #2 ($)	Mountain Run #3 ($)	Total Cost ($)
Bioretention	15,000	-	-	1,637,670	379,711	232,618	**2,250,000**
Rain Gardens	5,000	86,667	67,403	251,786	58,379	35,764	**500,000**
Infiltration Trench	11,300	391,733	304,663	1,138,074	263,875	161,655	**2,260,000**
Permeable Pavement	325,000	112,667	87,624	327,322	75,893	46,494	**650,000**
Manufactured BMP	75,000	-	-	750,000	-	-	**750,000**
Street Sweeping	1,000	-	-	100,000	-	-	**100,000**
Conservation Landscaping	360	21,960	16,920	63,360	14,760	9,000	**126,000**
Converted Dry Detention Ponds	2,900	-	-	1,113,600	46,400	-	**1,160,000**
Streambank Stabilization/Restoration	150	-	-	1,419,300	329,100	201,600	**1,950,000**
Stream Restoration	350	-	-	2,547,487	590,662	361,851	**3,500,000**
Constructed Wetland	2,900	539,400	713,400	870,000	324,800	452,400	**2,900,000**
Total Cost Stormwater BMPs		**1,152,427**	**1,190,011**	**10,218,601**	**2,083,581**	**1,501,381**	**16,146,000**

9.8 Costs of Education, Outreach and Technical Assistance

As was discussed in Sections 8.6 and 8.7, implementation of this plan will be enhanced greatly by a comprehensive education and outreach program throughout the IP project area, and direct technical assistance to agricultural producers, residential septic system owners, and individuals, businesses, and organizations seeking to better manage stormwater runoff from their properties. The cost of these activities is estimated to be approximately $965,000 (

Table 9-8) for the entire 15 year duration of this plan. Education and Outreach activities would ideally be given the greatest emphasis in the early years of plan implementation, while technical assistance (estimated at 01.0 FTE/year) should made available equally for the entire 15 year duration of the plan.

Table 9-8. Cost of Education, Outreach and Technical Assistance Benefits of Implementation

Program Activity	Total Costs ($)
Agricultural BMP education/outreach	15,000
Septic system education, for homeowners and realtors	15,000
Pet waste education program	10,000
Student water quality management educational activities	10,000
Stormwater management education and outreach	15,000
Education and Outreach Activities	**65,000**
Technical Assistance for Agricultural, Septic and Stormwater BMPs (1.0 FTE @ $60K/yr.)	**900,000**
Education, Outreach and Technical Assistance	**965,000**

The primary benefit of this plan is to reduce the amount of bacteria in impaired streams sufficient to meet the water quality criteria for the recreational use. Exposure to certain strains of *E.coli* bacteria through ingestion of contaminated water can damage the small intestine lining, leading to diarrhea and in rare cases kidney failure, as well as urinary tract infections, respiratory illness, pneumonia, and other illnesses. The Center for Disease Control and Prevention (CDC) has estimated that 265,000 cases of *E.coli* based infections occur annually, though most are from contaminated food exposure (CDC, 2021). Reducing the potential of exposure via surface water or untreated drinking water supplies is the primary benefit of the recommended BMPs. The selection of BMPs was also guided by a goal of maximizing the co-benefits of nutrient and sediment pollutant runoff, to address the benthic impairments within the Mountain Run watersheds.

Table 9-9

Type of BMP	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total Reductions
Livestock Exclusion Systems	2.16E+15	2.39E+15	3.00E+15	1.22E+15	1.22E+15	**9.98E+15**
Pasture and Cropland BMPs	4.35E+15	4.72E+15	6.74E+15	3.01E+15	3.03E+15	**2.19E+16**
Equine Operation BMPs	2.24E+11	2.24E+11	2.24E+11	8.40E+10	8.40E+10	**8.40E+11**
Residential Septic BMPs	1.27E+13	1.17E+13	2.13E+13	4.98E+12	4.41E+12	**5.51E+13**
Total Bacteria Reductions for IP Recommendations	**6.52E+15**	**7.12E+15**	**9.76E+15**	**4.23E+15**	**4.25E+15**	**3.19E+16**

Estimates do not include reductions for Afforestation, Sediment/Water Control Structures, Equine Composting, Pet Waste/Kennel, and Stormwater BMPs

Table 9-10Table 9-11 and

Table 9-12 present the estimated reductions in bacteria, total nitrogen, total phosphorus and sediments, respectively, that implementation of the recommended BMPs will produce for the IP project area in total.

Table 9-9. Estimated E.coli Bacteria Reductions (cfu/100mL)

Type of BMP	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total Reductions
Livestock Exclusion Systems	2.16E+15	2.39E+15	3.00E+15	1.22E+15	1.22E+15	**9.98E+15**
Pasture and Cropland BMPs	4.35E+15	4.72E+15	6.74E+15	3.01E+15	3.03E+15	**2.19E+16**
Equine Operation BMPs	2.24E+11	2.24E+11	2.24E+11	8.40E+10	8.40E+10	**8.40E+11**
Residential Septic BMPs	1.27E+13	1.17E+13	2.13E+13	4.98E+12	4.41E+12	**5.51E+13**
Total Bacteria Reductions for IP Recommendations	**6.52E+15**	**7.12E+15**	**9.76E+15**	**4.23E+15**	**4.25E+15**	**3.19E+16**

Estimates do not include reductions for Afforestation, Sediment/Water Control Structures, Equine Composting, Pet Waste/Kennel, and Stormwater BMPs

Table 9-10. Estimated Nitrogen (lbs/yr) Reductions

Type of BMP	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total Reductions
Livestock Exclusion Systems	2,481	2,757	3,446	1,379	1,379	**11,442**
Pasture and Cropland BMPs	10,209	22,020	30,864	25,972	23,050	**112,115**
Residential Septic BMPs	7,731	7,129	13,015	3,039	2,707	**33,620**
Urban Stormwater BMPs	2,881	3,595	6,695	2,121	2,468	**17,760**
Total Nitrogen (lbs/yr) Reductions for IP Recommendations	**23,302**	**35,500**	**54,020**	**32,511**	**29,603**	**174,937**

Estimates do not include nitrogen reductions for pet waste BMPs, street sweeping, manufactured BMPs, permeable pavement, and the conversion of dry detention ponds.

Table 9-11. Estimated Phosphorus (lbs/yr) Reductions

Type of BMP	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total Reductions
Livestock Exclusion Systems	336	373	466	187	187	**1,549**
Pasture and Cropland BMPs	1,308	1,983	3,266	2,023	1,819	**10,399**
Urban Stormwater BMPs	389	471	2,273	538	455	**4,125**
Total Phosphorus (lbs/yr) Reductions for IP Recommendations	**2,033**	**2,827**	**6,005**	**2,747**	**2,460**	**16,072**

Estimates do not include phosphorus reductions for pet waste BMPs, street sweeping, manufactured BMPs, and permeable pavement.

Table 9-12. Estimated Sediment (tons/yr) Reductions

Type of BMP	Muddy Run	Lower Hazel River	Mountain Run #1	Mountain Run #2	Mountain Run #3	Total Reductions
Livestock Exclusion Systems	296	329	411	164	164	**1,364**
Pasture and Cropland BMPs	0	1	1,175	273	168	**1,617**
Urban Stormwater BMPs	663	662	5,225	1,069	767	**8,386**
Total Sediments Reduced (tons/yr) for IP Recommendations	**959**	**992**	**6,810**	**1,506**	**1,099**	**11,367**

Estimates do not include sediment reductions for street sweeping, manufactured BMPs, permeable pavement, and conservation landscaping.

These pollutant reduction estimates were prepared from two separate sources. The first of these was the factors Virginia uses to calculate pollutant reductions from completed BMPs reported in DCR's BMP database. These estimates are sensitive to the landscape conditions of local watersheds, and this analysis drew upon completed BMPs in this IP's project area and several surrounding IPs with similar landscape settings. This approach supported estimates for most of the BMPs contained in this IP, but excluded urban BMPs (which are not reported to DCR) and several others, such as sediment/water control structures, which have not been completed in the surrounding area. For the urban BMPs, this analysis drew upon pollutant reduction factors used in the Chesapeake Assessment Scenario Tool (CAST) model. While the final estimates shown in the tables above are not comprehensive, they provide a conservative overall estimate of pollutant reductions expected from implementation of the recommended BMPs.

Resolving the bacteria and benthic impairments will produce benefits beyond simply reducing pollutants entering local streams. Numerous direct and indirect improvements made through implementation of the management measures include economic benefits to local agricultural producers, improved ecosystem health and habitat creation, protection of potential drinking water sources, enhanced recreation and tourism that benefits the local economy, and a more engaged, proactive community.

Further, the measures implemented as a part of this IP will reduce pollutants reaching the Chesapeake Bay and thus make progress towards achieving the Chesapeake Bay TMDL goals. The Bay TMDL focuses on impairments caused by excess sediment and nutrient (nitrogen and phosphorus) pollutant inputs to the Chesapeake Bay. As has been discussed already, many of the BMPs recommended in this "local" IP to reduce bacteria will also reduce sources of sediments and nutrients. In addition to addressing primary stressors of the Mountain Run benthic communities, reducing these pollutants contributes toward achieving the ambitious WIP III goals. Agricultural BMPs that create riparian buffers or improve crop or pasture land management will reduce sediments and nutrients carried by stormwater runoff from agricultural lands into local streams that ultimately drain into the Chesapeake Bay. Similarly, maintaining, repairing or replacing failing septic systems will reduce nitrogen discharges to local streams (and the Bay). Addressing stormwater runoff from developed lands can reduce both sediment and nutrient runoff, some of which would otherwise reach the Chesapeake Bay.

The benefits of agricultural, residential, and education and outreach practices are discussed in more detail in the sections below.

9.8.1 Agricultural Practices

Agricultural management measures (e.g. livestock exclusion, pasture and cropland, and equine practices) have numerous potential benefits in addition to reducing in stream bacteria. Keeping livestock out of the stream through installation of watering systems, stream fencing and crossings, riparian buffers, and other measures has the added benefit of preventing the spread of cattle diseases like *E. coli*, salmonella, leptospirosis, and mastitis (Nordstrom 2016). Additional livestock benefits of increased access to clean water can include weight gain, increased milk production, and decreased foot rot. Distributing water systems across pasture increases forage utilization which improves cattle productivity and, in some cases, may allow farmers to increase animal density (Zeckoski et al., 2007). Pasture and cropland management measures can increase profitability for the producer by reducing the amount of purchased feed required (DEQ 2016c).

Implementing improved pasture management systems, in conjunction with installing clean water supplies, provides economic benefits for the producer. Improved pasture management can allow a producer to feed less hay in winter months, increase stocking rates by 30 to 40 percent, and improve the profitability of the operation. With feed costs typically responsible for 70 to 80 percent of the cost of growing or maintaining an animal, increasing the amount of time that cattle are fed on pasture is a financial benefit to producers (Virginia Cooperative Extension, 1996). For decades the C-SWCD has worked in partnership with NRCS, VCE and FSA to promote and support adoption of improved agricultural conservation practices that bring these benefits to local producers. This plan recognizes the need for additional agricultural BMPs and will make the project area eligible for new technical and financial assistance through Section 319 grants.

More recently, the American Farmland Trust's "Sustainable Grazing Program" recognizes the multiple benefits of improving pasture management by promoting "…the adoption of regenerative farming practices that enhance soil health, sequester carbon, and increase productivity on farms and help to preserve agricultural lands from land development pressures. (AFT, 2021). This program is specifically focused on the Rappahannock River basin.

Stabilizing streambanks, installing sediment retention structures, and creating vegetative buffers can reduce pollutant transport to the stream, thereby improving aquatic habitat. These measures also create and/or improve existing aquatic and terrestrial wildlife habitats, while directly addressing the additional water quality impairments caused by excess sediment releases. The co-benefits of sediment reduction provided by some BMPs recommended to reduce bacteria, will greatly aid efforts to address the local stream segments (Mountain Run, Jonas Run and Flat Run) that are impaired for aquatic life use, as well as support sediment reduction goals of the Chesapeake Bay TMDL.

Vegetated buffers established from the installation of stream fencing reduce sediment and nutrient transport to the stream from upslope locations. While stream exclusion fencing placed at the top of the stream bank would reduce the bacteria loading from cattle in the stream, the additional benefit of reducing sediment and nutrient loadings from the upland would be lost without the riparian buffer. Streamside buffers of trees and shrubs help reduce erosion and provide shading of the stream. This helps keep water temperatures lower during the summer and allows for a greater amount of dissolved oxygen in the stream, which is beneficial for macroinvertebrates and fish.

Excessive sediment clogs the spaces in between river bed substrate that usually provides habitat for benthic macroinvertebrates, ultimately smothering and killing the invertebrate flora within that portion of a stream (Harrison et al., 2007). As excessive sedimentation begins to alter the macroinvertebrate community, some taxa are not able to survive, and less desirable pollution tolerant macroinvertebrates become more prevalent. The macroinvertebrate community serves as a major food source for freshwater fish. If their community is altered, there is potential for this to affect the fishery as well. Thus, the health of the whole aquatic ecosystem is dependent in part upon its physical habitat. Healthy fisheries will in turn provide more stock for local anglers. In 2011 alone, approximately $3.5 billion was spent on wildlife

recreation in Virginia (US Department of the Interior et al., 2011). Buffers can also improve habitat for wildlife and migratory songbirds that also benefit from having access to a healthy, thriving aquatic community.

9.8.2 Residential and Developed Land Practices

Residential measures like repair and replacement of septic systems, implementation of pet waste controls, and developed land stormwater management efforts have a number of benefits in addition to bacteria reductions. Proper septic tank maintenance extends the life of the system, which saves homeowners money in the long-run. Improved pet waste reduces the transport of bacteria to local streams, while enhancing community aesthetics. Better stormwater management reduces the transport of bacteria, nutrients, sediments, and other pollutants downstream, while also reducing localized flooding concerns. As shown in Figure 9-1**Error! Reference source not found.**, Mountain Run is prone to flooding following heavy precipitation events.

Figure 9-1. Flooding of Mountain Run in Yowell Meadow Park, June, 2021, Culpeper Star Exponent

Implementation of residential septic system BMPs will help convey to homeowners the knowledge and tools needed to properly maintain and extend the life of their septic systems. If properly maintained, the average septic system will last 20-25 years and the cost of this maintenance is relatively inexpensive compared to the costs of major septic system repairs or replacement.

Property owners can mitigate flood water damages and any associated costs by installing infiltration BMPs such as rain gardens and vegetated swales. At an individual residential scale, rain gardens can reduce water runoff from lots while supporting attractive plantings. Johnston et al. (2006) applied two different methods (one cost-based and one value-based) for estimating economic benefits of employing conservation design practices (vegetated swales, green roofs, permeable pavers, and native vegetation). The researchers found quantifiable economic benefits to property values downstream of areas where conservation practices were implemented. Residential measures also encourage community involvement and education, which is discussed below.

At a larger scale, riparian buffers, constructed or restored wetlands, bioretention, and wet ponds can all reduce stormwater runoff that carries bacteria and excess sediments and nutrients to local streams and the Chesapeake Bay. Wetlands in particular can have a broad suite of ecological services, including pollution

mitigation, that improve water quality and habitat values of adjacent aquatic resources. Stormwater infrastructure that manages runoff on-site can reduce losses from flood damage by $6,700-$9,700 per acre (Medina et al., 2011).

9.8.3 Education and Outreach

Participation of a wide range of local stakeholders will best support implementation of this plan and achievement of its water quality goals. Achieving high levels of landowner interest to adopt BMPs is essential to successful implementation. Reaching high levels of stakeholder involvement/landowner participation is possible with extensive education and outreach and technical assistance throughout the IP project area. By providing the local community with awareness of the current water quality problems, knowledge of pollutant sources, and an appreciation of the actions that are needed, the community is more likely to take and support actions to address both current and future environmental problems (Hungerford and Volk 1990). Increased public engagement in local water quality management can be a stepping stone to broader and sustained efforts by community members to address other local and regional challenges and opportunities.

10.0 Measureable Goals and Milestones

A clear set of output and outcome goals, and an ambitiously realistic schedule for plan implementation is critical to the successful watershed restoration. This section begins with a discussion of the phased schedule developed for implementation of the recommended BMPs, then discusses relative priorities within the IP project area for implementation of agricultural, residential septic, and stormwater management ("urban") BMPs, and concludes with a detailed discussion how the achievement of water quality goals will be assessed, including the water quality monitoring activities that will support evaluating water quality outcomes.

10.1 Phased Implementation of the IP's BMP Recommendations

It is projected that full implementation of this plan should occur over a 15 year timeframe, and two implementation phases have been developed. Phase I covers the first ten years of implementation, and the BMPs recommended are those that are expected to produce the greatest reduction in bacteria releases to IP project area waters. All livestock exclusion fencing and 80 percent of pasture management recommendations are included in Phase I. Turning to the residential septic systems, all septic pump out recommendations are included in Phase I, as their primary value is to foster better overall septic system maintenance, so that needed system repairs and replacements that achieve significant bacteria reductions will be conducted when needed. Other septic BMP recommendations are allocated equally over time, such that two-thirds of the recommendations are shown in Phase I (10 years) and one-third in Phase II (5 years). All pet waste BMPs, as well as education and outreach are recommended for Phase I, as they are inexpensive components of the plan that will produce their greatest benefits if completed early in implementation.

Phase II puts greater emphasis on urban BMPs, which contribute to bacteria reductions, but have even greater value in addressing nutrient and sediment pollutants that need to be reduced to restore the benthic community health in the three Mountain Run watersheds. Some of these measures are relatively expensive, and concentrating them more in the latter phase will improve the cost-effectiveness of early restoration measures. Turning back to agricultural BMPs, one of the most expensive measures is the construction of sediment retention/water control structures. Due to its cost and the need to take land out of agricultural production to implement it, this measure is infrequently implemented. Past IPs have typically placed it in Phase II, with the caveat that it would be given priority only if other measures prove insufficient to achieve bacteria reduction goals; 95% of this control measure is in Phase II of this plan.

Appendix C presents the recommended number of BMPs and their associated costs by Phase for each individual measure by BMP type. These distributions follow the pattern discussed above, and are intended to give a sense of the relative emphasis that each BMP type should receive during the early and latter stages of plan implementation. As implementation is dependent on the interests of individual producers and land/home owners, the BMP phasing pattern shown is suggestive of ideal implementation; actual progress toward the Phased BMP recommendations will vary from what is shown in the appendix.

Progress toward achieving the BMP implementation goals (outputs) can be assessed through tracking of control measure installations. For EPA-approved IPs that have Section 319 grants awarded to support project implementation, DEQ prepares regular reports to summarize progress toward achieving the BMP goals, as the percentage of the recommended implementation actions that have been installed. These same reports present water quality information as well, to show how water quality has responded to BMP implementation progress; water quality improvement is the ultimate outcome that this plan is designed to achieve. These output and outcome goals are inextricably linked because the implementation of proposed management measures is expected to improve water quality by predictable increments over time, ultimately restoring water quality to that established in the recreational and aquatic life use water quality standards.

10.2 Prioritizing BMP Implementation

From input provided by local stakeholders during IP development and data analysis performed by DEQ, several geographic and programmatic priorities became evident to guide implementation efforts in the years ahead and are discussed below. In addition, there is innovative work underway that will enable a systematic priority setting approach to BMP implementation.

Supported by a RRRC grant from NFWF, the Chesapeake Conservancy is developing a GIS tool to identify specific locations that are appropriate for many of the BMPs that are WIP III priorities for the local area. The specific BMPs for which the new GIS tool will assess place-based implementation opportunities include the following:

Agricultural BMPs:

- Livestock Exclusion Fencing
- Forest buffers
- Land retirement
- Grass buffers
- Tree Planting
- Wetland Restoration
- Agricultural drainage management

Urban BMPs:

- Wet ponds/wetlands
- Dry detention ponds
- Bioretention/rain gardens
- Tree Planting -- Canopy
- Bioswales
- Impervious Surface Reduction
- Forest Planting
- Forest Buffer

As a complement to this work, the planning team has developed, and FOR will pilot test a field protocol designed to validate hyper-resolution hydrography data produced by Chesapeake Conservancy to guide streambank stabilization and stream restoration BMPs. Together these efforts will provide new systematic support for efforts to identify the most appropriate and viable locations to focus voluntary BMP implementation in support of local and regional water quality and habitat restoration efforts.

10.2.1 Prioritizing Agricultural Actions

As was observed in Section 3, the TMDL reports showed that pasture lands contributed the greatest existing bacteria loads in the project area watersheds. Accordingly, to achieve water quality criteria, the greatest bacteria reductions need to come from this source. Agricultural conservation measures that prevent cattle access to streams through exclusion fencing, while providing alternative sources of water,

and creating riparian buffer areas that reduce bacteria runoff from pastures into area streams are essential to improving water quality to meet the State's standards discussed above.

Since livestock exclusion fencing eliminates 100 percent of direct deposits of bacteria into streams from cattle, while the buffer zone further reduces (by approximately 50%) bacteria reaching the streams in pasture runoff, this is the top priority management measure during plan implementation. Not only is eliminating cattle access to streams and creating riparian buffers along streams critical to reducing bacteria levels, it is also a top priority action to reduce nutrients and sediments that are the focus of WIP III. In recognition of this, the Virginia General Assembly enacted legislation setting a goal to exclude cattle from all perennial streams in Virginia by the 2025 implementation deadline of WIP III, as discussed in Section 8.8.

Given that the greatest single source of bacteria in the IP watershed is pasture lands, it will also be essential to give high priority to the discrete pasture improvement measures, and 80 percent of these BMPs are recommended for implementation during Phase I. This plan includes a broad suite of pasture management practice, and there are no implicit priorities among them, given that the specific practices are "interchangeable" with estimated bacteria reduction efficiencies of approximately 50 percent. Outreach to encourage implementation of whatever form of pasture management is of greatest interest to individual agricultural producers should be given a high priority in the early years of implementation. Nonetheless, converting highly erodible pasture and cropland with permanent vegetative cover will produce very high benefits at a modest cost, and this measure should be prioritized with outreach to producers who are currently working highly erodible lands.

Streambank Stabilization recommendations are also among the agricultural land BMP recommendations, and are included primarily for the sediment reduction benefits they will provide. This and accompanying stream restoration measures in the stormwater BMP recommendations are among the most valuable actions to reduce stress to benthic community health in the Mountain Run watersheds.

The exception to the high overall priority of pasture management measures in Phase I is the WP-1 Sediment Retention/Water Control Structure BMP, for which 95% of the BMP recommendation is deferred to Phase II. Because this practice removes land from agricultural production it has been undesirable to producers; therefore it would only be seriously considered late in implementation if other measures prove insufficient to achieve bacteria reduction goals. Turning to Cropland measures, they contribute less to bacteria reduction goals and are placed 50% in each phase, which equates to a relatively lower priority during the 10 years of Phase I.

The measures to reduce equine operation bacterial loads are limited in scope and cost, and the specific IP watersheds where there may be interest by horse owners to pursue the equine/small farm practices is not known at this time. To ensure these practices would be eligible in all IP watersheds, a small (but variable, based on estimated horse population) number of these BMPs are shown in each watershed, and all are allocated 67% in Phase I and 33% in Phase II to suggest equal implementation over the 15 year duration of this plan.

10.2.2 Prioritizing Non-Agricultural Actions

This section addresses priorities for residential septic systems, pet waste and developed land stormwater runoff sources of bacteria, nutrients and sediments. Effectively addressing pet waste sources of bacteria can eliminate potential hot spots created by failure to pick up wastes in areas that have heavy use by pet owners, while also serving as a visual reminder in heavily used public spaces of the need to eliminate all possible sources of pollutants to protect and restore water quality. These measures are inexpensive, and accordingly are all placed in Phase I to foster the earliest benefits of increased public attention and support for watershed cleanup efforts. Priority locations for new pet waste stations include the primary

access points to the public parks in the Town and Culpeper County, as well as areas of larger developments surrounding Culpeper where residents commonly walk their pets.

Better managing stormwater runoff from developed lands is a higher priority in this plan than is common for bacteria IPs, given its emphasis on achieving co-benefits of nutrient and sediment reductions to address the benthic impairments in the Mountain Run watersheds. Several of the stormwater BMPs have relatively high costs, so they are weighted more in Phase II, with 50 percent of these measures placed in the final 5 years of the IP. Geographically, the Mountain Run #1 watershed that contains the Town of Culpeper and the higher density development surrounding is the highest priority area for implementing these urban BMPs. Placing these practices in areas that have known flooding problems will provide additional co-benefits of plan implementation. Similarly placing these measures in locations that future water quality sampling in and around the Town of Culpeper by FOR (discussed in Section 10.3.2below) shows have higher than average bacteria levels will make them more cost-effective in achieving the primary water quality goal of this IP.

While funding assistance for residential septic systems should be made available throughout the project area, funds targeted to older homes located in areas with soils that are poorly suited for drainage could result in significant bacteria reduction benefits. As was shown and discussed in Section 8.5.1.2, the Mountain Run #3 watershed has much older housing stock, and a greater amount of poorly drained soils than the other project area watersheds. Especially when these homes are occupied by low-income residents, needed septic system maintenance, repair or replacement may be deferred to the point of becoming a major source of water quality impairments. Other areas in the IP watersheds also may have pockets of older housing located on poorly drained soils, and it would be valuable for Culpeper County, the C-SWCD, and VDH to work together to identify priority areas for targeted outreach.

One of the most effective ways to foster improved septic system maintenance is to provide financial support for regular system pump outs. Experience shows that this is one of the most effective ways to identify system performance problems before the septic system fails. Accordingly, all RB-1 septic system pump out BMPs are included in Phase I, to foster greater system maintenance in the early years of plan implementation, which is expected to identify opportunities and needs to address more significant septic system issues with repair and replacement BMPs throughout the duration of this plan.

10.3 Monitoring and Assessing Water Quality

Delisting the impaired waters in the plan area is the ultimate goal of this implementation plan. Currently there are 14 stream segments within the IP project area that are impaired for recreational uses due to excess bacteria levels, for aquatic life due to degraded benthic community health, or both (see Table 5-1). These water segments (aka, assessment units) within the plan area will continue to be monitored for *E. coli* levels and benthic health in accordance with DEQ's monitoring strategy to determine if water quality conditions are improving. Speaking first with regard to bacteria monitoring, under the *E.coli* criterion established in 2019, impaired waters must meet both the STV of 410 counts/100mL and the geometric mean of 126 cfu/100mL to be delisted. Once low-frequency (monthly or semi-monthly) monitoring indicates progress within an assessment unit towards meeting the new criterion, it will be a candidate for the frequency (i.e., weekly over a 90-day period) monitoring needed to assess against the current bacteria standards.

Turning to benthic community health monitoring, DEQ will prioritize follow-up monitoring, of both the water quality and benthic macroinvertebrates, to identify if the selected approach to address this impairment is leading towards a healthier benthic community. This monitoring will occur following DEQ's monitoring protocols for implementation plans that address benthic impairments. The general framework is that once monitoring shows water quality improvements, monitoring of the benthic macroinvertebrates will follow to identify if the benthic community is responding in a positive manner.

Should follow-up monitoring identify that the health of the benthic community is not improving, despite reductions of the probable stressors identified as causing stress, further investigation of causes of stress to the impaired benthic community may be warranted.

As shown in Figure 10-1, water quality monitoring has an essential role in the continuous planning process used by DEQ for water quality management. Monitoring conditions relative to the applicable water quality standards allows DEQ to determine which waters are in "attainment" and which are "impaired." The TMDL reports identified the level of bacteria reductions needed to restore the quality of impaired waters, and this TMDL Implementation Plan identifies specific actions recommended to restore water quality to again achieve standards. Future monitoring will be needed to gauge the water quality effects of the BMPs that are implemented, and ultimately determine whether water quality standards are attained.

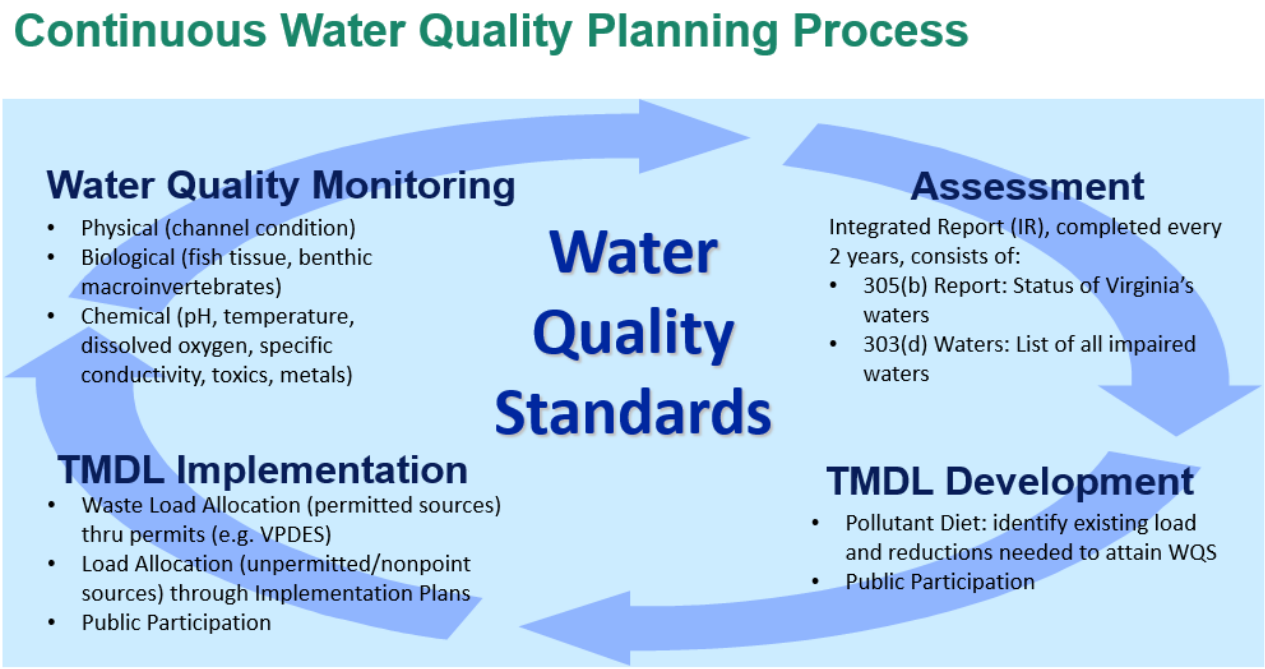


Figure 10-1. Continuous Water Quality Planning Process

When DEQ's monitoring is considered together with others' monitoring activities within the Mountain Run, Muddy Run, and Lower Hazel River watersheds, a much more complete understanding of the area's water quality will emerge over time. After covering DEQ monitoring in more detail, additional monitoring planned by FOR will also be discussed.

10.3.1 DEQ Monitoring

DEQ regularly monitors waters in the IP area as part of its overall water quality monitoring program for the Commonwealth. DEQ's monitoring program both facilitates evaluation of trends over time and allows updated assessments of progress towards achieving the applicable water quality standards. The full network of DEQ monitoring stations that contributed data to the 2020 IR are shown below in Figure 10.3. DEQ monitors water quality conditions at two "Trends" monitoring stations within the IP project area on a regular (bi-monthly) basis annually. In addition, on a five-year cycle DEQ samples other sites as a part of its probabilistic monitoring program. Other DEQ monitoring occurs periodically to meet specific program needs. Drawing from all applicable monitoring events, there were nine water quality

monitoring sites that had sufficient bacteria sampling points to include in review of bacteria overtime presented in Table 5-2.

"Implementation Monitoring" (IM) is done selectively in areas where BMPs have been implemented to determine the water quality response to actions taken and provide data to support updated water quality assessment decisions. Once implementation of this plan has been underway for a few years, the IP watersheds will be a priority for IM monitoring. DEQ will work with local stakeholders to identify IM monitoring priorities, and these monitoring efforts will continue and be adapted as necessary to evaluate progress towards meeting the bacteria water quality criteria.

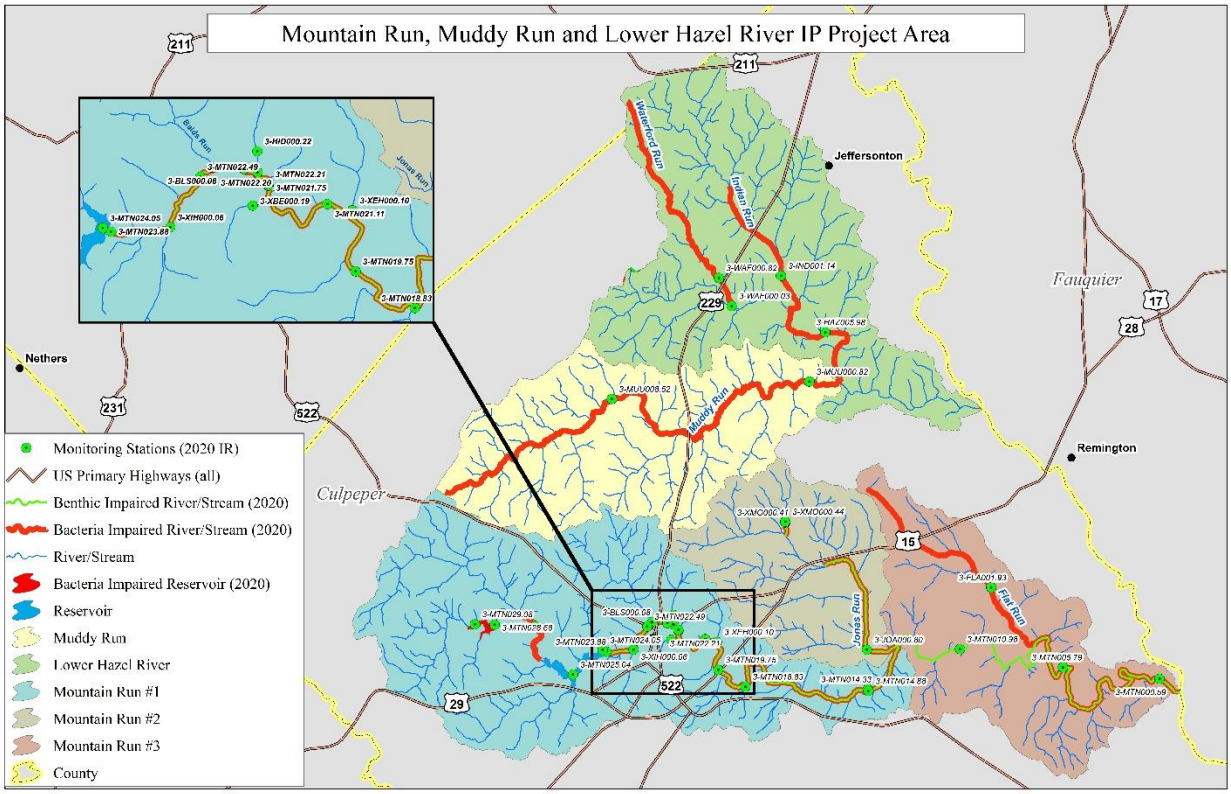


Figure 10-2. DEQ 2020 IR Monitoring Stations within the IP project area

Benthic monitoring by DEQ will occur at stations where biomonitoring has previously occurred in the Mountain Run watershed. The timing of biomonitoring efforts will be guided by the results from water quality monitoring, specifically of the probable stressors (nutrients and sediment), at locations where BMPs have been implemented. These stations may be the same as those selected for bacteria monitoring. Once the water quality at those sites indicate improvements (e.g. reduced levels of nutrients and/or sediment), follow-up monitoring of the benthic macroinvertebrate community at nearby biomonitoring stations will be recommended.

10.3.2 Monitoring by FOR, C-SWCD and others

Citizen monitoring data can greatly improve the understanding of water quality conditions over time, and DEQ provides both training and limited financial assistance each year to promote and support citizen monitoring programs. Often citizen voluntary monitoring programs begin with simplified field protocols that do not meet all DEQ QA/QC requirements for use in assessment decisions. "Level I and II" data is useful to enhance overall understanding of water quality conditions and may be used to identify priority

areas for additional DEQ monitoring. Friends of the Rappahannock have considerable experience conducting water quality monitoring and have recently received a voluntary monitoring program grant from DEQ to conduct monitoring within the IP project area and other nearby watersheds. As this report is being developed, FOR is framing its plans for monitoring bacteria levels and other parameters within the IP project area. Their monitoring results will likely provide valuable information to identify specific areas in and around the Town of Culpeper that show elevated bacteria levels, and this information can be extremely helpful in determining locations that would be most beneficial to locate urban BMPs that will have the greatest co-benefits of bacteria, nutrient and sediment runoff reductions.

In the adjacent EPA-approved IP project areas of Upper Hazel, Upper Rapidan and Robinson/Little Dark Run, the Culpeper-SWCD has also conducted bacteria monitoring as part of their Section 319 grants that provide cost-share support for BMP implementation. C-SWCD has much experience in bacteria monitoring that meets DEQ's Level 3 requirements, allowing their data to be utilized in bi-annual water quality assessments. Future monitoring by the District can also inform progress toward the water quality outcomes that are the ultimate goal of this plan.

Other voluntary citizen monitoring interest may emerge in the future and could further complement the work by DEQ, FOR, and C-SWCD. A helpful resource for groups interested to begin a monitoring is the 2016 Center for Watershed Protection report titled "Safe Waters, Healthy Waters: A Guide for Citizen Groups on Bacteria Monitoring in Local Waterways" (CWP, 2016). This report can serve as a valuable reference both for established citizen monitoring programs, and for those that may be formed in the future.

11.0 Stakeholder Roles and Responsibilities

Achieving the goals of this plan will be dependent on strong participation by many environmental conservation organizations and area landowners and community members. DEQ staff will work with the local SWCDs, the county and town, the NGO's, and other partners to promote and monitor implementation efforts and evaluate progress. This chapter describes the responsibilities and expectations for the primary stakeholders who can support implementation.

Section 319 Nonpoint Source grants are the most effective tool available to DEQ to foster continued engagement of local stakeholders during plan implementation in the years to come. DEQ will share the final IP report with stakeholders involved in its development, and ensure they are aware of the future eligibility of the project area for Section 319 grant funding. The 319 grant program was discussed in all IP development stakeholder meetings, and DEQ will notify eligible organizations in the IP project area of its annual Request for Applications for the Section 319 program. Through Rappahannock River Roundtable communications and other stakeholder engagement efforts, DEQ's natural resource management partners will also promote broad participation in and support for plan implementation.

11.1 Agricultural and Residential Landowners

Since nonpoint sources of runoff to streams is the dominant cause of the bacteria impairment of the IP watersheds, action by the many local landowners is essential to achieving the water quality restoration goals of this plan. While actions are required by many, and the cost of these actions are significant, government agencies are able to provide both technical and financial assistance to support landowner efforts. Local government, SWCD, VCE, and NRCS staff are uniquely positioned to serve as a liaison between individual landowners and the government agencies and programs that can assist them in addressing the sources of bacteria pollution. Their personal knowledge of the local communities, local economy, and natural resources positions them well to foster the collective actions required to achieve this plan's goals.

11.2 Culpeper Soil and Water Conservation District (C-SWCDs) and USDA Natural Resources Conservation Service (NRCS) staff

At the local level in Virginia, SWCDs work in partnership with the USDA/NRCS staff to deliver agricultural conservation technical advice and services to area producers. The Culpeper SWCD serves all of Culpeper and four other adjoining counties, and has among the largest geographic jurisdictions and staff capacity within Virginia. It has considerable technical assistance capabilities to offer landowners within the IP watersheds. Together with NRCS, C-SWCD continually reaches out to farmers within their watersheds to provide conservation practice technical expertise. In the absence of this plan, and grant funds that can support its implementation, these Districts would not have the ability to dedicate staff focused solely on the Mountain Run, Muddy Run and Lower Hazel River watersheds, and this would limit the ability to achieve the ambitious BMP implementation measures called for. With dedicated staffing capability for the IP watersheds, the District can better provide agricultural BMP design and layout assistance to individual producers, and District staff will more broadly communicate with landowners in the watersheds to help advance environmental education and encourage participation in conservation programs, both agricultural and residential programs that focus on septic systems and stormwater management. This IP meets the requirements for funding eligibility under EPA's Section 319 program, for which C-SWCD may apply for grant assistance to enable them to target their expertise to the IP project area landowners. For more information: http://www.culpeperswcd.org/, accessed 5/4/2021.

11.3 Culpeper County and the Town of Culpeper

Except for a small part of the Lower Hazel River IP watershed that extends west into Rappahannock County, the IP watersheds are exclusively within Culpeper County and the Town of Culpeper. Decisions made by local government staff and elected officials regarding land use and zoning will play an important role in the implementation of this plan. This makes the local governments key partners in long term implementation efforts. Culpeper County and the Town of Culpeper should be partners in residential septic and urban BMP outreach and implementation, and may assist with the promotion of pet waste BMPs. Mountain Run flows through three public parks, and these publicly owned lands present excellent opportunities for stormwater management and pet waste BMP implementation. For more information see: https://web.culpepercounty.gov/ (Culpeper County) and https://www.culpeperva.gov/ (Town of Culpeper), Accessed 2/3/21.

11.4 Virginia Department of Environmental Quality

DEQ has a lead role in the development of TMDL implementation plans, which identify the measures recommended for impaired waters to achieve their applicable water quality standards. DEQ also provides grant funding and technical support for TMDL implementation, and will work closely with interested partners on grant proposals for projects included in the implementation plan and track implementation progress.

DEQ will continue to monitor waters within the Mountain Run, Muddy Run, and the Lower Hazel River watersheds to assess water quality and determine when restoration has been achieved and the streams can be removed from Virginia's list of impaired waters. Every two years, DEQ completes the Virginia Water Quality Assessment 305(b)/303(d) Integrated Report (IR), and future IR reports will document the assessment status of waters in the IP area.

For more information: https://www.deq.virginia.gov/water/water-quality, accessed 5/4/2021.

11.5 Virginia Department of Conservation and Recreation

DCR works with the state's 47 soil and water conservation districts to help farmers install conservation measures to protect water quality and sustain agricultural productivity. The agency also teaches citizens and businesses lawn care techniques that keep pollution from reaching nearby streams and more distant waters, such as the Chesapeake Bay. DCR administers the VACS program, working closely with the SWCDs to provide cost share and operating grants needed to deliver this program at the local level and track implementation, and the state's Nutrient Management Program, which provides technical assistance to producers for manure storage and manure and commercial fertilizer. DCR helps landowners, land trusts and localities by serving as a clearinghouse and keeping an inventory of protected lands. The agency also identifies important open space and lands rich with plant and animal diversity, and oversees the Commonwealth's Scenic Rivers Program, and DCR provides grants and information on conservation easements and other land protection tools. For more information: http://www.dcr.virginia.gov/soil-and-water/, accessed 5/4/2021.

11.6 Virginia Department of Forestry

The DOF has a 2011 manual to inform and educate forest landowners and the professional forest community on proper BMPs and technical specifications for installation of these practices in forested areas (https://dof.virginia.gov/wp-content/uploads/BMPs-Imp-Monitoring-2011_pub.pdf, accessed 8/3/2021). Forestry BMPs are primarily directed to control erosion. For example, streamside forest buffers provide nutrient uptake and soil stabilization, which can benefit water quality by reducing the amounts of nutrients and sediments that enter local streams. Although the DOF's BMP program is intended to be voluntary, it becomes mandatory for any silvicultural operation occurring within state

waters (VA Silvicultural Water Quality Law 10.1-1181.2). For more information: visit Chapter 10 in the aforementioned manual. For more information: http://www.dof.virginia.gov/conservation/ accessed 5/4/2021.

11.7 Virginia Department of Health

The VDH is responsible for adopting and implementing regulations for onsite wastewater treatment and disposal. The Sewage Handling and Disposal Regulations require homeowners to secure permits for handling and disposal of sewage (e.g. repairing a failing septic system or installing a new treatment system). VDH staff provide technical assistance to homeowners with septic system maintenance and installation, and respond to complaints regarding failing septic systems and straight pipes. For more information: http://www.vdh.virginia.gov/environmental-health/onsite-sewage-water-services-updated/, accessed 5/4/2021.

11.8 Virginia Cooperative Extension

The local office of VCE is located in Culpeper, and connects residents to Virginia's land-grant universities, Virginia Tech and Virginia State University. Through educational programs based on research and developed with input from local stakeholders, VCE offices help to improve local communities with programs in Agriculture and Natural Resources, Family and Consumer Sciences, 4-H Youth Development, and Community Viability. For more information: http://ext.vt.edu/, accessed 5/4/2021.

11.9 Rappahannock River Basin Commission (RRBC)

The RRBC was established by the Virginia legislature "To provide guidance for the stewardship and enhancement of the water quality and natural resources of the Rappahannock River Basin. The Commission shall be a forum in which local governments and citizens can discuss issues affecting the Basin's water quality and quantity and other natural resources." The Commission's technical workgroup provides an excellent forum for collaboration among stakeholders interested in the natural resources of the Basin. For more information, see" https://rrbcnews.wordpress.com/contact-us/, Accessed 2/3/21.

11.10 Friends of the Rappahannock (FOR)

Along with the RRBC, FOR has offered longstanding leadership of efforts to protect and improve the quality of the natural and cultural resources of the Rappahannock River basin. FOR's goals are organized around advocacy, restoration, and education, and they are highly active on each of these fronts. Its education and outreach efforts are supported in part by a Chesapeake Bay "Roundtable" grant designed to foster broadened support for local and regional efforts to restore water quality, and engage citizens and stakeholder organizations in collaborative efforts toward that end. FOR has a Rappahannock River basin headwaters office in Culpeper, Virginia, and has framed a Mountain Run initiative to focus efforts to improve water quality in the IP project area. For more information: https://riverfriends.org/, accessed 2/3/21.

11.11 Piedmont Environmental Council

PEC was formed in 1972 and works with the citizens of its nine-county region to conserve land, create high-quality communities, strengthen rural economies, celebrate historic resources, protect air and water quality, build smart transportation networks, promote sustainable energy choices, restore wildlife habitat, and improve people's access to nature. PEC works to empower citizens to protect what makes the Piedmont a wonderful place and encourage them to pursue a positive vision for the region's future. PEC

has a long history of working with land owners to conserve their land through easements, is active in water quality monitoring, is jointly pursuing the Headwaters Stream Initiative with FOR to increase riparian tree plantings in the upper Rappahannock basin, and manages the "Culpeper Fund" that provides resources to support local environmental quality restoration projects in Culpeper County. *For more information:* https://www.pecva.org/ accessed 2/3/21.

11.12 American Farmland Trust

The American Farmland Trust, a national program founded in 1980, recently established a "Sustainable Grazing Program" that is currently focused on the Rappahannock River basin. This program promotes the adoption of regenerative farming practices that enhance soil health, sequester carbon, and increase productivity on farms and help to preserve agricultural lands from land development pressures. Seven grazing producers in the Culpeper area already are participating in these programs, which promote land management practices that are in harmony with the goals of this plan. *For more information:* https://farmland.org/, accessed 6/8/21.

12.0 Integration with Other Planning Initiatives

There are several existing local area plans that are especially relevant to this IP, and implementation of each can be mutually reinforcing and create valuable synergy for achieving their articulated goals.

12.1 Culpeper County Comprehensive Plan (2015, under revision)

The current Comprehensive Plan was approved in 2015, and a comprehensive revision of this central guide to ensuring future development occurs in a manner that maximizes benefits to the County, without negatively impacting existing County attributes was initiated in 2020. The Plan includes a chapter dedicated to environmental protection. The plan may be accessed at: https://web.culpepercounty.gov/Government/DepartmentsP-V/PlanningandZoning, accessed 5/4/2021.

12.2 Town of Culpeper Comprehensive Plan (2016, revised 2018)

The current Comprehensive Plan was approved by the Town Council in 2016, and subsequently revised in 2018. The Plan is the central guide to ensuring future development occurs in a manner that will preserve existing community character and positive attributes. It may be accessed at: https://www.culpeperva.gov/Documents/CompPlan_2_26_18.pdf, accessed 5/4/2021.

12.3 Rappahannock-Rapidan Regional Commission

Environmental and natural resource planning is a long-standing project area for the Regional Commission. Recent efforts include coordination of the development and implementation of the Region's Chesapeake Bay Watershed Implementation Plan and a Regional Green Infrastructure Plan, The Commission's Land Use and Environment Committee provides valuable input on these projects. RRRC has noted that it can be helpful to link both local and regional watershed restoration goals in project proposals to funders, such as NFWF's Chesapeake Bay Restoration grant program. More information on RRRC's existing plans and activities may be accessed at: https://www.rrregion.org/program_areas/environmental/index.php, accessed 5/4/2021.

12.4 Virginia's Chesapeake Bay TMDL Watershed Implementation Plan

A Total Maximum Daily Load (TMDL) was prepared by EPA for the Chesapeake Bay in 2010. The overall watershed pollutant loadings are divided among the Bay states and their major tributary basins, as well as by major source categories (wastewater, urban storm water, septic, agriculture, air deposition). Virginia and other Bay states have been required by the EPA to prepare Watershed Implementation Plans (WIP) to guide their efforts to achieve the pollutant reductions called for in the TMDL. During 2018-19, local government jurisdictions, regional commissions, and soil and water conservation districts were all engaged in a detailed effort to prepare a "bottom-up" plan of specific conservation measures designed to achieve Virginia's Bay TMDL goals by 2025. For the IP watershed area, this local planning was conducted through the RRRC. Virginia's Phase III WIP may be accessed at: https://www.deq.virginia.gov/water/chesapeake-bay/phase-iii-wip#, accessed 5/4/2021.

12.5 Friends of the Rappahannock - Mountain Run Initiative

Friends of the Rappahannock's Mountain Run initiative works with partners of the Rappahannock River Roundtable, businesses, and local communities to improve water quality and ecosystem health in the Mountain Run watershed. This includes green infrastructure, tree planting, pet waste management, river cleanups, education programs, and other technical assistance as needed. For more information, see: https://riverfriends.org/mountain-run-initiative-improving-water-quality-in-culpeper/, accessed 12/21/2021.

12.6 Piedmont Environmental Council – Headwaters Stream Initiative

Piedmont Environmental Council's Headwaters Stream initiative will cover 100% of the costs associated with technical assistance, project design, materials, and installation of riparian buffers along streams in the piedmont headwaters of the Potomac and Rappahannock river basins. If livestock are present, the property must have exclusion fencing in place, with a minimum 35' setback. The entire IP project area is within the geographic scope of this initiative. For more information, see: https://www.pecva.org/work/air-water/headwater-stream-initiative/headwater-stream-initiative-faq/, accessed 12/21/2021.

12.7 American Farmland Trust – Sustainable Grazing Project

Launched in 2019, American Farmland Trust's Sustainable Grazing Project is focused on promoting the adoption of regenerative farming practices that enhance soil health, sequester carbon, and increase productivity on farms and operations. This project is based in the Rappahannock Region in Virginia. For more information, see: https://farmland.org/project/sustainable-grazing-project/, accessed 5/4/2021.

13.0 Funding for Implementation

A list of potential funding sources available for implementation is presented and discussed below. Detailed descriptions can be obtained from the parent agencies and at the websites shown. While funding is currently being provided to the local SWCDs for agricultural BMPs and technical assistance for farmers, additional funding commitments are needed to fully implement the agricultural, residential, and urban practices included in the plan.

13.1 Virginia Nonpoint Source Implementation Program

Virginia's NPS implementation program is administered by DEQ through local SWCDs, local governments, nonprofits, planning district commissions, and local health departments to improve water quality in the Commonwealth's streams and rivers and in the Chesapeake Bay. DEQ, through its partners, provides cost-share assistance to landowners, homeowners, and agricultural operators as an incentive to voluntarily install NPS best management practices in designated watersheds. The program uses funds from a variety of sources, including EPA 319(h) and the state-funded Water Quality Improvement Fund (WQIF) to install BMPs with the goal of ultimately meeting Virginia's water quality standards for impaired waters. Although resource-based problems affecting water quality can occur on all land uses, the nonpoint source program focuses cost-share assistance on agricultural, residential, and urban lands. The geographic extent of eligible lands is identified in grant agreements and in watershed based plans, including IPs approved by DEQ and EPA. For more information: https://www.deq.virginia.gov/water/water-quality/nonpoint-source-management, accessed 5/4/2021.

13.2 Virginia Stormwater Local Assistance Fund

The Virginia Stormwater Local Assistance Fund (SLAF) is administered by DEQ, and provides matching grants to local governments for the planning, design, and implementation of stormwater best management practices (BMPs) that address cost efficiency and commitments related to reducing water quality pollutant loads. Eligible capital projects types can include: new stormwater BMPs, retrofits of stormwater BMPs, stream restoration, low impact development projects, buffer restoration, pond retrofits, and wetlands restoration. Funds are awarded competitively on an annual basis, as fund availability allows. For more information: https://www.deq.virginia.gov/water/clean-water-financing/stormwater-local-assistance-fund-slaf, accessed 12/15/2021.

13.3 Virginia Agricultural Best Management Practices Cost-Share Program

The VACS program is administered by the Virginia Soil and Water Conservation Board and DCR, who allocate annual funding to Virginia's 47 local SWCDs. The program goal is to improve water quality in the state's streams, rivers, and the Chesapeake Bay. VACS offers cost-share assistance as an incentive to carry out construction or implementation of selected BMPs. The VACS program encourages the voluntary installation of agricultural BMPs to meet Virginia's NPS pollutant reduction water quality objectives. VACS gives special emphasis on the reduction of nutrients (nitrogen and phosphorus), and sediment delivered to the Chesapeake Bay; by preventing additional pollution from entering state waters; and meeting the criteria for Virginia's compliance with Section 319 of the Clean Water Act. For more information: http://www.dcr.virginia.gov/soil-and-water/costshar2, accessed 5/4/2021.

13.4 Virginia Agricultural Best Management Practices Tax Credit Program

For all taxable years, any individual or corporation engaged in agricultural production for market, who has in place a soil conservation plan approved by the local SWCD, is allowed a credit against the tax imposed by Section 58.1-320 of the Code of Virginia equaling 25 percent of the first $70,000 expended

for agricultural BMPs. Any practice approved by the local SWCD Board must be completed within the taxable year in which the credit is claimed. The amount of the credit cannot exceed $17,500 or the total amount of the tax imposed by this program (whichever is less) in the year the project was completed. If the amount of the credit exceeds the taxpayer's liability for such taxable year, the excess may be carried over for credit against income taxes in the next five taxable years until the total amount of the tax credit has been taken. This program can be used independently, or in conjunction with other cost-share programs on the landowner's portion of BMP costs. It is also approved for use in supplementing the cost of repairs to streamside fencing. For more information: http://www.dcr.virginia.gov/soil-and-water/costshar, accessed 5/4/2021.

13.5 Virginia Conservation Assistance Program

The Virginia Conservation Assistance Program (VCAP) can provide financial incentives and technical and educational assistance to residential/urban landowners who install stormwater BMPs. The program is administered by SWCDs, who accept and review BMP plans submitted by landowners, verify project eligibility, and issue and track reimbursements for completed projects. All non-agricultural property owners (including businesses and public and private lands) in eligible districts may apply for project funding to reduce erosion, and address poor drainage and poor vegetation that contribute to water quality problems. A program manual includes standards and specifications for the urban BMPs that are eligible for reimbursement. The local SWCDs may have staff members available to apply for funds through this program in order to work with interested property owners on eligible BMPs. For more information: https://vaswcd.org/vcap, accessed 5/4/2021.

13.6 Virginia Community Development Block Grant Program

"The Virginia Community Development Block Grant (CDBG) program provides funding to eligible units of local government for planning and implementing projects that address critical community development needs, including housing, infrastructure and economic development. The goal of the CDBG Program is to improve the economic and physical environment in Virginia's communities through activities which primarily benefit low- and moderate-income persons, prevent or eliminate slums and blighting conditions or meet urgent needs which threaten the welfare of citizens." For more information: https://www.dhcd.virginia.gov/cdbg, accessed 5/4/2021.

13.7 Virginia Water Quality Improvement Fund

This is a permanent, non-reverting fund established by the Commonwealth of Virginia in order to assist local stakeholders in reducing point and nonpoint nutrient pollutant loads to surface waters. Eligible recipients include local governments, SWCDs, and individuals. Grants for point sources are administered through DEQ and grants for nonpoint sources are administered through DCR. Most WQIF grants provide matching funds on a 50/50 cost-share basis. The Virginia Natural Resources Commitment Fund was established as a subfund of WQIF in 2008 and monies placed in the subfund are solely available for the VACS program as well as agricultural needs for targeted TMDL implementation areas, such as the Mountain Run, Muddy Run, and Lower Hazel River IP. Watersheds addressed in the water quality improvement plan are eligible for these funds, which are appropriated by DCR to local SWCDs. For more information: https://www.deq.virginia.gov/water/clean-water-financing/water-quality-improvement-fund-wqif, accessed 5/4/2021.

13.8 Virginia Department of Forestry Logging BMP Cost Share Program

When WQIF funding is made available, DOF offers cost-share assistance to timber harvest operators through a unique program that shares the cost of installing forestry BMPs on timber harvest sites by

harvest contractors. Contractors may receive up to 50% of direct project costs, not to exceed $2,500 per parcel, for BMP installation practices involving streams. If the project scope involves the purchase of a portable bridge, assistance shall be 50% of direct project costs plus the portable bridge cost, not to exceed $5,000. For more information: https://dof.virginia.gov/water-quality-protection/logger-assistance/forestry-best-management-practices-bmps-for-water-quality/, accessed 5/4/2021.

13.9 Virginia Riparian Forest Buffer Tax Credit Program

The primary goal of this program is to provide an incentive to landowners through a tax credit for preserving riparian forest buffers along waterways during a timber harvest operation. In 2000, the Virginia General Assembly enacted the Riparian Buffer Tax Credit to provide a non-refundable credit to: individuals, family partnerships, grantors trusts, and limited liability corporations. Applicants must own land that abuts a waterway on which timber is harvested. Recipients must refrain from timber harvesting on certain portions of the land for 15 consecutive years. The amount of the credit is equal to 25 percent of the value of the timber retained as a buffer up to a specified limit. The buffer must be at least 35 feet wide and no more than 300 feet and remain intact for 15 years. The applicant must have a stewardship plan for the tract to qualify. For more information: https://dof.virginia.gov/water-quality-protection/water-quality-protection-landowner-assistance/riparian-forest-buffer-tax-credit/, accessed 5/4/2021.

13.10 Virginia Trees for Clean Water Program

Grants are awarded through this program to encourage local government and citizen involvement in creating and supporting long-term and sustained canopy cover. Through funds from the U.S. Forest Service's Chesapeake Watershed Forestry Program, DOF has developed the Virginia Trees for Clean Water program. It is designed to improve water quality in the Chesapeake Bay through on-the-ground efforts to plant trees where they are needed most. Projects include tree planting activities of all types: riparian buffer tree planting, community and neighborhood tree plantings etc. Grant funds will be reimbursed at the conclusion of the project and funding is available on a 50/50 match basis, with in-kind match including volunteer time permissible. For more information: https://dof.virginia.gov/urban-community-forestry/urban-forestry-community-assistance/virginia-trees-for-clean-water-grant-program/, accessed 5.4.2021.

13.11 Environmental Protection Agency Section 319 Grant Project Funds

Through Section 319, EPA awards Virginia grant funds to implement NPS programs. DEQ administers the money annually on a competitive grant basis to fund TMDL implementation projects, outreach and educational activities, water quality monitoring, and technical assistance for staff of local sponsor(s) coordinating implementation. Section 319 funding provides for implementation of BMPs in IP watersheds with approved local TMDL IPs; the types and number of BMPs identified in Section 8 are the specific activities that may be supported through these grants. Because the Mountain Run, Muddy Run and Lower Hazel River watersheds are located in Virginia's Chesapeake Bay drainage, BMPs that are identified in Table 3 of Chapter 8.2 in Virginia's Phase III WIP III document and will result in nutrient and associated sediment reductions both within the local watershed and within Virginia's Rappahannock River Basin will also be considered for funding under this program. For more information: https://www.epa.gov/nps/319-grant-program-states-and-territories, accessed 5/4/2021.

13.12 EPA/VA Clean Water State Revolving Fund

EPA awards grants to Virginia for its Clean Water Revolving Loan Funds (VCWRLF). The VCWRLF make loans for priority water quality activities throughout the Commonwealth. As recipients make payments, money is available for new loans to be issued to other recipients. Eligible projects include point

source, nonpoint source, and estuary protection projects. Point source projects typically include building wastewater treatment facilities, combined sewer overflow and sanitary sewer overflow correction, urban stormwater control, and water quality aspects of landfill projects. Nonpoint source projects include agricultural, silvicultural, rural, and some urban runoff control; on-site wastewater disposal systems (septic systems); land conservation and riparian buffers; leaking underground storage tank remediation, etc. For more information: https://www.deq.virginia.gov/water/clean-water-financing/virginia-clean-water-revolving-loan-fund, accessed 5/4/2021.

13.13 U.S. Department of Agriculture Conservation Reserve Program

Through this program, cost-share assistance is available to establish cover of trees or herbaceous vegetation on cropland. Offers for the program are ranked, accepted and processed during fixed signup periods that are announced by the USDA Farm Service Agency (FSA). If accepted, contracts are developed for a minimum of 10 and not more than 15 years. Payments are based on a per-acre soil rental rate. To be eligible for consideration, the following criteria must be met: 1) cropland was planted or considered planted in an agricultural commodity for two of the five most recent crop years, and 2) cropland is classified as "highly-erodible" by NRCS. Application evaluation points can be increased if certain tree species, spacing, and seeding mixtures that maximize wildlife habitats are selected. The payment to the participant is up to 50% of the cost for establishing ground cover. Incentive payments for wetlands hydrology restoration equal 25% of the cost of restoration. For more information: https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/, accessed 5/4/2021.

13.14 USDA Conservation Reserve Enhancement Program

This program is an "enhancement" of the existing USDA CRP Continuous Sign-up. It has been "enhanced" by increasing the cost-share rates from 50% to 75% and 100%, increasing the rental rates, and offering a flat rate incentive payment to place a permanent "riparian easement" on the enrolled area. Pasture and cropland (as defined by USDA) adjacent to streams, intermittent streams, seeps, springs, ponds and sinkholes are eligible to be enrolled. Buffers consisting of native, warm-season grasses on cropland, to mixed hardwood trees on pasture, must be established in widths ranging from the minimum of 30% of the floodplain or 35 feet, whichever is greater, to a maximum average of 300 feet. Cost-sharing (75% - 100%) is available to help pay for fencing to exclude livestock from the riparian buffer, watering facilities, hardwood tree planting, filter strip establishment, and wetland restoration. NRCS and the local SWCD determine and design appropriate conservation practices. A 40% incentive payment is offered upon project completion and an average rental rate of $70/acre on stream buffer area is provided for 10-15 years. The Commonwealth of Virginia will make an additional incentive payment to place a perpetual conservation easement on the enrolled area. For more information: https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-enhancement/index, accessed 5/4/2021.

13.15 USDA Environmental Quality Incentives Program

This program provides a single voluntary conservation program for farmers and landowners to address significant natural resource needs and objectives. EQIP offers one to 10-year contracts to landowners and farmers to provide cost-share assistance, tax credits, and/or incentive payments to implement conservation practices and address the priority concerns statewide or in the priority area. Eligibility is limited to persons who are engaged in livestock or agricultural production, NS eligible land includes cropland, pasture, and other agricultural land in priority areas, or land that has an environmental need that matches one of the statewide concerns. For more information: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/, accessed 5/4/2021.

13.16 USDA Regional Conservation Partnership Program

The USDA Regional Conservation Partnership Program (RCPP) is a five-year program that promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. The RCPP competitively awards funds to conservation projects designed by local partners such as SWCDs and nonprofit organizations specifically for their region. Local partners can then work with interested landowners to utilize these funds for BMP implementation. The Chesapeake Bay watershed is one of eight "Critical Conservation Areas" identified in this program. For more information: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/rcpp/, accessed 5/4/2021.

13.17 USDA Agricultural Conservation Easement Program (ACEP)

The Agricultural Conservation Easement Program (ACEP) provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps Federally-recognized Indian Tribes, state and local governments and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect and enhance enrolled wetlands. For more information: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/, accessed 5/4/2021.

13.18 USDA Water & Waste Disposal Loan & Grant Program

The Water & Waste Disposal Loan and Grant Program offers funding as either low-interest loans or grants to qualified applicants who are not otherwise able to obtain commercial credit on reasonable terms. Most state and local governments, private nonprofits and federally-recognized tribes are eligible to apply for assistance to aide rural areas and towns with populations of 10,000 or less, Tribal lands in rural areas, and Colonias. Funds may be used to finance the acquisition, construction or improvement of drinking water and wastewater infrastructure; solid waste management; and stormwater collection, transmission and disposal. Funding is provided in long-term, low-interest loans, and partial grant funding is possible based on financial need and funds availability. For more information: https://www.rd.usda.gov/programs-services/water-waste-disposal-loan-grant-program, accessed 5/4/2021.

13.19 Southeast Rural Community Assistance Project

The mission of the Southeast Rural Community Assistance Project (SER-CAP) project is to promote, cultivate, and encourage the development of water and wastewater facilities to serve low-income residents at affordable costs and to support other development activities that will improve the quality of life in rural areas. They can provide (at no cost): on-site technical assistance and consultation, operation and maintenance/management assistance, training, education, facilitation, volunteers, and financial assistance. Financial assistance includes $1,500 toward repair/replacement/ installation of a septic system and $2,000 toward repair/replacement/installation of an alternative waste treatment system. Funding is only available for families making less than 125 percent of the federal poverty level. For more information: https://sercap.org/about/who-we-serve/community-government-groups, accessed 5/4/2021.

13.20 National Fish and Wildlife Foundation

The NFWF administers the Chesapeake Bay Stewardship Fund, which is dedicated to the protection and restoration of the Chesapeake Bay. The Stewardship Fund is supported through partnerships with government agencies and private corporations, and typically awards $8 million to $12 million per year through two competitive grant programs (Innovative Nutrient and Sediment Reduction Grants and Small

Watershed Grants) and a technical assistance program. Individual grants generally range between $10,000 and $150,000. A request for proposals is typically issued in the spring and awards are made in the fall. For more information: https://www.nfwf.org/, accessed 5/4/2021.

13.21 Wetland and Stream Mitigation Banking

Mitigation banks are sites where aquatic resources such as wetlands, streams, and streamside buffers are restored, created, enhanced, or in exceptional circumstances, preserved for the express purpose of providing compensatory mitigation in advance of authorized impacts to similar resources. Mitigation banking is a commercial venture that provides compensation for aquatic resources. Mitigation banks are required to be protected in perpetuity, to provide financial assurances, and long-term stewardship. The mitigation banking processes is overseen by the Inter-Agency Review Team (IRT) consisting of state and federal agencies and chaired by DEQ and the Army Corps of Engineers. For more information: https://www.deq.virginia.gov/water/wetlands-streams/compensatory-mitigation#, accessed 5/4/2021.

13.22 Additional Sources of Funding

The following programs may be additional potential sources of funding:

- Virginia Outdoors Foundation (VOF). For more information: http://www.virginiaoutdoorsfoundation.org/, accessed 5/4/2021.
- Virginia Nutrient Mitigation Bank Program. For more information: http://www.deq.virginia.gov/Programs/Water/PermittingCompliance/PollutionDischargeElimination/NutrientTrading.aspx/, accessed 4/12/2019.
- U.S. Fish and Wildlife Service (FWS) Conservation Grant Program. For more information: https://www.fws.gov/grants/programs.html, accessed 5/4/2021.
- Trout Unlimited (TU). For more information: https://www.tu.org/conservation/, accessed 5/4/2021.
- Ducks Unlimited. For more information: http://www.ducks.org/, accessed 5/4/2021.

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APPENDIX A. Meeting Summaries

A.1. First Public Meeting – October 28, 2020

October 28, 2020: 6:30 – 8:00pm via Webinar

Participants: A total of 33 people participated in the Public Meeting webinar, including 9 DEQ staff. Non-DEQ participants were from the Culpeper Soil and Water Conservation District, the Rappahannock-Rapidan Regional Commission, several Virginia state agencies, the Town of Culpeper and Culpeper County, Friends of the Rappahannock, Piedmont Environmental Council, a reporter from the Culpeper Times, and several area residents. One phone participant was not identified; others who registered for the webinar are identified below, in alphabetic order of their last name.

Blomstrom, Maggie (Piedmont Environmental Council)

Bottenfield, Sara (Virginia DEQ, Valley Regional Office)

Brooks, Anne (Town of Culpeper)

Calloway, Heningham (Culpeper Soil and Water Conservation District)

Chromey, Brian (Wetlands Studies and Solutions, Inc.)

Cook, Steve (Virginia Department of Health)

Cross, Deborah (Virginia Department of Conservation and Recreation)

Dellinger, Kendall (Culpeper Soil and Water Conservation District)

Edwards, Michelle (Rappahannock-Rapidan Regional Commission)

Evans, David (Virginia DEQ, Northern Regional Office)

Foster, Carol (private citizen)

Foster, John (private citizen)

Furlow, Edward (Virginia Department of Forestry)

Greenfield, October (Friends of the Rappahannock)

Gully, Josh (Culpeper Times)

Hankins, Victoria (private citizen)

Harmon, Nicole (private citizen)

Hofmann, Bryan (Friends of the Rappahannock)

Jacobs, Richard (Culpeper Soil and Water Conservation District)

Lesnichi, Alexey (private citizen)

Massie, David (Culpeper Soil and Water Conservation District)

Mauney, Patrick (Rappahannock-Rapidan Regional Commission)

McCullen, Amanda (Culpeper Soil and Water Conservation District)

Nicely, Cathy (Virginia DEQ, Northern Regional Office)

Owens, Roland (Virginia DEQ, Northern Regional Office)

Shrout, Roy (private citizen)

Shoemaker, Rebecca (Virginia DEQ, Northern Regional Office)

Sivers, Sarah (Virginia DEQ, Northern Regional Office)

Stuart, Ed (Virginia DEQ, Northern Regional Office)

Thomas, Bryant (Virginia DEQ, Northern Regional Office)

Unknown Phone Participant

Wichelns, Greg (Culpeper Soil and Water Conservation District)

Wyrick, Tara (Virginia DEQ, Valley Regional Office)

Welcome and Introduction

DEQ provided an overview of the GoToWebinar platform used for the Public Meeting, and explained the means attendees had available to participate, and informed attendees that the meeting would be recorded.

The formal opening remarks prepared for this virtual meeting were read. These remarks included an explanation of the DEQ staff support roles for the webinar, and a sense of the breadth of attendees present and the organizations they represented.

David Evans of DEQ presented a series of MS PowerPoint slides in two parts that explained DEQ plans for development of an Implementation Plan (IP) for the project area, and presented data summaries relevant to plan development.

Part I: DEQ presented the following information:

- Overview of water quality impairments within the project area, including bacteria impairments in all watersheds, and benthic impairments present in Mountain Run.
- DEQ noted that Mountain Run also has PCB impairments, which will be addressed in separate TMDL study that will begin early 2021.
- Land cover data overview and general population density and numbers
- Poll Question #1 was conducted on "where I live….": 72% voted
- 39%: within the IP project area
- 22%: outside the project area
- 39%: live outside, work within
- Further information on water quality impairments, bacteria and benthic, and the primary/likely sources and concerns that need to be addressed.
- TMDL allocations (sources and reductions needed) overview for each of the three (3) Bacteria TMDL reports that the IP will address.
- Bacteria level trends (2002-2020) were presented and discussed. DEQ noted that 2018 was a very wet season, as well as subsequent years in comparison to earlier years. Bacteria levels are highest following significant precipitation events, and that makes a comparison of bacteria levels over time challenging.
- Virginia Stream Condition Index (VSCI) scores for Mountain Run and its tributaries (Jonas Run and Flat Run) were presented and discussed. Benthic community health index (VSCI) scores were discussed, noting that recent values both along Mountain Run and its tributaries have been below the threshold value (60), resulting in benthic impairments.

- Overview of Water Quality planning process, with a more detailed focus on the TMDL implementation plan portion
- Poll Question #2 was conducted on "I'm most interested in….": 88% voted
    - Agriculture: 35%
    - Septic Systems: 22%
    - Stormwater: 43%
    - Other: 0%
- Overview of technical methodology being used for this IP, which uses comparative analysis of similar watersheds in previous/approved IPs. This approach saves the expense of technical contractor support and improves the cost efficiency of preparing this (and potential other future) bacteria IP(s).

Part I Q&A:

- Question: A participant (J. Gully) requested a copy of the meeting recording. DEQ stated that a copy of the presentation recording will be provided to all registered attendees.
- Question from Victoria Hawkins: How do bacterial levels in the watersheds correlate to those in groundwater? Can we expect the project addressing the watershed bacteria loads will improve well water quality? DEQ observed that unless there is karst topography, the interaction between surface runoff of bacteria and bacteria levels in aquifers is limited. There may be more correlation of surface and shallow groundwater bacteria levels, but shallow groundwater typically isn't used as a drinking water source.
- Mountain Run Lake questions:
    - Question from John Foster: The map indicates that Mountain Run Lake is significantly polluted. How did the drawdown of the lake over the past 2 years impact its current condition? Question from Ray Shrout: I'm new to the area but isn't Mountain Run Lake part of the drinking supply for the county, and if so, how is this project addressing those concerns?
    - DEQ answered these questions with the general observation that lakes typically don't have high bacteria levels, but when they do it is usually associated with a heavy rain event. DEQ will review the specifics of bacteria sampling results for the lake and share findings at future workgroup meetings to explain when the exceedance occurred relative to heavy rain events. DEQ also noted that if a drinking water source has elevated bacteria levels, the water would be treated to remove excess bacteria before it is distributed to public water supply users. Bryan Hofmann of Friends of the Rappahannock shared his understanding that Mountain Run Lake is the backup drinking water supply for the region.

Part II: DEQ presented the following information:

- Overview of the human population data and growth trends, with note that pet populations can be estimated from the human population.
- Agricultural sources of bacteria from livestock and agricultural lands were highlighted from the TMDL reports, the draft 2020 Integrated Report by the Virginia Department of

Conservation and Recreation, and recent land cover analysis. DEQ noted that in earlier email communications, Carl Stafford of Virginia Cooperative Extension had shared his sense that dairy cattle in local watersheds are lower that the draft 2020 report shows.

- Septic system data analysis and opportunities for sewer connections were summarized.
- Poll Question #3 was conducted on "My residence is on…..:" 80% voted
    - Septic: 65%
    - Sewer: 30%
    - Not Sure: 5%
- Data on Agri. and Residential Septic BMPS installed from 2000-2020 was provided.
    - Question by Bryan Hofmann: "Do these figures include NRCS data?" DEQ responded that BMPs exclusively funded by NRCS are not included, but the data summary included BMPs where state and federal funds were combined.
    - Question: Does the $4.1M for Agricultural and Residential Septic BMPs for 2000-2020 cover the PDC region, specifically? DEQ responded that the data presented is only for BMPs located within the IP watersheds.
- Several slides were discussed that showed potential control measures for agricultural, residential septic, pet waste and stormwater sources of bacteria.
- A slide was presented on local planning efforts and DEQ noted its desire to explore and capitalize on opportunities for synergy with these efforts/initiatives and the new IP.

Part II Q&A

Questions from Bryan Hofmann: Will this project require or benefit from additional WQ monitoring sites? DEQ answered that workgroup discussions may identify areas where additional water quality monitoring could better inform IP development. In general, DEQ would find additional monitoring (beyond what DEQ can perform) to be most helpful in the future to identify areas most important for additional BMPs and to identify the effect of implemented BMPs.

Question from Michelle Edwards: Has the Culpeper Equestrian association been invited to participate? DEQ stated that it wasn't aware of that organization and requested their contact information so staff can reach out to them.

Additional Comments from Participants

Bryan Hofmann observed that the Mountain Run Watershed had the lowest score of all sampled watersheds in the Friends of the Rappahannock's 2019 Upper Rappahannock River Report Card. He shared his appreciation for the IP development process and all the work DEQ and its partners are putting into the IP process.

Patrick Mauney of the Rappahannock-Rapidan Regional Commission noted that IP watershed population estimate of 50-60,000 seemed very high. The 52,000 County population estimate is inclusive of the ~20,000 town population. DEQ thanked Mr. Mauney for this insight, and will adjust its project area population estimate accordingly.

Roy Shrout recommended that DEQ invite the Virginia Department of Emergency Management to participate in IP development, and shared the VDEM local coordinator's contact information.

Meeting Closure

DEQ summarized the timing (Oct 29 – November 30, 2020) and process to submit formal public comments on this project, and provided information for participants to provide feedback on the virtual meeting format (which are submitted to the Virginia FOIA Council). Lastly, DEQ announced the first workgroup meeting would be held the next day, Oct. 29th from 10am-12 pm, and shared information on how interested members of the public could participate.

A.2. First Meeting of the Agricultural and Residential Workgroups – October 29, 2020

October 29, 2020: 10am – Noon via Webinar/Conference Call

Participants: A total of 32 people participated in the Workgroup Meeting webinar, including 6 DEQ staff. Non-DEQ participants were from the Culpeper Soil and Water Conservation District, the Rappahannock-Rapidan Regional Commission, several Virginia state agencies, the Town of Culpeper and Culpeper County, Friends of the Rappahannock, Piedmont Environmental Council, a reporter from the Culpeper Star Exponent, and a few area residents. Participants are identified below, in alphabetical order of their last name.

Bayne, Melanie: Town of Culpeper

Blomstrom, Maggi: Piedmont Environmental Council

Calloway, Heningham: Culpeper Soil and Water Conservation District (SWCD)

Champion, Allison Brophy: Culpeper Star Exponent

Cook, Steve: Virginia Department of Health

Cross, Deborah: Virginia Department of Conservation and Recreation

Dellinger, Kendall: Culpeper SWCD

Edwards, Michelle: Rappahannock-Rapidan Regional Commission (RRRC)

Evans, David: Virginia Department of Environmental Quality (DEQ)

Foster, John: Culpeper resident (Mountain Run Lake)

Furlow, Edward: Virginia Department of Forestry (DOF)

Greenfield, October: Friends of the Rappahannock (FOR)

Hardy, Andrew: Culpeper County

Hermoso, Dina:

Hofmann, Bryan: FOR

Holt, Ben: Town of Culpeper

Andrew Hopewell, Town Of Culpeper

Howard, Paul: Culpeper County

Jacobs, Richard: Culpeper SWCD

Massie, David: Culpeper SWCD

McCullen, Amanda: Culpeper SWCD

Owens, Roland: DEQ

Cathy Nicely, DEQ

Rossetti, Joe: DOF

Sivers, Sarah: DEQ

Stafford, Carl: Virginia Cooperative Extension

Stuart, Ed: DEQ, and Culpeper County resident

Thomas, Bryant: DEQ

Wichelns, Greg: Culpeper SWCD

Unknown Phone Participant #1: (540) 825-8591

Unknown Phone Participant #2: (540) 727-3412

Unknown Phone Participant #3: (540) 219-3460

Welcome and Introduction

DEQ provided an overview of GoToMeeting platform and explained the means by which attendees could participate and contribute to the discussion. DEQ informed attendees that the meeting would be recorded.

The formal opening remarks were read, and they included an introduction of the DEQ staff helping with the webinar. Attendees were invited to introduce themselves by posting their name and organization in the chat box.

DEQ then summarized the purpose and the objectives of the meeting, which were to seek and receive member input on the information shared during the meeting, and proceeded to discuss the MS PowerPoint presentation posted to DEQ's website and shared by email with participants.

Project Overview

- The DEQ presentation began with a summary of the water quality impairments within Implementation Plan (IP) project area, which include bacteria impairments in all watersheds, and benthic impairments in Mountain Run.
    - DEQ noted that Mountain Run also includes some PCB impairments that will be addressed in a new TMDL study to begin early 2021.
- A quick review of the WQ planning process was provided, with a more detailed focus on the TMDL implementation plan portion and public involvement.

Part I – Agricultural Workgroup Discussion

- Agricultural sources of bacteria from livestock and agricultural lands were highlighted, from the TMDL reports, the draft 2020 Integrated Report by the Virginia DCR, and recent land cover analysis. DEQ noted that Carl Stafford of Virginia Cooperative Extension previously shared his sense that dairy cattle in local watersheds are lower than the draft 2020 report shows.
- DEQ summarized land use changes from 2001-2020 and why the analysis looked at both National Land Cover Dataset (NLCD) as well as Virginia Land Cover Dataset (VLCD). The latter is considered the most accurate data due to more detailed resolution of the land imagery. NLCD data is available in time-series and was used to portray land use changes over time, while VLCD data was used to present the most accurate sense of current land use in the IP project area.
- DEQ presented and discussed summary information on the $4.1 million in Agricultural and Residential Septic BMPS installed from 2000-2020. This was followed by a discussion of bacteria level trends (2002-2020), which show a higher level in bacteria criteria exceedances in recent years.
- DEQ explained the challenge of evaluating bacteria trends due to the inability to control for the timing of sampling events relative to rainfall/runoff, and noted that 2018 had record levels of rain, and 2019 and 2020 have had above average rainfall; this impacted bacteria sampling results.
- Greg Wichelns, District Manager of Culpeper SWCD (C-SWCD), was invited to summarize their agricultural program activities. He asked David Massie, who manages the District's Agri. BMP cost share program, to provide summary remarks:
    - C-SWCD has 5 staff, covering five counties, who in the past 10 years have worked to carry out grant projects in 4 other IP areas. There has been a high level of interest from agricultural producers, and C-SWCD has been able to complete much work on the ground.
    - Section 319 grant funds, which provide targeted funding within IP project areas, enable the statewide VACS funds to go further. Historically Section 319 grants have supported higher cost-share rates that are attractive to producers, and allow

for more flexibility than VACS, such as variable setback distances for fencing. While VACS now includes some of those flexibilities and higher cost-share rates for fencing, the Section 319 funds continue to enable increased overall cost-share funding in the IP watersheds.

- Additional comments by David Massie included the following:
    - Completion of an IP allows funds to be used to educate the public on what they can do, in terms of both agricultural and residential septic measures.
    - While most believe agriculture is the greatest bacteria pollutant source, significant bacteria levels also come from the Town, wildlife and septic systems.
    - Maintaining good relationships (with a neutrality and partnership approach) with area producers enables the District to achieve more conservation on the ground.
    - The Department of Forestry provides technical assistance to assist with plans for buffer planting, and Virginia Cooperative Extension shares questions or needs from citizens with C-SWCD for detailed follow up.
    - The U.S. Dept. of Agriculture's NRCS is co-located with C-SWCD; this presents opportunities to collaboratively address producers' interests and issues.
    - Andrew Hopewell, the new Town of Culpeper Director of Planning and Community Development, was recognized due to his need to leave the call early. He had no specific remarks and expressed appreciation for the ability to participate.
- DEQ then provided an overview of the comparative analysis methodology being used to develop preliminary (aka "strawman") recommendations for a set of "core" BMPs, which include livestock exclusion fencing, buffers and pasture management as well as septic repairs/installation. The focus on these BMPs is because all bacteria IPs give primary focus on those measures. The methodology was discussed using the Jonas Run watershed as an example.
    - Question by Greg Wichelns: are the BMPs that are already implemented excluded from the recommendations? DEQ responded that completed BMPs were not subtracted from the comparative analysis strawman. Greg observed that about 60% of the exclusion fencing strawman value has already been accomplished (the 80 miles completed from 2001-2020 could be subtracted the estimated 123 miles needed). DEQ noted that while a simple subtraction may not be warranted, adjustments to account for completed BMPs are warranted, and will be the subject of further discussions within the Agriculture workgroup.
    - Question by Greg Wichelns: Is the 741 acres of buffer the result of livestock exclusion fencing? Greg also asked DEQ to clarify if CREP or federal funding (NRCS) was included in completed BMPs. DEQ responded that the buffer totals included those accomplished both in Livestock Exclusion Fencing systems and separate buffer BMPs. CREP-funded projects are included, but those funded solely by the federal government, such as EQIP, are not included.
- DEQ asked participants to respond to the questions posed on the Agricultural Discussion slide, and the following observations were shared:
- David Massie noted that since 2019, VACS program changes enabled up to 100% cost share for fencing projects, with additional payments for riparian buffer areas. This has significantly increased interest from producers. Several recent projects have been installed in the Mountain Run watershed. Soon there will also be an option for cost-share

funding for temporary fencing, which may be of interest for flood-prone areas in the eastern portion of the Mountain Run watershed.

- Greg Wichelns noted that the District has potential funding to purchase movable shade areas. Use of movable shade is valuable for producers who use rotational grazing, and could reduce the undesired practice of allowing cattle to access forested riparian areas during the summer months to escape the heat of sunny pastures.
- David Massie noted that pasture management practices that maintain grass heights and control weeds improve nutrient absorption to the soil, and reduce bacteria runoff. Cropland management is challenging, but moving to variable fertilizer application rates is recommended, and shallow tillage practices (except when incorporating bio-solids into the soil). These all are becoming popular practices in the area.
- Carl Stafford asked whether tree planting has the potential to become similar to wetlands banking, to help offset the land clearing associated with large-scale solar power projects. DEQ observed that the Virginia General Assembly has passed legislation to establish a program to support forest preservation and afforestation through participation in carbon markets. Joe Rosetti of DOF noted that this program is in its very early stage of development, but could provide forestry incentives in the future.
- Joe Rosetti asked if there would be a mechanism to add limited tree planting to provide shade within pastures. Greg Wichelns responded that this could be a producer's choice, but that in context of rotational grazing, movable shade provides greater flexibility and doesn't require 10 yrs or so for the planted trees to mature. Bryan Hofmann noted that Friends of the Rappahannock can support tree planting and is interested to discuss this further.
- Joe Rosetti commented that the percent of forest in the IP watershed (referring to the data on Jonas Run) was extremely low and any buffer/afforestation occurring in the watershed would be beneficial, with riparian tree planting most valuable. October Greenfield noted that afforestation should be a priority, and that FOR has gotten a lot of interest and that afforestation projects are opportunities for partnerships with C-SWCD, FOR, DOF, PEC and local volunteers. Bryan Hofman and Carl Stafford expressed support for such partnerships and bundling support/assistance.
- Maggi Blomstrom agreed with these comments, and asked if the IP project area watersheds could benefit from added incentives such as those provided in Rappahannock County by the Krebser Fund (which provided for 100% cost-share for fencing when the State rate was lower). Greg Wichelns observed that the "Krebser model" of providing additional incentives as beneficial and would be helpful for this project area. Bryan Hofmann then noted that the Rappahannock River Roundtable also has funding to offer additional incentives for this region, and Maggi Blomstrom observed that the "Culpeper Fund" can also support additional incentives.

Part II – Residential Workgroup Discussion

- DEQ presented a series of slides that summarized information on human population estimates (which can be used to project pet populations), septic system analysis and opportunities for sewer connections, land use change from 2001-2020 with focus on developed lands, and completed residential septic BMPs in the watershed.

- DEQ then discussed the comparative analysis methodology used to create strawman septic BMP recommendations, and noted the strawman values did not take into account septic BMP work done already.

Comments/Perspective from CSWCD, Local Government and NGO

- Michelle Edwards spoke for RRRC, with a focus on their work in support of the Chesapeake Bay WIP III
    - In 2018, RRRC led development of a set of recommended BMPs and implementation strategies for the urban/septic sector to meet its Bay TMDL nutrient reduction allocations. These included wet ponds, urban tree planting, constructed wetlands, infiltration practices and other BMPs that have both bacteria and nutrient removal benefits.
    - RRRC's Upper Rappahannock Watershed planning effort is advancing WIP III implementation in the area, by spatially prioritizing BMP recommendations. A primary focus of Phase I is to compile and digitize data from different partners to support plan implementation. Data will be available to partners through a MOU due to data sensitivity (to maintain privacy information).
    - Phase II, which is supported by a NFWF grant, will be a partnership with the Chesapeake Conservancy to develop a customized web-based platform to support planning on a variety of spatial levels, using enhanced hydrography and land cover data. RRRC is contracting with FOR to ground-truth this planning tool, support the effort with WQ monitoring and site-specific assessments, and conduct education and outreach.
    - Green infrastructure planning conducted in the past identified areas for WQ protection, and provide another resource for project area planning. RRRC recently completed and posted to their website a Homeowners Guide to water quality management, and has experience with pet waste management programs conducted under past Section 319 grants to C-SWCD.
- Greg Wichelns, C-SWCD then discussed the District's experience implementing Residential Septic cost-share and VCAP programs.
    - The District's Residential Septic cost-share program is well known in the five counties the District encompasses. In addition to the four IP project areas eligible for Section 319 funding, the District recently completed a 4 year WQIF septic project that filled in areas not covered by 319 funding. Broad area education and outreach has been very effective, and strong partnership with VDH and County Health Departments are in place.
    - Private contractors have become familiar with the cost-share program, and are instrumental in moving the project forward. Greg would like to see more funds available (319 or WQIF) to support the program, and noted that this IP area is the least funded part of the C-SWCD's jurisdiction. The septic cost-share program has enabled the District to interact with a wider range of citizens than previously (focused most attention on the Agricultural sector).
    - VCAP program: Richard Jacobs was instrumental in creating many of the specifications for the Virginia Conservation Assistance Program (VCAP). In recent years Richard and Henny Calloway have completed many projects

throughout the five counties, these have been primarily residential, retrofit-type projects.
    - The District's residential lawn soil testing program brings science to decisions on fertilizing lawns; it has a high participation rate, working with the Virginia Tech Soil testing lab.
- October Greenfield, the FOR River Steward for the Culpeper area, shared an overview of their ongoing and planned activities, which include:
    - Partnerships built in Town and County of Culpeper through urban buffer plantings (several in Mountain Run and one along Muddy Run). FOC has teamed with RRRC and Culpeper County Parks and Recreation to give away one gallon trees to county residents and businesses. Efforts are focused on outreach, programs to garner interest and participation on getting tree planting on the ground. FOR's Mountain Run initiative is aimed at addressing urban stormwater.
    - Bryan Hofmann then commented Rappahannock River Roundtable also supports projects that get practices on the ground and provide outreach. Examples include urban forests and urban nutrient management. FOR looks forward to hearing ideas on how they could find regional funds to help support additional on the ground projects.
- Maggi Blomstrom shared comments about the work Piedmont Environmental Council is doing in the area:
    - PEC joins in partnerships (with DOF, FOR, SWCDs) to get more tree planting on the ground.
    - PEC has developed a proposal for the "Rapidan-Rappahannock River Partnership". This is a project application for funding from NRCS to support practices such as tree planting, riparian buffers and strategic conservation areas.

Residential Workgroup Discussion

- Greg Wichelns asked about the comparative analysis tables – is the data built using a core assumption from the older IPs that a higher septic failure rates are from older homes? DEQ said that is reflected in general, but because different contractors prepared the IPs used for comparative analysis, the original methodologies are not likely to be fully consistent. The strawman recommendations provide a very basic starting point and can be refined as we continue discussions.
- Carl Stafford observed that increased human activity is the largest change in the watershed. He noted that the ratio of pets to people is important to assess, and observed that when land is developed, many people believe it pushes water fowl and wildlife out. Carl shared his observations that development creates new opportunities and habitat for wildlife like small mammals. It is important to recognize these are all sources of bacteria.
- Michelle Edwards noted that RRRC has had success with installing pet waste stations in follow up to previous IPs, but did not have success with pet composters. She recommended not including pet waste composters in the IP recommendations.
- Bryan Hofmann noted that FOR has funding available to provide pet waste stations to high priority areas within Mountain Run. Many areas within the parks already have them installed, but there are opportunities in the residential areas and along trail areas for additional pet waste stations, and there is a need for targeted outreach and to assess the

specifications for pet waste station BMPs. Michelle Edwards shared her agreement with Bryan's comments.

- Ben Holt of the Town of Culpeper said there is a need to place more pet waste stations at Yowell Meadow Park and along the adjacent greenway trail.
- Greg Wichelns asked if there was a strategy to identify the effectiveness of urban practices such as rain gardens to reduce the bacteria pollutant load. DEQ replied that this is a good question that will warrant continued discussion. DEQ observed that in the most recent completed IP (Mattaponi River) approved by EPA did not include specific assessment of the bacteria reductions from those BMPs, and that the stormwater BMPs were accepted for inclusion based on generic bacteria reduction efficiencies.
- Ben Holt share a comment that uncontrolled stormwater runoff can create infiltration for old sewer pipes, exacerbating the issue and causing those sewer pipes to leak. He asked if this was a concern within and around the Town's wastewater treatment facility. DEQ suggested follow up with the Town on the question and noted there is a fine line between what can be addressed in this IP versus what is subject to permit requirements.
- Bryan Hoffman recommended targeting BMPs with more direct impacts on nutrients and sediment (vs. bacteria) to the streams and in surrounding areas where there are benthic impairments.

Part III – Synergy with Other Local Planning Efforts

- DEQ briefly noted other local planning efforts in the region in reference to the slide that listed several such plans/initiatives.
- Maggie Blomstrom noted that the Krebser Fund for Rappahannock County provides funding to headwater stream initiatives and additional incentives for landowners to install conservation practices. In Culpeper Co., the "Culpeper Fund" can do similar activities, and has historically supported conservation easements. The foundation resources are very flexible in terms of their allowable uses.

Meeting Closure

- DEQ highlighted the preliminary project timeline, and noted that moving at the desired pace would create the possibility of a Section 319 grant application for the project area in the 2022 RFA, that will be posted in the Summer of 2021.
- DEQ is seeking input from participants on their desire to participate in the workgroups and in which focus area, agriculture or residential/septic/urban, their interests lie.
- DEQ noted that the public comment period for input on DEQ's plans for this IP runs through November 30, 2020, and provided information for participants to share feedback on the virtual meeting format (send to FOIA Council).
- DEQ quickly noted the additional MS PowerPoint slides at the end of the presentation, that were included to provide more detailed bacteria data, and additional reference information for participants to look at on their own.
- DEQ thanked all participants for their interest in the project, and committed to share draft meeting summary notes within a week for review and comment.

A.3. Second Agricultural Workgroup Meeting – January 28, 2021

January 28, 2021 – via Webinar/Conference Call

Attendees:

Dave Evans, DEQ

Roland Owens, DEQ

Cathy Nicely, DEQ

Sarah Sivers, DEQ

Kendal Dellinger, Culpeper SWCD

Amanda McCullen, Culpeper SWCD

Greg Wichlens, Culpeper SWCD

October Greenfield, FOR

Allison Brophy, Culpeper Star Exponent

David Massie, Culpeper SWCD

Susan Ralston, Watershed resident

Bryan Hofmann, FOR

William Schmidt, Watershed resident

Maggi Bloomstrom, PEC

Carl Stafford, VCE

Michelle Edwards, RRRC

Joe Rossetti, DOF

Melanie Bayne, Town of Culpeper

Debbie Cross, DCR

Welcome and Introductions

Dave Evans of DEQ opened the workgroup meeting with an overview of meeting logistics and shared formal opening remarks explaining the rationale for holding an entirely virtual workgroup meeting. Following that he went over the meeting agenda and objectives.

Discussion

A MS PowerPoint presentation provided an overview of the type and amount of best management practices (BMPs) that are relevant to addressing bacteria sources from agriculture practices. Information shared included (1) the methodology and preliminary results of a comparative analysis drawing upon approved IP BMP recommendations for livestock exclusion fencing and pasture management, (2) additional agricultural BMPs contained in seven EPA-approved bacteria IPs, and (3) agricultural BMPs included in the WIP III for the project area that can reduce both bacteria and nutrients and/or sediments. Roland Owens (DEQ) clarified that the WIP III measures that were presented were developed to achieve Nitrogen reduction targets for cleanup of the Chesapeake Bay. The following discussion occurred during and after the information presented by DEQ.

Comment: Greg Wichelns, Culpeper Soil and Water Conservation District (C-SWCD) asked DEQ to expand on the exceedances for bacteria, the 10% rule and the data leading to the impairment. The comment was that some of the project area waters may be only marginally impaired.

Answer: DEQ addressed the question in general terms, and committed to follow up with more specific data. (This was shared with workgroup members by email on Jan. 28, 2021).

Question: Carl Stafford, Virginia Cooperative Extension (VCE) questioned how samples taken during wet events when the waterbody is stirred up could be representative of the waterbody. In response to DEQ's

initial comments (which noted that some extremely high bacteria levels have been detected in recent years, which have included many heavy precipitation events which resulted in a flushing of bacteria into streams), Carl noted there should be caution in using terms of "extremely high", etc.

Answer: DEQ responded that high precipitation events can lead to bacteria readings that are not representative of average conditions, and explained that DEQ plans and schedules its monitoring work each year to enable coverage of the entire region. DEQ then mentioned that the monitoring program adheres to the planned schedule and locations unless conditions are unsafe. DEQ further clarified that monitoring efforts do not target specific weather conditions, so that water quality conditions under a range of conditions are identified. DEQ also noted that the water quality standards are designed to be protective during all conditions, not just during average conditions. DEQ uses a water quality criterion threshold to assess waters as "supporting" or "not supporting" their designated uses; a few exceedances (<10.5%) are possible without resulting in an impairment ("not supporting"), and also explained that the impairment might be more or less significant based on the bacteria levels present and the frequency the criterion is exceeded.

Comment: Bryan Hofmann (Friends of the Rappahannock, (FOR) informed the group that FOR was awarded a water quality monitoring grant from DEQ to do enhanced monitoring on Mountain Run and other tributaries in the project area. They are willing to consider monitoring at specific locations that workgroup members may be interested in. Their monthly monitoring will be sent for laboratory analysis, which results in Level III data that DEQ can use in its water quality assessment decisions.

Comment: Greg Wichelns (C-SWCD noted that it is important to remember the source of bacteria is not known.

Answer: DEQ responded that is very good point and also noted that land use analysis can shed some light on possible sources.

Carl Stafford (VCE) added a comment that identifying the actual sources of bacteria is his primary concern and interest in this project.

Question: Debbie Cross, Virginia Department of Conservation and Recreation (DCR) asked if horses are included in the IP?

Answer: Yes, horses are considered.

Question: Roland Owens (DEQ asked workgroup members to share their perspectives on how agriculture is evolving in the watershed? He noted that DEQ has looked at DCR's Nonpoint Source assessment data.

Answer: Carl Stafford (VCE) noted that dairy farms are decreasing and being replaced with beef cattle and crops. Also, land use changes from agriculture to developed land are also occurring. He recommended focusing on known bacteria sources and influences, and observed that wildlife sources are likely significant. Greg Wichelns (C-SWCD) agreed with Carl's observation on land use changes, and stated they are not radical but moderate in scope, and Debbie Cross (DCR) noted that developed land expansion is primarily around the Town of Culpeper. The rate of development is not as high as it was 10-15 years ago; County population growth was approximately 13 percent over the last decade.

Question: Carl Stafford (VCE) asked DEQ to speak to the average citizen who will be listening through the reporter's words, in terms of why additional livestock exclusion fencing is prioritized.

Answer: DEQ noted that in the water quality planning program, it has its greatest experience developing TMDLs and Implementation Plans for bacteria. The TMDL program has conducted extensive modeling throughout Virginia that identifies the main sources of bacteria pollutants. Run-off from pasture

lands is consistently shown to be the largest source of bacteria in impaired watersheds. In addition, real world experience with livestock exclusion fencing and riparian buffers also has shown that these projects can significantly improve water quality.

Comment: Carl Stafford (VCE) said Thumb Run study found an example where bacteria runoff was higher from the forest and not the pasture land.

Answer: DEQ commented that the focus of Implementation Plans (IPs) is on human activity based sources of bacteria, such as from cattle farming, septic systems and pet wastes. DEQ noted that wildlife sources of bacteria are more challenging, but that some practices such as buffers could help to address wildlife bacteria to some extent. Mr. Stafford (VCE) replied that it was important that DEQ communicate that the practices recommended will be focused on the sources we can address, but that it does not mean those sources are the greatest contributors of bacteria in the watershed.

Comment: David Massie (C-SWCD) commented that incentives for stream exclusion entice producers to sign-up for those practices. Accordingly, the IP should recommend all applicable practices to promote the broadest suite of incentives/encourage BMP sign-ups.

DEQ asked a follow up question of Mr. Massie, relative to a comment he had made in the October 29, 2020 workgroup meeting, that the lowest section of Mountain Run had wetlands and flood prone areas that might be appropriate for a new VACS "Portable Fencing" BMP. DEQ asked if there are similar landscapes at each of the stream confluences, with relatively flat, flood-prone areas and wetlands. Mr. Massie observed that this was generally the case, both for the confluence of Muddy Run with the Hazel River, and the Hazel River with the Rappahannock. He also said the confluences of Flat Run and Jonas Run with Mountain Run also can stay relatively wet.

Question: Bryan Hofmann (FOR) asked if DEQ had received feedback on the zero interest agricultural loan program? He has heard that producers feel it is more cumbersome than necessary and consequently not of great interest.

Answer: DEQ recently reinstated its agricultural loan program, which is now in its 2nd year. Dave Evans said he hadn't heard of the type of feedback Bryan noted, but would follow up with the staff person who leads that program because opportunities to streamline program delivery are welcome.

Comment: Bryan Hofmann (FOR) commented, in response to DEQ's prompting question whether aerial photo analysis may be helpful to identify livestock exclusion fencing needs, that FOR may be doing a similar analysis with RRRC to use aerial imagery and GIS to identify gaps in forested buffers and livestock fencing. This work is supported by a National Fish and Wildlife Foundation (NFWF) grant, and currently RRRC is waiting on GIS data from DCR before being able to move forward.

Comment: Greg Wichelns (C-SWCD) responded to DEQ's inquiry as to whether there are geographic areas within the project area that are of greatest priority for additional BMPs; he doesn't favor focusing in that way. Rather, competent payment for practices and maximum program flexibility has proven to be the most successful way to encourage agricultural producer participation in water quality conservation programs/practices.

Bryan Hofmann (FOR) echoed Greg's comment that flexibility needs to be built in to programs to encourage maximum participation.

DEQ asked a question about forage and biomass planting BMPs, which were recently suggested in another forum. Carl Stafford (VCE) noted that long term pastures put carbon into the ground and that this benefit has been underestimated in the past. David Massie (C-SWCD) noted that hayfields and cropland do not provide the same carbon storage, and this is a reason to recommend encouraging long term

pastures with fencing. Cost-share support for rotational grazing and other pasture improvements require that stream exclusion fencing be in place.

Bryan Hofmann (FOR) mentioned there is a lot of interest to incorporate warm season grasses into forage; doing so encourages deep root system growth and provides desirable wildlife habitat.

Comment: Bryan Hofmann, FOR) commented that the lack of up front funding for BMPs is a hurdle. DEQ's loan program needs to be streamlined. FOR has offered a myriad of simple upfront 0% loans to producers/ landowners for livestock exclusion fencing , forest buffers, and afforestation when DEQ program isn't working.

Comment William Schmidt, (citizen) noted, recognizing that this meeting is centered on agriculture and pasture use, that he lives and owns property along Muddy Run, about half way along the stream course (just as it turns south and then back east). His property is all forested, and he is concerned about bacteria levels in terms of recreational use, as he and his family recreate in the water. A lot of his property is in the flood plain, and he inquired as to whether setting in a several acre retention pond just outside the floodplain, and then rerouting the water back into Muddy Run might help with bacteria and mineral levels. His concern recreationally is focused around his children playing in it as well as he has wanted to stock with trout seasonally and have a warrior retreat.

Answer: Greg Wichlens (C-SWCD) responded that C-SWCD can meet with Mr. Schmidt onsite and discuss his concern and interests.

Bryan Hofmann (FOR) mentioned the Virginia Dept. of Forestry (DOF) will develop a Forest Stewardship Plan for private property owners interested in improving forest stand/diversity, etc. Joe Rossetti (DOF) provided his contact information and offered to provide assistance as desired. Contact joe.rossetti@dof.virginia.gov or 540-359-1693. Mr. Rossetti offered to join with David Massie (C-SWCD) or Bryan Hofmann (FOR) to visit with Mr. Schmidt and discuss opportunities for improved conservation of his property.

Comment: Bryan Hofmann (FOR) shared information from the Upper Rappahannock River Report Card completed by FOR in 2019. Both the Lower Hazel River and Mountain Run watersheds were graded "F" for their low levels (11.9% and 4.4% respectively) of protection of open space within 300' of a perennial stream. Bryan noted that Richard Jacobs (C-SWCD) can share information about additional types of stream buffer BMPs that may be relevant to our plan for the project area watersheds.

Comment: David Massie (C-SWCD) commented that an off stream water supply (such as a water trough) is important to keep cattle out of streams and prevent direct deposition of manure in the stream. While water troughs are fairly low cost, they tend to be outside the realms of the cost share program.

Comment: Joe Rossetti (DOF), in response to DEQ inquiring whether smaller streams might be good opportunities for grassed buffers, observed that small tributaries should be fenced in addition to having buffers. Absence of fencing will not keep bacteria from being directly deposited to the small streams, which empty to larger area streams.

Question: Dave Evans (DEQ) asked if portable fencing have relevance to smaller tributaries that may not otherwise be fenced?

Answer: David Massie (C-SWCD) responded that this could be a good option, and having additional practices available is helpful. Portable fencing is less expensive, and may be especially relevant in circumstances of rotational cattle grazing or for agricultural operations using land rental contracts. Joe Rossetti of DOF then observed that portable fencing may cause forested buffers to be more practical around smaller channels, and can reduce fence maintenance costs.

Comment: William Schmidt (citizen) expressed interest to learn more about what could be done with more forest and stream conservation areas, and thanked DEQ for its time in organizing the meeting.

Next Steps

DEQ wrapped up the meeting by outlining the content planned for the Residential Workgroup meeting scheduled for February 17th, and the process moving forward that is aimed at completing the Mountain Run, Muddy Run, and Lower Hazel River IP by Fall 2021. Completion of the IP report on that timeframe would make the IP watersheds eligible to apply for a Section 319 grant in the next grant cycle (applications submitted Summer 2021).

DEQ asked participants if it would be valuable to plan for another Agricultural Workgroup meeting, and no comments/input was received. DEQ will keep participants informed of next steps, and will circulate draft notes from this meeting within a week.

A.4. Second Residential Workgroup Meeting – February 17, 2021

February 17, 2021 – via Webinar/Conference Call

Attendees:

Dave Evans, DEQ

Roland Owens, DEQ

Sarah Sivers, DEQ

Joe Rossetti, DOF

Carl Stafford, VCE

Heningham Calloway, Culpeper SWCD

Richard Jacobs, Culpeper SWCD

Greg Wichelns, Culpeper SWCD

Bryan Hofmann, FOR

October Greenfield, FOR

Maggi Bloomstrom, PEC

Allison Brophy, Culpeper Star Exponent

Sam McClearen, Culpeper County: Planning Director

Paul Howard, Culpeper County: Environmental Services Director

Melanie Bayne, Town of Culpeper: Public Works/Environmental Services

Ben Holt, Town of Culpeper: Planning/ Community Development

Andrew Hopewell, Town of Culpeper: Planning/Community Development Director

Matthew Decatur, RRRC

Michelle Edwards, RRRC

John Foster, Mt Run Lake property owner

Welcome and Introductions

Dave Evans of DEQ opened the workgroup meeting with an overview of meeting logistics and shared formal opening remarks explaining the rationale for holding an entirely virtual workgroup meeting. Following that he went over the meeting agenda and objectives.

Discussion

A MS PowerPoint presentation provided an overview of the type and amount of best management practices (BMPs) that are relevant to addressing bacteria sources from residential/developed lands. Information shared included (1) the methodology and preliminary results of a comparative analysis drawing upon approved IP BMP recommendations for residential septic systems, (2) WIP III septic system and stormwater management BMP recommendations, (3) analysis of IP project area populations, income levels, and land use zoning prepared by RRRC, and (4) DEQ's preliminary analysis of benthic impairments in Mountain Run. The following discussion occurred during and after the information presented by DEQ.

- Comment: C. Stafford (Virginia Cooperative Extension, VCE): Carl asked why the lower portion of Mountain Run does not have a bacteria impairment. DEQ responded that there is not sufficient bacteria data available for that segment of Mountain Run to be reported as impaired, although the land uses are similar to other impaired areas, and it is likely that water quality monitoring in that section would show elevated bacteria levels.
    - Chat comment: Lower Mountain Run map status may need clarity to explain why that section is different (i.e. lack of data).
    - G. Wichelns (Culpeper SWCD): Recalled that at some point in the past, maps showed that all of Mountain Run was impaired. DEQ responded, after looking at the assessment information for this segment, that this segment of Mountain Run has not been listed as impaired since 2016IR due to insufficient data.
    - Chat comment: stream (*RA-19 watershed)* is spelled "Hiders Branch"
- Comment (Greg Wichelns, C-SWCD): Greg asked how the comparative analysis BMP recommendations related to Stage I and Stage II goals that are shown in approved TMDL Implementation Plans. DEQ responded that the comparative analysis methodology is a less precise approach to framing BMP recommendations, and is not amenable to dividing them into stages. Typically BMP recommendations are developed using WQ modeling, and the BMPs for Stage I are associated with achieving less than a 10.5% exceedance rate of the single sample maximum bacteria level (until recently, 235 cfu/100mL). Stage II goals typically were the additional BMPs that modeling showed as necessary to achieve the geometric mean WQ criterion level of 126 cfu/100mL. Although precise stage goals linked to achieving WQ criteria will not be prepared for this IP, to address EPA's requirements for IP approval, we will need to develop some type of schedule for BMP implementation over time.

Related Local Area Planning Efforts: several workgroup members offered brief comments about ongoing and planned efforts that are relevant to IP development.

Rappahannock-Rapidan Regional Commission (RRRC): RRRC led development of a regional plan (suite of recommended BMPs) to address the Chesapeake Bay TMDL pollutant reduction goals. This effort focused mostly on nutrients and sediment, but some recommended measures are also relevant to bacteria reduction. Among these are tree planting, septic pump-outs, stream restoration and bioretention basins.

In ongoing and planned follow on efforts, the region wants to better prioritize and geographically plan for putting BMPs on the ground. Participants have found and worked to fill data gaps, and digitized data to facilitate mapping. Next, in partnership with the Chesapeake Conservancy, BMPs will be prioritized for implementation. FOR will ground truth BMP priorities and conduct targeted water quality monitoring. RRRC also recently completed and communicated a revised Homeowners guide for watershed friendly landscaping.

Town of Culpeper: Recent work has included identifying gaps in the park/trail system's dog waste disposal stations. The Yowell Meadows, Wine Street, and Rockwater parks are all within the Mountain Run watershed. Recently the Town has partnered with FOR to conduct stream trash removal and tree planting projects, with students and scout troops, and more such efforts are envisioned for the future. The Town of Culpeper also has two permitted facilities, including the Town wastewater treatment facility.

Culpeper SWCD: There are five significant impoundments of Mountain Run that help to treat stormwater runoff. The SWCD has a long-standing and effective septic system program, supported by Section 319 and a recently completed WQIF grant that covered all 5 counties within the District's jurisdiction. VDH is a very significant partner the District relies on, and their absence from the workgroup meeting was noted for DEQ follow up. The Virginia Conservation Assistance Program (VCAP), is a funding source for stormwater management projects. The Culpeper SWCD provides technical assistance on variety of land and water conservation topics.

Friends of the Rappahannock (FOR): The FOR Mountain Run initiative will entail targeted water quality monitoring, and is getting underway with the support of a DEQ voluntary WQ monitoring grant. The initiative also includes park/stream clean-ups, and developing interpretive signage for the Spring Street entrance to Yowell Meadows park, tree give-aways, educational programs, and training focused on advancing citizen science. Guided paddle events are held on Lake Pelham, which include catch-n-release fishing.

Septic/Pet Waste BMP discussion

- The most effective way to help people with septic system maintenance is to offer cost-share assistance and continued education and outreach to individuals.
- Sewer Service Area– all of the Town and some adjoining areas of Culpeper County are served by the Town of Culpeper's wastewater treatment facility. Most residents within Town limits are connected to the sewer system. Some properties in town still have their own septic systems and private water wells, but they are relatively few and don't warrant focused attention. The Town offers discounted fees as an incentive for sewer connections. DEQ commented that connections to sewer lines for failed septic systems is a BMP that has a 50-80% cost-share rate, depending on homeowners income, and this could promote additional sewer connections.
- In response to DEQ inquiring if there are areas of the IP watersheds where septic system failures are prominent, it was noted that Triassic Basin soils have poor percolation capabilities, and it may be helpful to locate them within the IP project area. More generally, older septic systems and those requiring frequent pump outs warrant attention. It was noted that some companies appear to work in some counties more than others, and there may be opportunities to more evenly distribute the public dollars provided as septic cost-share assistance.
- Pet Waste BMPs: Relative to DEQ's pet waste BMP questions, it was noted that in the past, pet waste bag stations have been useful, while pet waste composters have not been of interest to residents. Friends of the Rappahannock communicated their ability to support pet waste management efforts, and it was also noted that there is a VCAP pet waste station practice, but it is currently unfunded.

- Mountain Run Lake – a large goose population is present at the lake, and a question was posed as to whether any BMPs can address this concern.
    - DEQ doesn't have BMPs that address this concern, and indicated it will follow up with DWR (formerly DGIF) to discuss whether they can help with situations like this.
    - FOR is working with Virginia Tech to plan development of an IP for the Lower Rappahannock River (Tidal Tributaries) and this question has been raised with DWR. Bryan Hofmann will share any relevant information provided.
    - Carl Stafford noted that geese don't like overgrown areas, and concentrate in mowed grassy areas where predators are few. Residents could manage their yards areas differently and that might reduce geese infestation.
    - The Town has had citizens raise this concern, particularly about Yowell Meadow Park. Coordination with DWR about potential measures, such as chemical (oil) application to reduce egg survivability, could be helpful. Parklands along Mountain Run (and Lake) may provide good opportunities for addressing the concern with local goose numbers.

Benthic Impairments: Roland Owens, DEQ, presented his preliminary work to summarize and analyze the benthic impairments that are within all three of the Mountain Run watersheds (RA-19, 20, and 21), An additional impaired segment (Flat Run) is expected in DEQ's 2022 assessment report. He posed several questions for discussion and input, which generated the follow questions and comments:

- Where do you draw the line of likely stressors when setting up the benthic stressor analysis?
    - DEQ uses a probabilistic program that has established thresholds for the most likely stressors.
- Do PCBs have a potential impact on benthic community health?
    - DEQ will follow up on this question; the separate Mountain Run PCB TMDL project will address this issue.
- Ambient monitoring, what other "chemicals" is DEQ aware of in waterbodies and is that part of the stressor analysis?
    - DEQ noted that in addition to the standard suite of water quality parameters (DO, pH, nutrients, etc.), the stressor analysis also looks at metals data collected during clean metals sampling events.
- Is baseline or historical data important?
    - DEQ noted that historic data is incorporated in the assessment of the impairment. For the stressor analysis, DEQ looks at the more recent data to identify the probable stressors currently impacting the benthic community.

Stormwater Discussion: DEQ presented a summary of stormwater BMPs that are allocated to the IP project area watersheds in the WIP III, while acknowledging that the amount of many BMPs was adjusted upward by DEQ from the levels proposed locally in order to achieve required nitrogen reductions called for in the WIP. There was just 10 minutes to initiate discussion of stormwater BMPs, and additional workgroup discussions will be held in the future (approximately May 1) once the benthic stressor analysis is completed. Preliminary stormwater management comments included:

- John Foster, a property owner on Mountain Run Lake, indicated that reductions in nutrients and sediment are his primary interest. He noted that the water level of the lake rises 4-6 feet following heavy precipitation events, and that sediment and runoff from developed areas flows in raging torrents directly into the lake. This has significantly filled the lake with sediments over time, and he is interested in reducing further lake sedimentation. A comment was made that it will be valuable to identify where current loads are before building or improving BMPs.

- Culpeper SWCD/RRRC has a good inventory of stormwater BMPs, but most are just retention ponds that don't address water quality. Richard Jacobs shared his thoughts that modifying/ converting existing facilities into practices that have water quality benefits may be the best option to improve stormwater management. Most retention ponds are vegetated with grass and have limited retention capacity (dry detention). Overgrown ponds may not be functioning to their design standards and could be enhanced with vegetation, such as filter strips to better address sheet flow from imperious areas. Most existing stormwater detention basins are in and around the Town of Culpeper, with many owned by HOAs, but some are on privately owned properties.
- RRRC has a NFWF grant with Warrenton and Fauquier Co. to assess their publicly owned BMPs and convert existing facilities into bioretention and/or wetlands. It would be worthwhile for Culpeper to pursue a similar grant.

DEQ closed the meeting with its appreciation for workgroup member's participation and contributions, along with a reminder that a second meeting of the Residential Workgroup will be scheduled for a time when the benthic stressor analysis is completed, tentatively about May 1st. DEQ will send a draft summary of the meeting discussions, along with the webinar recording, to workgroup members for their review and comment.

A.5. Third Residential Workgroup Meeting – May 11, 2021

May 11, 2021 – via Webinar/Conference Call

Attendees: Dave Evans, DEQ

Roland Owens, DEQ

Cathy Nicely, DEQ

Heningham Calloway, Culpeper SWCD

Richard Jacobs, Culpeper SWCD

Greg Wichelns, Culpeper SWCD

Bryan Hofmann, FOR

October Greenfield, FOR

Andrew Hardy, Culpeper County: Parks and Recreation Director

Paul Howard, Culpeper County: Environmental Services Director

Melanie Bayne, Town of Culpeper: Public Works/Environmental Services

Ben Holt, Town of Culpeper: Planning/ Community Development

Andrew Hopewell, Town of Culpeper: Planning/Community Development Director

Matthew Decatur, RRRC

Michelle Edwards, RRRC

John Foster, Mt Run Lake property owner

Emily Melton, Mt Run resident

Welcome and Introductions

Dave Evans of DEQ opened the meeting with an overview of meeting logistics and shared formal opening remarks explaining the rationale for holding an entirely virtual workgroup meeting. Following that he went over the meeting agenda and objectives.

Residential Septic and Pet Waste BMP Recommendations

Preliminary recommendations for residential septic, pet waste and kennel BMP recommendations were presented by DEQ. A brief discussion of these followed:

Greg Wichelns observed that the presentation slide on residential septic BMPs did not include any sewer line connections (RB-2 practice). Dave Evans clarified there will be recommendations for sewer connections in RA-19 (Mt Run – Hiders Branch) and RA-20 (Jonas Run), the two IP watersheds where the Culpeper wastewater treatment facility sewer use area is located. The RB-2 recommendations were

not included in the table shown in the presentation because they were not calculated with the comparative analysis approach used for the other Septic BMPs.

Ben Holt shared information on the Town's plans for purchasing and installing another 11 pet waste stations along Mountain Run and its tributaries this summer. These will complement the 3-4 stations already in place in the Town, and were supported with 50% cost-share funding from Friends of the Rappahannock (FOR).

Bryan Hofmann of FOR asked that information on the specific pet waste station model being purchased be communicated locally, as additional stations would ideally be compatible. Ben shared information that these stations, which include bag dispensers, wastebaskets and signage, cost $230 from https://dogwastedepot.com/dog-waste-station/

Richard Jacobs noted that there is a station at Culpeper Sports in the Jonas Run watershed, and that there are a few additional stations in area HOA properties. He asked if the pet waste stations BMP recommendations took existing stations into account, and Dave Evans noted they do not, and that the recommendations can be refined if workgroup members think changes in the total or distribution across IP watersheds is warranted.

Greg Wichelns asked, relative to the Confined Canine Facility (CCF) recommendations, whether any participants were aware of existing waste treatment at area kennels. No one had information to share on that, and Dave Evans noted that when DEQ conducted a literature search to support the new CCF BMP, there was little information available on existing local requirements for kennel waste management.

Mountain Run Benthic Impairment Analysis

Roland Owens of DEQ presented an update of the ongoing benthic impairment analysis he is conducting. He communicated the approach DEQ takes in conducting benthic life WQ assessments, how he has applied the methodology in Mountain Run, and presented the initial summary results of his ongoing analysis of benthic impairments in the Mountain Run, Jonas Run, and Flat Run watersheds.

Richard Jacobs asked whether the DEQ benthic assessment protocol was different based on the stream substrate, and in a written (chat) comment Melanie Bayne asked to get a copy of DEQ's benthic assessment protocol. Bryan Hofmann noted in a written comment that he understood that DEQ's method differed for rocky vs. muddy stream bottoms. Roland said he would look into this and provide additional information in follow up communications from DEQ (the 1999 DEQ document *"Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers"* was shared with workgroup members, along with these meeting notes.)

Richard Jacobs observed, relative to the data results for the Jonas Run benthic assessment unit, that there had been a gravel road near the tributary to Jonas Run up until several years ago, there is significant sediment accumulation in the tributary, and the former gravel road may have had a significant effect on benthic community health.

Greg Wichelns noted that some of the segments (Jonas and Flat Run) have very limited data points, and that DEQ should be cautious in making conclusions on seasonal patterns. Roland Owens noted that the complexity and staff time requirements for benthic data analysis limit the amount of observations that are feasible.

Greg also asked if his assumption that Total Nitrogen includes organic nitrogen was correct, and Roland confirmed it was. Greg also asked about DEQ data on Total Suspended Solids (TSS). Roland noted that DEQ doesn't routinely collect that data, because there is not a criterion/ stressor threshold for TSS. Bed stability and habitat data observations are the best proxy for the impact of sediments on benthic health.

The State Water Control Board has directed DEQ to develop a turbidity standard and that work is ongoing.

Bryan Hofmann noted that FOR has turbidity tubes and trained volunteers who could perform TSS data collection if that would be helpful, and asked DEQ to share its protocols for TSS collection. Roland will follow up with Bryan on this.

Stormwater BMP Discussion

Dave Evans presented a listing of Stormwater BMPs that were most frequently included in six Sediment IPs that he reviewed, along with a table of the Stormwater BMPs allocated to the IP watersheds in the local WIP III BMP "input deck". Workgroup members then shared their thoughts on the type of Stormwater BMPs they believe should be included in the Mountain Run, Muddy Run and Lower Hazel River IP.

Greg Wichelns suggested that DEQ identify the likely sources of bacteria in the developed areas in and around the Town of Culpeper, so that stormwater management BMPs would be located in areas that will provide the most bacteria reduction benefit. October Greenfield commented that FOR's bacteria sampling plan for Mountain Run is under development, as well as a plan to sample in the Rush and Lower Hazel Rivers. Both citizen science volunteers and FOR staff will participate in the sampling efforts, which is being done in collaboration with the Alliance for Chesapeake Bay. The FOR-led sampling in Mountain Run should help to identify areas with high bacteria levels in stormwater runoff.

Michelle Edwards, who was unable to participate by audio, noted in written comments that the Upper Rappahannock Watershed Plan being developed by RRRC will include a data application, under development by the Chesapeake Conservancy that will identify the type and location of BMPs that will achieve the greatest benefits. Bryan Hofmann noted that this tool will be based on high resolution imagery and Lidar and should provide much help in guiding BMP planning.

Emily Melton shared comments that she sees great value in the inclusion of low cost practices like wetlands (constructed and fringe) and tree planting/live stakes to establish root mass that stabilizes streambanks prone to erosion. It will be very important for the IP to have a strong education and outreach component to encourage landowners to embrace these practices; many people currently believe wetlands will foster mosquito growth, and may believe maintenance costs are high for environmentally beneficial practices. Educational materials can help communicate the water quality, habitat, and aesthetic value of stream bank vegetation and wetlands.

Richard Jacobs shared a comment that many HOAs/residents have objected to having "no mow" zones and other environmentally beneficial practices, for concern with mosquitos and wildlife; he seconded the call for education and outreach. He then noted that there are opportunities to add new stormwater management practices in developed areas with untreated storm drains, and to improve the performance of existing stormwater BMPs. Adding filtering and infiltration features to dry detention ponds would be valuable, and converting dry detention to wet ponds would provide even greater water quality benefits. Also, some of the few wet ponds that currently exist, upstream of the Town of Culpeper, are mowed right up to the pond edge. Schools and other public buildings in and around the Town may present the best opportunities to add/improve stormwater management.

Richard also observed that increasing the frequency of street and storm drain cleaning could reduce bacteria and other pollutants from entering local waters. Michelle Edwards noted in written comments

that the local WIP III "input deck" had included these measures, but DEQ removed them in the final WIP III because those practices don't address nitrogen (the focus of WIP III planning efforts).

Bryan Hofmann mentioned that FOR and Culpeper County have jointly prepared an application for a NFWF grant to conduct a stormwater management opportunity assessment. Bryan also summarized the extensive tree planting efforts by FOR, and welcomed input from meeting participants on any suggestions for additional tree planting. Bryan offered FOR's assistance if any of the participating organizations were interested to apply for a Department of Forestry "Trees for Clean Water" grant.

Greg Wichelns noted that the biggest concern for water quality comes with the "first flush" of runoff during a storm event. Dave Evans concurred, noting that in a Stormwater Management class DEQ sponsored the point was emphasized that infiltrating runoff during the beginning of a storm generally has the greatest water quality benefits.

October Greenfield recapped a number of local area initiatives FOR has completed recently, including (1) youth environmental education programs in the parks, (2) a bird watching program at the Cedar Mountain battlefield, (3) several river cleanup projects, (4) Spring tree planting at many sites in the County, and (5) plans for a Summer 2021 rain barrel education program, with approximately 20 rain barrels given away to participants.

Bryan Hofmann welcomed additional input from meeting participants on suggestions for water quality monitoring locations in Mountain Run, and encouraged anyone interested to participate in the May 20 (10am) Land Use and Environment Committee meeting that Michelle Edwards leads. The meeting will include details on the Chesapeake Conservancy BMP location tool that was noted during the workgroup discussions.

DEQ closed the meeting with a summary of the remaining steps in IP development, including a meeting this Summer (TBD) to share and discuss the benthic stressor analysis in more detail. DEQ requested volunteers to participate in the Steering Committee, which is tentatively planned for late this Summer. DEQ shared its appreciation for workgroup member's participation and contributions, and committed to send a draft summary of the meeting discussions, along with the webinar recording, to workgroup members for their review and comment within the next couple days, and asked for comments back quickly to enable a public posting of the meeting summary within 10 days, per Agency policy.

A.6. Steering Committee Meeting – October 15, 2021

October 15, 2021 at Lenn Park Pavilion, Culpeper, VA

Participants: A total of 12 people participated in the Steering Committee Meeting, including 3 DEQ staff and a Culpeper Star-Exponent reporter. Other participants were from the Culpeper Soil and Water Conservation District, the Rappahannock-Rapidan Regional Commission, Virginia Cooperative Extension, the Town of Culpeper, Friends of the Rappahannock, and American Farmland Trust. Participants are identified below by alphabetical order of last names.

Champion, Allison Brophy: Culpeper Star Exponent
Edwards, Michelle: Rappahannock-Rapidan Regional Commission (RRRC)
Evans, David: Virginia Department of Environmental Quality (DEQ), Northern Regional Office (NRO)
Gilley, Jacob: American Farmland Trust
Hopewell, Andrew: Town Of Culpeper
Jacobs, Richard: Culpeper Soil and Water Conservation District (C-SWCD)
Massie, David: C-SWCD
Shaw, Michael: Friends Of The Rappahannock (FOR)
Sivers, Sarah: DEQ - NRO
Stafford, Carl: Virginia Cooperative Extension
Wendt, Ashley: DEQ – Central Office
Wichelns, Greg: C-SWCD

Meeting Summary

DEQ welcomed participants to the meeting and all introduced themselves by name, organization, and their position. DEQ thanked all attending, and said that in addition to verbal input provided during the meeting, Steering Committee written input would be welcomed through November 22, 2021. A question was asked as to whether DEQ planned to share a revised draft of the report after addressing the Committee's input. DEQ explained that it would follow up individually with members who suggest changes to the draft IP report, so they know how their input was addressed, but that the revised draft would not be shared for a second round of Steering Committee comment. Rather, the revised draft report will be presented at a final public meeting (likely in January 2022) with a formal 30 day public comment period.

DEQ then began its presentation, which opened with a review of the project area, the water quality impairments being addressed, and the purpose of the Steering Committee meeting. The presentation then turned to each category of Best Management Practices (BMP) recommended in the draft Implementation Plan (IP) report. DEQ encouraged participants to ask questions and share their perspectives as the preliminary recommendations were presented. The following notes capture the highlights of the discussion that ensued, and the feedback/input on BMP recommendations provided by Steering Committee members:

Livestock Exclusion Fencing (LEF): The DEQ presentation highlighted the preliminary BMP recommendations, which include the Virginia Agricultural Cost Share (VACS) SL-6 exclusion

fencing system practices, portable fencing, and small farm grazing systems. DEQ also noted that language is included in the IP report to ensure that related LEF practices through State and Federal conservation programs can also be funded with future Section 319 grants if they are preferred by area producers.

The Culpeper SWCD recommended increasing the amount of total fencing recommendations that are SL-6 practices, to about 90% of total fencing. Portable fencing, a new VACS practice, is not expected to be widely used for reasons noted below. Both the average size (DEQ had used 4,000 linear feet) and number of portable fencing systems should be reduced. DEQ committed to making changes of this nature.

Participants expressed views that permanent fencing would be preferable to portable fencing, although it could be of interest for leased farms, and perhaps to address small streams or wetlands. Portable fencing would have the advantage of being able to be moved if that was of interest to the producer, but the modest cost-share amount may not be attractive enough to justify the required paperwork. Additionally new water sources and shade may be needed and are not included in the new practice specification. The IP report should make note of these issues.

Pasture Management (PM), Cropland and Equine Operation BMPs: DEQ summarized the pasture BMP recommendations, and explained that in consultation with C-SWCD, the majority of pasture improvements are recommended to be the VACS SL-10 grazing land management systems BMP. Other individual pasture practices are included in modest amounts, so that if individual producers wish to install them they would be eligible under future 319 grants.

There was discussion of the Sediment Retention structure practice, addressing a question about how to interpret the 2,430 acres recommended. It was clarified that this is the "treated area", which will be dependent on site slope and other factors. While BMP installation records obtained from the Department of Conservation and Recreation (DCR) don't show any of these WP-1 practices having been installed in nearby IP project areas, C-SWCD said some producers have done similar practices on their own. It was also discussed that a wet pond or wetland practice would have greater environmental benefits, but that the WP-1 specification doesn't provide for such features.

C-SWCD recommended shifting the WP-1 practice to the Cropland category, as that is the setting where it would normally apply. Additionally C-SWCD recommended shifting the WP-2A (Streambank Stabilization), WP-3 (Sod Waterway) and WP-4 (Animal Waste Control) into a new "Other Agricultural BMPs" category.

The DEQ Central Office participant asked why this IP is planned for a 15 year implementation timeframe, and noted that 10 years is more common. The 15 year horizon of this plan matches other recent DEQ-NRO plans, and seems more realistic that 10 years based on experience implementing IPs in the surrounding area, some of which are already over 10 years in duration with active grants and water quality restoration needs remaining.

Turning to Cropland BMPs, there was a question about the inclusion of some practices that are not normally perceived to address bacteria. DEQ noted that some measures were included primarily for their nutrient and sediment reduction benefits that are needed to address the aquatic

life impairments associated with degraded benthic community health in Mountain Run. Comments were also made that such measures could reduce bacteria from wildlife somewhat, and that bacteria can adhere to sediments, so reducing sediment runoff could indirectly benefit bacteria reduction efforts.

A question was posed as to whether there was sufficient cropland not yet in "no-till" practices to warrant a recommendation of 1,000 additional acres in conservation tillage. The Cooperative Extension agent replied that he believes that is a viable amount to include in the IP.

There was a comment and brief discussion that the cost-share rate and overall funding for Grass Filter Strips is not sufficient to encourage use of that practice. Participants requested that the IP report highlight this observation as support for future efforts to bolster the marketability of the WQ-1 practice.

An observation was offered that the SL-1 Permanent Vegetative Cover practice recommendation of 200 acres seemed very low, with a suggestion made to increase it several times to about 1,000 acres.

DEQ summarized the Equine (Horse) Operation BMP recommendations, and there was no follow up discussion. Approximately 1,000 horses are kept in the IP watersheds.

Residential Septic and Pet Waste BMPs: There was brief discussion of the septic BMP recommendations with the following comments offered:

- The RB-5 alternative on-site septic system practice is very expensive, and even with an 80 percent cost-share available to the lowest income homeowners, its cost can be prohibitive. A question was raised about other sources of funding to complement 319 grant assistance, and a suggestion that this be discussed in the IP report.
- The Town of Culpeper offers a $5,000 reduction of the normal $10,000 fee for connecting existing septic system homes within the Town's sewer service area to sewerage. DEQ will call this out in the IP report.
- A participant observed that it would be valuable to have the local health department increase its follow up with homeowners who have failing septic systems.

C-SWCD noted how valuable it has been to engage private sector providers in septic BMP outreach to homeowners. A similar approach could pay dividends for improved pet waste management through work with local veterinarians.

It was noted that in addition to creating eligibility of the IP project area for 319 grant funds that offer cost-share for septic and other non-VACS BMPs, an EPA-approved IP designation can help leverage additional restoration resources. RRRC has connected local IP restoration and Chesapeake Bay cleanup goals in successful National Fish and Wildlife Foundation (NFWF) grant proposals in the recent past.

Stormwater BMPs: C-SWCD observed that the number of rain gardens that would be required to achieve the recommended 300 acres treated is unrealistic. This was echoed by RRRC, who also noted that bioretention has been a popular practice supported under a NFWF grant.

Participants recommended that the bioretention BMP recommendation be increased, and the rain gardens goal be decreased.

FOR has experience implementing bioretention and other stormwater BMPs, and RRRC is funding Chesapeake Conservancy work to develop a web application that conservation planners can use to identify areas most appropriate for various types of BMPs. The IP report should highlight this new App and encourage its use to support local and regional (WIP III) implementation efforts.

There were questions and discussion of how stormwater BMPs that are required under program regulations relate to this IP. DEQ noted that actions that are required by regulation or to satisfy a permit requirement don't "count" toward the IP's goals, though actions beyond permit/regulatory requirements could count.

A related question asked was whether BMPs required to address nutrient reduction goals, that also have a bacteria reduction benefit value, could count toward the IP's goals. DEQ plans to follow-up on this.

Technical Assistance: DEQ had included 0.5 FTE annually for technical assistance to IP project area producers and property owners. C-SWCD recommended that this be increased to 1.0 FTE/year, noting that technical assistance for IP project area septic systems alone would require appropriately 0.5 FTE, and that agricultural, stormwater and other BMPs will also require a similar level of technical assistance.

Meeting Closure: With the meeting ending time reached, DEQ quickly noted the manner in which plan implementation will be tracked, both biennial IP project reports, and ongoing water quality monitoring and analysis. DEQ also noted that it expects the IP to be completed in time for EPA approval in advance of the next round of Section 319 grant applications that will be due Aug. 31, 2022. This would enable a new grant award for the IP project area to be awarded by Fall 2023.

DEQ thanked participants for their time and valuable input during the meeting. Written comments are welcome through Nov. 22nd in whatever form participants wish, including edits to the draft report itself (redline/strikeout/comments). If comments are sent separately, all specific comments should note the report section and page number(s) for each comment, to facilitate DEQ follow up action.

A.7. Final Public Meeting - 2022

APPENDIX B. Methodology for BMP Recommendations

B.1. Narrative Summary

Goals/Basics/Key Terms:

- Primary goals of this project were to:
  - respond to stakeholder interest for DEQ to complete a bacteria IP for long-standing TMDLs in three adjoining Culpeper County watersheds
  - address more recent Mountain Run benthic impairments with a TMDL alternative approach
  - develop and test a comparative analysis methodology drawing on approved IPs, to enable new IP development without technical contractor support
- Basic approach entailed profiling characteristics of the new IP watersheds, identifying and compiling data on comparable watersheds for analysis, and extracting BMP recommendations from Sediment IPs to maximize pollutant reduction co-benefits relevant to the benthic impairments (see Table at end)
- Key terms that used below include:
  - "Core" bacteria BMPs - livestock exclusion fencing (LEF), pasture management (PM), and residential septic (essentially all bacteria IPs include these BMP types)
  - "Supplemental" BMPs - other BMPs in bacteria IPs are more variable, but pet waste, cropland measures, and urban practices are all commonly included
  - Selected WIP III BMPs - the input deck measures that provide both bacteria and nutrient reduction benefits were highlighted to stakeholders attention
  - "In-life Span" BMPs – measures already in place in the IP project area that remain in their practice life span, typically 5, 10 or 15 years

Developing Core Bacteria IP BMP Measures:

- Identified nearby approved bacteria IP watersheds that were similar in landscape setting and land uses to the new IP watersheds
- Extracted LEF, PM and Septic BMP recommendations for comparison IP watersheds
- Adjusted the BMP goals in approved IP watersheds to address their differences in WS size/land uses compared to the new IP watersheds
- Computed preliminary new IP BMP goals as the average of adjusted goals for the comparison watersheds
- Subtracted completed, in-life span BMPs from Preliminary BMP Recommendations
- Adjusted initial recommendations by reallocating across IP watersheds by BMP opportunities (for LEF, the pasture/stream interface; for PM, acres of pasture; for Septic, number of septic systems), as well as Stakeholder feedback
- Consulted with stakeholders to frame the specific LEF and PM BMPs included in IP
- Rounded BMP Recommendations to avoid sense of false precision

Additional Agricultural and Stormwater (Urban) BMPs

Selected WIP III BMP Allocations to the IP Watersheds:

- Summarized the allocation of selected WIP III BMPs (those with bacteria, nutrient and sediment reduction benefits) to IP Watersheds

- Discussed with Residential Workgroup members which of these measures were most relevant to include in the IP, to gain their sense of priorities

Supplemental BMPs Comparative Analysis

- For both pasture/cropland and urban practices, extracted and summarized the BMP recommendations from 28 EPA-approved Sediment IPs to hone in on BMPs that would help to address benthic impairments in Mountain Run
- As with Core bacteria BMPs, adjusted the Sediment IP BMP goals to account for differences in WS size with the new IP watersheds
    - For measures commonly included in bacteria IPs, the goals were adjusted to the full IP project area size, for others, goals were adjusted to the size of the Mountain Run watersheds
- Preliminary BMP goals are the average of adjusted BMP goals from the Sediment IP watersheds, after removing outlier values (0 and those > order of magnitude above the initial average), then rounded the new IP BMP goals to avoid sense of false precision
- Compared these preliminary goals with similar WIP III goals, and made final adjustments with stakeholder feedback and to manage the overall cost of the new IP (initial stormwater BMP recommendations were pared back to improve cost-effectiveness)

Additional BMPs for Sewer Connections, Pet Waste and Equine Operations

- These BMPs were not developed from comparative analysis
- Sewer connections are applicable in just two new IP watersheds, numbers are tentative (need further consultations)
- Pet Waste stations allocated according to population by IP watershed; Confined Canine Facility BMPs from kennel licenses issued by Culpeper County
- Equine BMPs allocated by horse population, using stakeholder input on # BMPs recommended

B-2. Core Bacteria BMP Derivation Tables

B.2.1. Muddy Run Comparative Analysis

Table B- 1. Muddy Run Watershed Size and Land Use

Watershed	Plan	WS Size (Acres)	Pasture/ Crop	Forest	Developed
Blue Run	2015 Upper Rapidan River IP	20,955	41%	52%	5%
Marsh/Rippin Run Comb.	2015 Upper Rapidan River IP	18,187	32%	61%	5%
Hawksbill/Mill Creek	2008 Hawksbill/Mill Creek IP	65,263	31%	56%	12%
Muddy Run	**New WS Plan**	**18,826**	**30%**	**60%**	**10%**

Table B- 2. Muddy Run: BMP Recommendations in Comparison Watersheds

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Blue Run	45	8,006	252	150	94	8
Marsh/Rippin Run Comb.	21.3	4,188	292	194	91	7
Hawksbill/Mill Creek	26.3	14,749	936	57	63	41

Table B- 3. Preliminary Muddy Run Core BMP Recommendations from Adjusted BMPs

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Blue Run	29.6	5,263	453	270	169	14
Marsh/Rippin Run Comb.	20.4	4,007	578	384	180	14
Hawksbill/Mill Creek	7.3	4,067	222	14	15	10
Muddy Run	**19.1**	**4,445**	**417**	**222**	**121**	**13**

B.2.2. Lower Hazel River Comparative Analysis

Table B- 4. Lower Hazel River Watershed Size and Land Use

Watershed	Plan	WS Size (Acres)	Pasture/ Crop	Forest	Developed
Blue Run	2015 Upper Rapidan River IP	20,955	41%	52%	5%
Marsh/Rippin Run Comb.	2015 Upper Rapidan River IP	18,187	32%	61%	5%
Hawksbill/Mill Creek	2008 Hawksbill/Mill Creek IP	65,263	31%	56%	12%
Lower Hazel River	**New WS Plan**	**24,837**	**31%**	**59%**	**9%**

Table B- 5. Lower Hazel River: BMP Recommendations in Comparison Watersheds

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Blue Run	45	8,006	252	150	94	8
Marsh/Rippin Run Comb.	21.3	4,188	292	194	91	7
Hawksbill/Mill Creek	26.3	14,749	936	57	63	41

Table B- 6. Preliminary Lower Hazel River Core BMP Recommendations

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Blue Run	40.3	7,175	538	320	201	17
Marsh/Rippin Run Comb.	27.8	5,463	686	456	214	16
Hawksbill/Mill Creek	9.9	5,544	264	16	18	12
Lower Hazel River	**26**	**6,060**	**496**	**264**	**144**	**15**

B.2.3. Mountain Run #1 Comparative Analysis

Table B- 7. Mountain Run #1 Watershed Size and Land Use

Watershed	Plan	WS Size (Acres)	Pasture/ Crop	Forest	Developed
Craig, Brown, Marsh Run IP Watersheds	2010 Craig, Brown, Marsh Run IP	29,400	55%	34%	11%
Hawksbill/Mill Creek	2008 Hawksbill/Mill Creek IP	65,263	31%	56%	12%
Mountain Run #1	**New WS Plan**	**30,397**	**46%**	**32%**	**22%**

Table B- 8. Mountain Run #1: BMP Recommendations in Comparison Watersheds

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Craig, Brown, Marsh Run IP Watersheds	65.0	14,545		266	138	44
Hawksbill/Mill Creek	26.3	14,749	936	57	63	41

Table B- 9. Preliminary Mountain Run #1 Core BMP Recommendations

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Craig, Brown, Marsh Run IP Watersheds	55.8	12,492	-	575	298	95
Hawksbill/Mill Creek	18.0	10,068	789	48	53	35
Mountain Run #1	**36.9**	**11,280**	**395**	**311**	**176**	**65**

B.2.4. Mountain Run #2 Comparative Analysis

Table B- 10. Mountain Run #2 Watershed Size and Land Use

Watershed	Plan	WS Size (Acres)	Pasture/ Crop	Forest	Developed
Craig Run	2010 Craig, Brown, Marsh Run IP	5,360	70%	20%	10%
Cromwells Run	2018 Upper Goose Creek IP	12,088	67%	25%	8%
Little River	2018 Upper Goose Creek IP	35,203	66%	25%	9%
Rap #1/Poplar Combined WS	2015 Upper Rapidan River IP	15,786	57%	32%	10%
Mountain Run #2	**New WS Plan**	**11,378**	**76%**	**13%**	**11%**

Table B- 11. Mountain Run #2: BMP Recommendations in Comparison Watersheds

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Craig Run	12.7	3,333	0	36	20	6
Cromwells Run	4.5	906	615	9	27	10
Little River	10.4	1,036	3,069	208	27	10
Rap #1/Poplar Combined WS	32.4	6,360	226	129	53	4

Table B- 12. Preliminary Mountain Run #2 Core BMP Recommendations

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Craig Run	29.3	7,682	-	84	47	14
Cromwells Run	4.8	967	796	12	35	13
Little River	3.9	386	1,212	82	11	4
Rap #1/Poplar Combined WS	31.0	6,090	187	107	44	3
Mountain Run #2	**17.2**	**3,781**	**549**	**71**	**34**	**9**

B.2.5. Mountain Run #3 Comparative Analysis

Table B- 13. Mountain Run #3 Watershed Size and Land Use

Watershed	Plan	WS Size (Acres)	Pasture/ Crop	Forest	Developed
Blue Run	2015 Upper Rapidan IP	20,955	41%	52%	5%
Beautiful Run	2015 Upper Rapidan IP	14,702	50%	46%	3%
Brown Run	2010 Craig, Brown, Marsh Run IP	7,070	50%	45%	5%
Upper Goose Creek	2018 Upper Goose Creek IP	105,447	49%	44%	6%
Mountain Run #3	**New WS Plan**	**15,891**	**47%**	**49%**	**4%**

Table B- 14. Mountain Run #3: BMP Recommendations in Comparison Watersheds

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Blue Run	45	8,006	252	150	94	8
Beautiful Run	20.2	6,440	161	99	57	5
Brown Run	16.3	3,148		58	31	9
Upper Goose Creek	8.9	7,783	2,790	188	27	10

Table B- 15. Preliminary Mountain Run #3 Core BMP Recommendations

Watershed	Livestock Exclusion Fencing (Miles)	Pasture Mgmt (Acres)	Septic Pump-outs	Septic Repairs	New Conven-tional	New Alternative
Blue Run	39.1	6,960	153	91	57	5
Beautiful Run	20.5	6,543	232	143	82	7
Brown Run	34.4	6,651	-	104	56	16
Upper Goose Creek	1.3	1,125	280	19	3	1
Mountain Run #3	**23.8**	**5,320**	**166**	**89**	**49**	**7**

APPENDIX C. Phased Implementation BMP Tables

Table C- 1. Livestock Exclusion Fencing (100% Phase I)

BMP Name	BMP Code	Muddy Run		Lower Hazel River		Mountain Run #1		Mountain Run #2		Mountain Run #3		Total IP Watersheds	
Cattle Exclusion Fencing		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Stream Exclusion, w/ Grazing Land Mgmt - Wide Buffer	SL-6W	12	0	13	0	16	0	7	0	7	0	**55**	**0**
Stream Exclusion, w/ Grazing Land Mgmt - Narrow Buffer	SL-6N	6	0	7	0	9	0	3	0	3	0	**28**	**0**
Portable Fencing BMP	WP-2P	12	0	12	0	16	0	8	0	8	0	**56**	**0**
Cost of BMPs												**0**	**0**
Stream Exclusion, w/ Grazing Land Mgmt - Wide Buffer	SL-6W	360,000	-	390,000	-	480,000	-	210,000	-	210,000	-	**$ 1,650,000**	**$ -**
Stream Exclusion, w/ Grazing Land Mgmt - Narrow Buffer	SL-6N	120,000	-	140,000	-	180,000	-	60,000	-	60,000	-	**$ 560,000**	**$ -**
Portable Fencing BMP	WP-2P	6,600	-	6,600	-	8,800	-	4,400	-	4,400	-	**$ 30,800**	**$ -**
Total Cost Exclusion Fencing BMPs		**486,600**	**-**	**536,600**	**-**	**668,800**	**-**	**274,400**	**-**	**274,400**	**-**	**$ 2,240,800**	**-**

Table C- 2. Pasture Management (80% Phase I, 20% Phase II and Other Agricultural BMPs (67% Phase I, 33% Phase II)

BMP Name	BMP Code	Muddy Run		Lower Hazel River		Mountain Run #1		Mountain Run #2		Mountain Run #3		Total IP Watersheds	
Pasture Management BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Grazing Land Management	SL-10	1,674	418	1,836	459	2,251	563	1,115	279	1,124	281	**8,000**	**2,000**
Extend Watering Systems	SL-7	4	1	5	1	6	1	2	1	3	1	**20**	**5**
Woodland Filter Buffer Area	FR-3	34	8	37	9	45	11	22	6	22	6	**160**	**40**
Afforestation	FR-1	88	22	121	30	155	39	102	25	94	24	**560**	**140**
Cost of BMPs													
Grazing Land Management	SL-10	125,520	31,380	137,700	34,425	168,840	42,210	83,640	20,910	84,300	21,075	**$ 600,000**	**$ 150,000**
Extend Watering Systems	SL-7	100,000	25,000	120,000	30,000	140,000	35,000	60,000	15,000	80,000	20,000	**$ 500,000**	**$ 125,000**
Woodland Filter Buffer Area	FR-3	15,300	3,600	16,560	4,050	20,160	4,950	10,080	2,700	9,900	2,700	**$ 72,000**	**$ 18,000**
Afforestation	FR-1	13,200	3,300	18,120	4,500	23,280	5,850	15,240	3,750	14,100	3,600	**$ 83,940**	**$ 21,000**
Total Cost Pasture Management BMPs		**$ 254,020**	**$ 63,280**	**$ 292,380**	**$72,975**	**$ 352,280**	**$ 88,010**	**$ 168,960**	**$ 42,360**	**$ 188,300**	**$47,375**	**$ 1,255,940**	**$ 314,000**
Other Agriculture BMPs													
Streambank Stabilization	WP-2A	666	666	918	917	1,180	1,177	768	768	720	720	**4,252**	**4,248**
Sod Waterway	WP-3	2	1	3	1	5	1	3	1	2	1	**15**	**5**
Animal Waste Control Facilities	WP-4	1	-	1	-	2	1	1	-	1	-	**6**	**1**
Cost of BMPs													
Streambank Stabilization	WP-2A	99,900	99,900	137,700	137,550	177,000	176,550	115,200	115,200	108,000	108,000	**$ 637,800**	**$ 637,200**
Sod Waterway	WP-3	3,200	1,600	4,800	1,600	8,000	1,600	4,800	1,600	3,200	1,600	**$ 24,000**	**$ 8,000**
Animal Waste Control Facilities	WP-4	150,000	-	150,000	-	300,000	150,000	150,000	-	150,000	-	**$ 900,000**	**$ 150,000**
Total Cost Other Ag BMPs		**253,100**	**101,500**	**292,500**	**139,150**	**485,000**	**328,150**	**270,000**	**116,800**	**261,200**	**109,600**	**1,561,800**	**795,200**

Table C- 3. Cropland BMPs (50% Phase I, 50% Phase II, except WP-1, 95% Phase II)

BMP Name	BMP Code	Muddy Run		Lower Hazel River		Mountain Run #1		Mountain Run #2		Mountain Run #3		Total IP Watersheds	
Cropland BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Cover Crops	SL-8	26	26	139	138	201	200	207	208	177	178	**750**	**750**
Permanent Vegetative Cover on Critical Areas	SL-11	5	5	28	28	40	40	41	42	36	35	**150**	**150**
Sediment Retention/Water Control Structure	WP-1	19	362	26	499	34	639	22	417	21	391	**122**	**2,308**
Grass Filter Strips	WQ-1	1	1	5	5	6	7	7	6	6	6	**25**	**25**
Conservation Tillage	SL-15A	17	17	93	93	133	133	139	139	118	118	**500**	**500**
Permanent Vegetative Cover on Cropland	SL-1	17	17	93	93	133	133	139	139	118	118	**500**	**500**
Costs of BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Cover Crops	SL-8	1,300	1,300	6,950	6,900	10,050	10,000	10,350	10,400	8,850	8,900	**$ 37,500**	**$ 37,500**
Permanent Vegetative Cover on	SL-11	6,000	6,000	33,600	33,600	48,000	48,000	49,200	50,400	43,200	42,000	**$ 180,000**	**$ 180,000**
Sediment Retention/Water Control Structure	WP-1	2,850	54,300	3,900	74,850	5,100	95,850	3,300	62,550	3,150	58,650	**$ 18,300**	**$ 346,200**
Grass Filter Strips	WQ-1	175	175	875	875	1,050	1,225	1,225	1,050	1,050	1,050	**$ 4,375**	**$ 4,375**
Conservation Tillage	SL-15A	1,700	1,700	9,300	9,300	13,300	13,300	13,900	13,900	11,800	11,800	**$ 50,000**	**$ 50,000**
Permanent Vegetative Cover on	SL-1	2,975	2,975	16,275	16,275	23,275	23,275	24,325	24,325	20,650	20,650	**$ 87,500**	**$ 87,500**
Total Cost Cropland BMPs		**15,000**	**66,450**	**70,900**	**141,800**	**100,775**	**191,650**	**102,300**	**162,625**	**88,700**	**143,050**	**$ 377,675**	**$ 705,575**

Table C- 4. Equine Operation BMPs (67% Phase I, 33% Phase II)

BMP Name	BMP Code	Muddy Run		Lower Hazel River		Mountain Run #1		Mountain Run #2		Mountain Run #3		Total IP Watersheds	
Equine Operation BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Small Acreage Grazing System	(SL-6AT)	5	3	5	2	6	3	2	1	2	1	**20**	**10**
Small Scale Equine Manure Composting – Static Systems	(EM-1T)	3	2	3	2	3	2	1	1	1	1	**11**	**8**
Small Scale Equine Manure Composting – Aerated Systems	(EM-1AT)	2	1	1	1	2	1	1	1	1	0	**7**	**4**
Small Acreage Grazing System	(SL-6AT)	45,000	27,000	45,000	18,000	54,000	27,000	18,000	9,000	18,000	9,000	**$ 180,000**	**$ 90,000**
Small Scale Equine Manure Composting – Static Systems	(EM-1T)	9,000	6,000	9,000	6,000	9,000	6,000	3,000	3,000	3,000	3,000	**$ 33,000**	**$ 24,000**
Small Scale Equine Manure Composting – Aerated Systems	(EM-1AT)	10,000	5,000	5,000	5,000	10,000	5,000	5,000	5,000	5,000	-	**$ 35,000**	**$ 20,000**
Total Cost Equine Operation BMPs		**64,000**	**38,000**	**59,000**	**29,000**	**73,000**	**38,000**	**26,000**	**17,000**	**26,000**	**12,000**	**$ 248,000**	**$ 134,000**

Table C- 5. Pet Waste BMPs (100% Phase I)

BMP Name	BMP Code	Muddy Run		Lower Hazel River		Mountain Run #1		Mountain Run #2		Mountain Run #3		Total IP Watersheds	
Pet Waste BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Pet Waste Stations	PW-1	4	0	3	0	24	0	2	0	1	0	**34**	**-**
Confined Canine Facilities Waste Treatment	PW-3	1	0	0	0	2	0	1	0	0	0	**4**	**-**
Cost of Pet Waste BMPs													
Pet Waste Stations	PW-1	1,200	-	900	-	7,200	-	600	-	300	-	**$ 10,200**	0
Confined Canine Facilities Waste Treatment	PW-3	12,000	0	-	0	24,000	0	12,000	0	-	0	**$ 48,000**	0
Total Pet Waste BMPs		**13,200**	0	**900**	0	**31,200**	0	**12,600**	0	**300**	0	**$ 58,200**	0

Table C- 6. Residential Septic BMPs (67% Phase I, 33% Phase II, except RB-1, 100% Phase I)

BMP Name	BMP Code	Muddy Run		Lower Hazel River		Mountain Run #1		Mountain Run #2		Mountain Run #3		Total IP Watersheds	
Septic System BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Septic Pumpout	RB-1	450	-	400	-	700	-	150	-	100	-	**1,800**	**-**
Sanitary Sewer Connection	RB-2	-	-	-	-	18	7	7	3	-	-	**25**	**10**
Septic System Repair	RB-3	94	46	87	43	147	73	34	16	20	10	**382**	**188**
New Conventional Septic System	RB-4	80	40	74	36	127	62	27	13	34	17	**342**	**168**
New Alternative On-site Septic System	RB-5	13	7	13	7	24	11	7	3	17	8	**74**	**36**
Cost of Septic System BMPs													
Septic Pumpout (RB-1)	RB-1	157,500	-	140,000	-	245,000	-	52,500	-	35,000	-	**$ 630,000**	**$ -**
Sanitary Sewer Connection (RB-2)	RB-2	-	-	-	-	198,000	77,000	77,000	33,000	-	-	**$ 275,000**	**$ 110,000**
Septic System Repair (RB-3)	RB-3	328,300	304,850	515,900	150,500	70,350	255,500	119,000	56,000	70,350	35,000	**$ 1,103,900**	**$ 801,850**
New Conventional Septic System (RB-4)	RB-4	720,000	360,000	666,000	324,000	1,143,000	558,000	243,000	117,000	306,000	153,000	**$ 3,078,000**	**$ 1,512,000**
New Alternative On-site Septic System (RB-5)	RB-5	312,000	168,000	312,000	168,000	576,000	264,000	168,000	72,000	408,000	192,000	**$ 1,776,000**	**$ 864,000**
Total Septic System BMPs Cost		**1,517,800**	**832,850**	**1,633,900**	**642,500**	**2,232,350**	**1,154,500**	**659,500**	**278,000**	**819,350**	**380,000**	**$ 6,862,900**	**$ 3,287,850**

Table C- 7. Urban Stormwater BMPs (50% Phase I, 50% Phase II)

BMP Name	**BMP Codes**	**Muddy Run**		**Lower Hazel River**		**Mountain Run #1**		**Mountain Run #2**		**Mountain Run #3**		**Total IP Watersheds**	
Stormwater BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Bioretention	BR-1,2, 6 (BR)	-	-	-	-	55	55	13	12	8	7	**76**	**74**
Rain Gardens	BR-10 (RG)	9	8	7	7	24	25	6	6	4	4	**50**	**50**
Infiltration Trench	IP-5, IP-6 (IF)	18	18	13	13	50	50	12	12	7	7	**100**	**100**
Permeable Pavement	IP-4 (PP)	0.2	0.1	0.1	0.2	0.5	0.5	0.1	0.1	0.1	0.1	**1.0**	**1.0**
Manufactured BMP	MBMP-1	-	-	-	-	5	5	-	-	-	-	**5**	**5**
Street Sweeping	SS-1	-	-	-	-	50	50	-	-	-	-	**50**	**50**
Conservation Landscaping	UB-2,4 (CL)	30	30	24	24	88	88	20	20	13	13	**175**	**175**
Converted Dry Detention Ponds	DP-1	-	-	-	-	145	145	34	34	21	21	**200**	**200**
Streambank Stabilization/Restoration	U-5, USR-2	-	-	-	-	4,731	4,731	1,097	1,097	672	672	**6,500**	**6,500**
Stream Restoration	USR-1	-	-	-	-	3,639	3,639	844	844	517	517	**5,000**	**5,000**
Constructed Wetland	UW-2 (CW)	93	93	123	123	150	150	56	56	78	78	**500**	**500**

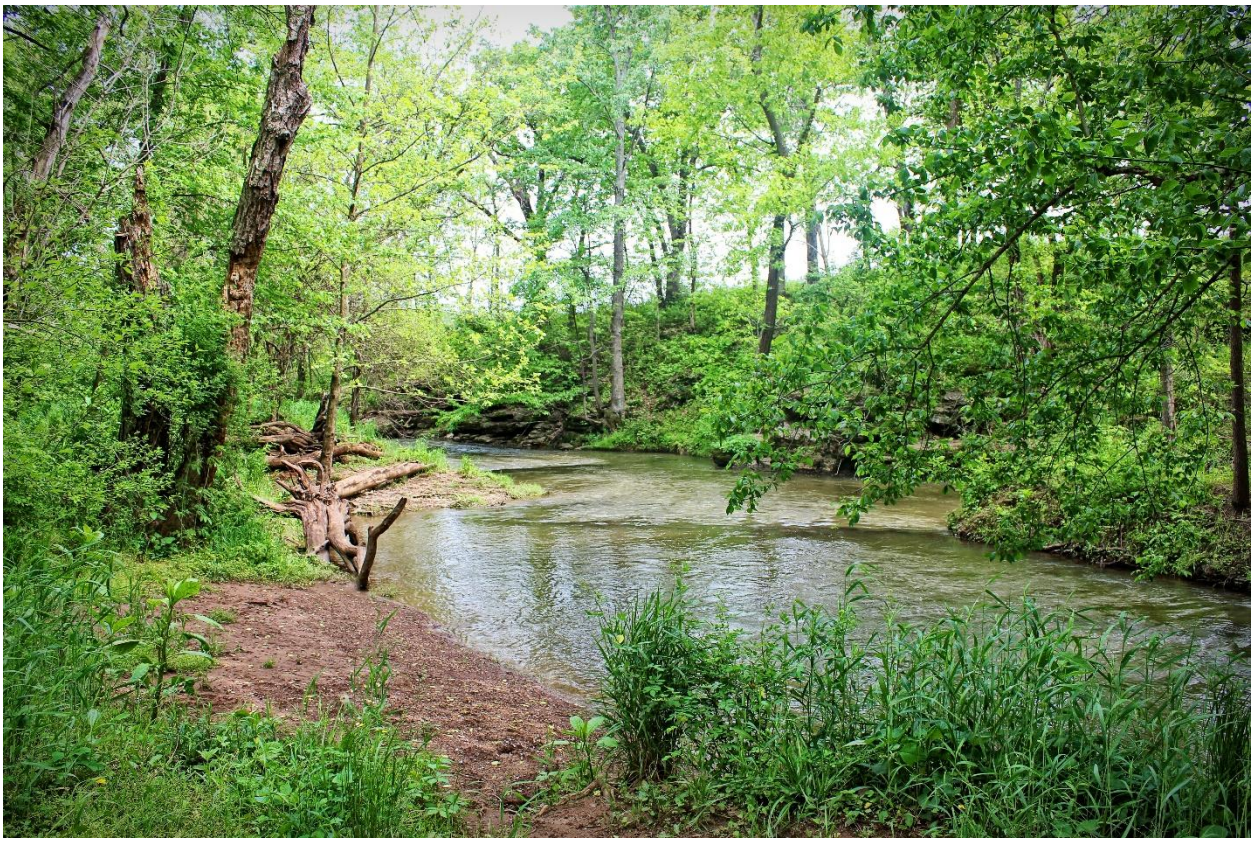
BMP Name	BMP Codes	Muddy Run ($)		Lower Hazel River ($)		Mountain Run #1 ($)		Mountain Run #2 ($)		Mountain Run #3 ($)		Total IP Watersheds ($)	
Cost of Stormwater BMPs		**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Bioretention	BR-1,2, 6 (BR)	-	-	-	-	825,000	825,000	195,000	180,000	120,000	105,000	**$ 1,140,000**	**$ 1,110,000**
Rain Gardens	BR-10 (RG)	45,000	40,000	35,000	35,000	120,000	125,000	30,000	30,000	20,000	20,000	**$ 250,000**	**$ 250,000**
Infiltration Trench	IP-5, IP-6 (IF)	203,400	203,400	146,900	146,900	565,000	565,000	135,600	135,600	79,100	79,100	**$ 1,130,000**	**$ 1,130,000**
Permeable Pavement	IP-4 (PP)	65,000	32,500	32,500	65,000	162,500	162,500	32,500	32,500	32,500	32,500	**$ 325,000**	**$ 325,000**
Manufactured BMP	MBMP-1	-	-	-	-	375,000	375,000	-	-	-	-	**$ 375,000**	**$ 375,000**
Street Sweeping	SS-1	-	-	-	-	50,000	50,000	-	-	-	-	**$ 50,000**	**$ 50,000**
Conservation Landscaping	UB-2,4 (CL)	10,800	10,800	8,640	8,640	31,680	31,680	7,200	7,200	4,680	4,680	**$ 63,000**	**$ 63,000**
Converted Dry Detention Ponds	DP-1	-	-	-	-	420,500	420,500	98,600	98,600	60,900	60,900	**$ 580,000**	**$ 580,000**
Streambank Stabilization/Restoration	U-5, USR-2	-	-	-	-	709,650	709,650	164,550	164,550	100,800	100,800	**$ 975,000**	**$ 975,000**
Stream Restoration	USR-1	-	-	-	-	1,273,650	1,273,650	295,400	295,400	180,950	180,950	**$ 1,750,000**	**$ 1,750,000**
Constructed Wetland	UW-2 (CW)	269,700	269,700	356,700	356,700	435,000	435,000	162,400	162,400	226,200	226,200	**$ 1,450,000**	**$ 1,450,000**
Total Cost Stormwater BMPs		**593,900**	**556,400**	**579,740**	**612,240**	**4,967,980**	**4,972,980**	**1,121,250**	**1,106,250**	**825,130**	**810,130**	**$ 8,088,000**	**$ 8,058,000**

Table C- 8. Education, Outreach and Technical Assistance (Education/Outreach in Phase I, Technical Assistance Phase I & II)

	IP Project Area (Total Costs)	
Education, Outreach, and Technical Assistance	**Phase I**	**Phase II**
Agricultural BMP education/outreach	$ 15,000	
Septic system education, for homeowners and realtors	$ 10,000	
Pet waste education program	$ 10,000	
Student water quality management educational activities	$ 10,000	
Stormwater management education and outreach in project area	$ 20,000	
Education and Outreach Activities	**$ 65,000**	
Technical Assistance for Agricultural, Septic and Stormwater BMPs (0.5 FTE @ $60K/yr.)	**$600,000**	**$ 300,000**
Education, Outreach and Technical Assistance	**$665,000**	**$ 300,000**

APPENDIX D. Benthic Stressor Analysis for Mountain Run Watershed

Stressor Analysis to Identify Probable Stressors to the Impaired Benthic Macroinvertebrate Community in the Mountain Run Watershed



Submitted and Prepared by:

Virginia Department of Environmental Quality

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List of Abbreviations

AU	Assessment Unit
BCG	Biological Condition Gradient
CWA	Clean Water Act
DEQ	Virginia Department of Environmental Quality
DO	Dissolved Oxygen
EPT	Ephemeroptera, Plecoptera, and Trichoptera taxa
HBI	Hilsenhoff Biotic Index
IP	Implementation Plan
IR	305(b)/303(d) Water Quality Assessment Integrated Report
LRBS	Log_{10} Relative Bed Stability Index
MS4	Municipal Separate Storm Sewer Systems
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PT	Trichoptera taxa
SSURGO	Soil Survey Geographic database
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
UT	Unnamed tributary
VLCD	Virginia Land Cover Dataset
VPDES	Virginia Pollution Discharge Elimination System
VSCI	Virginia Stream Condition Index
VSMP	Virginia Stormwater Management Program
WQS	Water Quality Standards

Units of Measure

°C	degrees Celsius
CCU	cumulative criterion unit
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
mg/L	milligrams per liter
SU	standard units

14.0 INTRODUCTION

The Clean Water Act (CWA) requires that waters in the United States support swimming, sustain aquatic life, and maintain other beneficial uses, like water supply. In order to meet the requirements of the CWA, Virginia has adopted water quality standards (WQS) and assesses water quality monitoring data to determine if waterbodies are meeting the WQS. Waterbodies not meeting standards, i.e. impaired waterbodies, are reported in the biannual 305(b)/303(d) Water Quality Assessment Integrated Report (IR) or "dirty waters list".

The Mountain Run watershed is located in Culpeper County with a drainage area of roughly 90.6 square miles (58,000 acres) and includes the Town of Culpeper. The watershed originates near the western border of the county and flows into the Rappahannock River. Mountain Run, Jonas Run and an unnamed tributary Jonas Run are listed as impaired for aquatic life designated use based upon assessment of the benthic macroinvertebrates, meaning there is not a healthy and diverse community. Based on recent data, Flat Run, which is also in the watershed, will likely also be listed as impaired for aquatic life designated use in the 2022 IR.

This report summarizes the analysis conducted to identify probable cause(s) of stress to the impaired benthic community in the Mountain Run watershed. A stressor analysis is an investigation of available information, such as Department of Environmental Quality (DEQ) monitoring data and scientific literature, to identify stressors that result in an unhealthy benthic macroinvertebrate community. Once probable stressors are known, approaches to address those, such as Total Maximum Daily Load (TMDL) development or one that favors "straight to implementation", can be considered.

This Benthic Stressor Analysis (BSA) was developed in conjunction with the Mountain Run, Muddy Run and Lower Hazel River Implementation Plan (IP) to support an approach aimed to achieve co-benefits through implementing best management practices (BMPs) that address more than one pollutant. Depending on the stressors identified by a BSA, potential may exist for implementation efforts to address not only bacteria impairments but also benthic impairments through implementation of BMPs that minimize multiple pollutants, such those that address nutrients and/or sediment in addition to bacteria. For this watershed, based upon preliminary review of existing land uses and DEQ experience from approximately 20 years of TMDL development, it was anticipated that the probable stressors identified as contributing to an unhealthy benthic community would be ones which also can be managed by BMPs typically selected to address bacteria impairments. Therefore, the BMPs prioritized in the Mountain Run, Muddy Run and Lower Hazel River IP are those that also minimize the pollutants identified as probable stressors by this BSA for the Mountain Run watershed.

Because DEQ is taking an approach that aims to leverage and utilize BMPs that provide co-benefits, TMDL development is not being pursued for the pollutants identified as probable stressors to the impaired benthic community. Instead DEQ will recommend that the streams impaired due to an unhealthy benthic community identified in this BSA be re-categorized in the next 305(b)/303(d) Water Quality Assessment Integrated Report. Currently the waters covered by this analysis are classified as category 5A where a WQS is not attained (in this case for the aquatic life use due to an impairment for benthic macroinvertebrates impairment) and a TMDL is required. Once the related IP is approved by EPA, DEQ will propose that these water be re-categorized to 5R, meaning that while the WQS is not attained and the water is impaired, the implementation of an EPA-accepted restoration plan is expected to result in attainment. Status updates are provided in each IR for waters categorized as 5R.

14.1 Applicable Water Quality Standards

Virginia's WQS are contained in 9VAC25-260 et seq. and are comprised of three components: identification of designated or beneficial uses, the criteria (narrative and/or numeric) to ensure beneficial uses are protected and antidegradation. According to Virginia WQS (9VAC25-260-10):

> *"All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish."*

Water quality criteria can be numerical or narrative. The General Criteria defined in the Virginia WQS (9VAC25-260-20) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. Section A of the General Criteria states in part:

> *"State waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life."*

14.2 Aquatic Life Designated Use

One indicator of an impairment of the aquatic life use is a degraded benthic community. DEQ administers a biological monitoring program in Virginia that evaluates compliance of the General Standard. Evaluations of monitoring data from this program focus on the benthic (bottom-dwelling) macro (large enough to see) invertebrates (insects, mollusks, crustaceans, and annelid worms), which are used to determine whether a stream segment has a benthic impairment. Changes in water quality generally result in alterations to the quantity and diversity of the benthic organisms that live in streams and other water bodies. Besides being the major intermediate constituent of the aquatic food chain, benthic macro-invertebrates are "living recorders" of past and present water quality conditions. This is due to their relative immobility and their variable resistance to the diverse contaminants within a water body. The community structure of these organisms provides the basis for the biological analysis of water quality.

A multi-metric macroinvertebrate index, the Virginia Stream Condition Index (VSCI), is used to assess the aquatic life use status for wadeable freshwater streams and rivers in non-coastal areas of the state. VSCI scores range from 0 to 100, with higher scores indicating relatively better ecological health. DEQ has set a score of 60 as the threshold for impairment. Scores below 60 indicate an impaired benthic community, while scores above 60 indicate a healthy benthic community.

14.3 Impairment Listing

While this report is focused on data since 2015 to assess the current conditions of the Mountain Run watershed, including Jonas Run, and understanding probable stressors to the macroinvertebrate community based on this more current data, it is also important to consider the conditions which lead up to the listing as impaired. Note that no macroinvertebrate health data is available for Flat Run prior to data window used in this report.

The mainstem of Mountain Run below the Lake Pelham dam was first monitored for macroinvertebrate health on September 15, 1994 and since that time there have been 40 sampling events at 6 monitoring stations. The median and average VSCI scores in the watershed have been below the impairment threshold with a median value of 59.09 and an average value of 55.65 (Figure 1-1). On average, fall samples had a higher VSCI score (60.22, n=21) compared to spring samples (50.6, n=19).

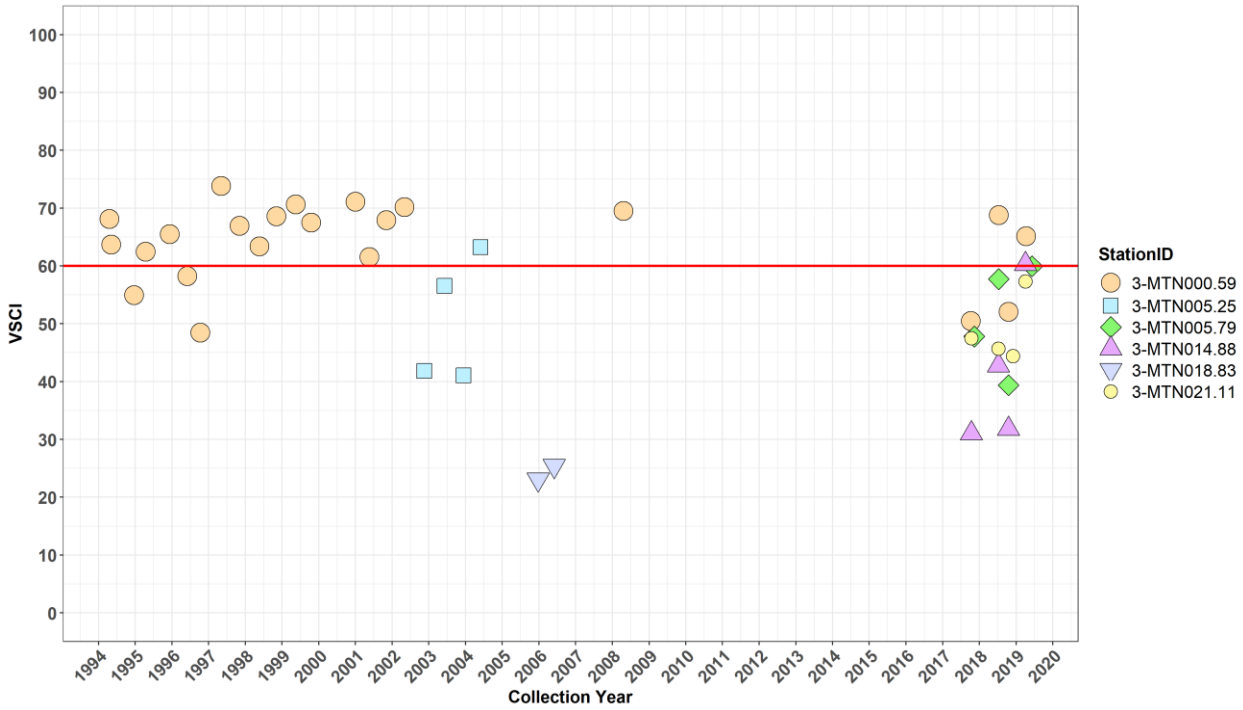


Figure 14-1. Historic Virginia Stream Condition Index (VSCI) Data for the Mountain Run Watershed

The Jonas Run watershed was first monitored for macroinvertebrate health on April 16, 2003 and since that time there have been 8 sampling events at 3 monitoring stations. The VSCI scores in the watershed have been below the impairment threshold with a median value of 41.88 and an average value of 46.14 (Figure 1-2). On average, fall samples had a higher VSCI score (55.57, n=4) compared to spring samples (36.71, n=4).

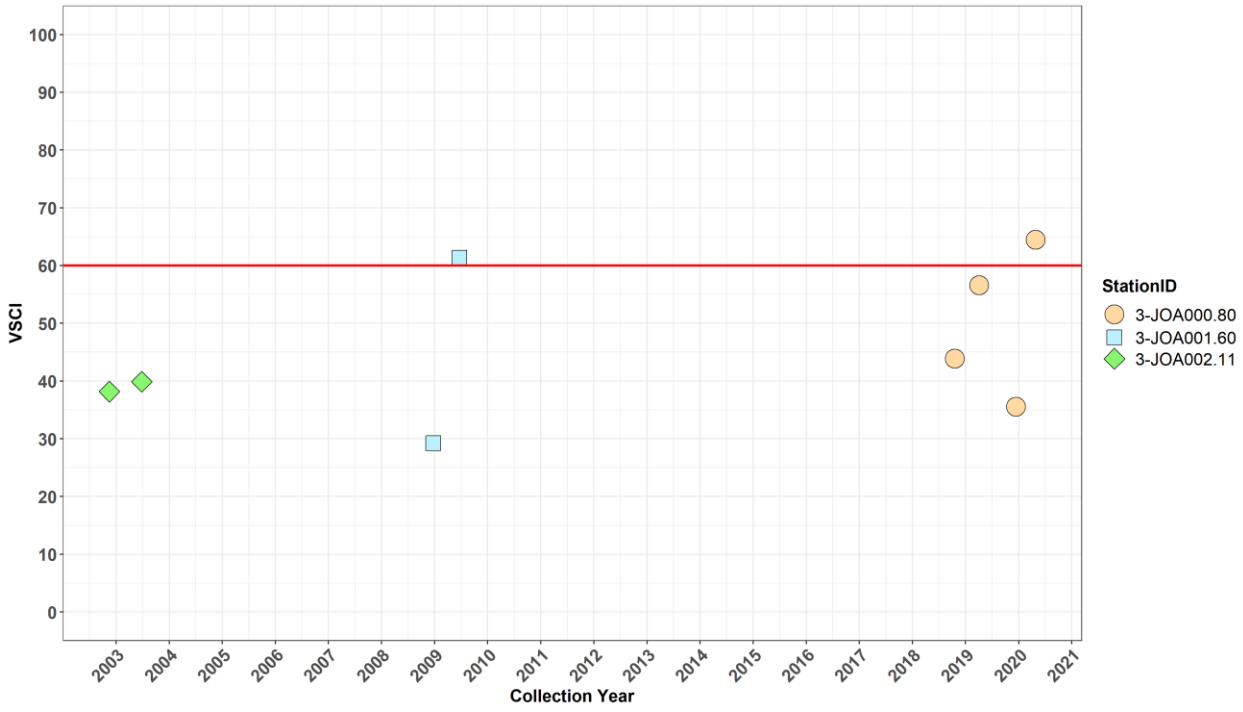


Figure 14-2. Historic Virginia Stream Condition Index (VSCI) Data for the Jonas Run Watershed

The current benthic impairments in the Mountain Run watershed are defined by six assessment units (AU) based on the 2020 IR. The mainstem of Mountain Run, from the confluence with the Rappahannock River upstream to the outlet from Lake Pelham to the, is covered by the following four AUs: VAN-E09R_MTN01A00, VAN-E09R_MTN02A04, VAN-E09R_MTN03A00 and VAN-E09R_MTN04A04. Jonas Run, from the confluence with an unnamed tributary at approximately river mile 3.74 downstream to the confluence with Mountain Run, is covered by AU VAN-E09R_JOA01A06. Above this Jonas Run AU an unnamed tributary to Jonas Run, from its confluence with an unnamed tributary (below Swan Dam) downstream to the confluence with Jonas Run, is covered by AU VAN-E09R_XMO01A20. Note that the section of Jonas Run from where AU VAN-E09R_XMO01A20 intersects Jonas Run to the upstream boundary of AU VAN-E09R_JOA01A06 has not been assessed for macroinvertebrate health.

Table 14-1. Impairments in the Mountain Run Watershed

305B ID	Stream Name	Length (miles)	Location Description	Impairment Cause	Year First Listed for Benthics
VAN-E09R_JOA01A06	Jonas Run	3.78	Segment begins at the confluence with an unnamed tributary to Jonas Run (XDZ), at approximately rivermile 3.74, and continues downstream until the confluence with Mountain Run.	**Benthic Macroinvertebrates Bioassessments**, Escherichia coli (E. coli)	2012
VAN-E09R_MTN01A00	Mountain Run	7.59	Segment begins at the confluence with Flat Run and continues downstream until the confluence with the Rappahannock River.	**Benthic Macroinvertebrates Bioassessments**, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue	2008
VAN-E09R_MTN02A04	Mountain Run	5.67	Segment begins at the confluence with Jonas Run and continues downstream until the confluence with Flat Run.	**Benthic Macroinvertebrates Bioassessments**, Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue	2008
VAN-E09R_MTN03A00	Mountain Run	6.65	Segment begins at the Route 15/29 bridge crossing and continues downstream until the confluence with Jonas Run.	**Benthic Macroinvertebrates Bioassessments**, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue	2008
VAN-E09R_MTN04A04	Mountain Run	4.63	Segment begins at the outlet from Lake Pelham and continues downstream until the Route 15/29 bridge crossing.	**Benthic Macroinvertebrates Bioassessments**, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue	2020
VAN-E09R_XMO01A20	Unnamed tributary to Jonas Run	0.54	Segment begins at the confluence with an unnamed tributary (downstream from Swan Dam) and continues downstream to the confluence with Jonas Run.	**Benthic Macroinvertebrates Bioassessments**, Escherichia coli (E. coli)	2020

In addition to these six AUs this stressor analysis also includes the AU for Flat Run (VAN-E09R_FLA01A08), which begins at the headwaters of Flat Run and continues downstream until the confluence with Mountain Run. This AU was not assessed nor listed as impaired for benthics in the current IR (2020) but all or a portion is expected to be listed in the 2022 IR based on the assessment period of 2015-2020 and data collected during 2019 and 2020. Note that while the entire reach of Flat Run is shown as potentially impaired in Figure 1-3 below, the actual length and placement of the impairment will be determined by DEQ staff during the assessment effort for the 2022 IR.

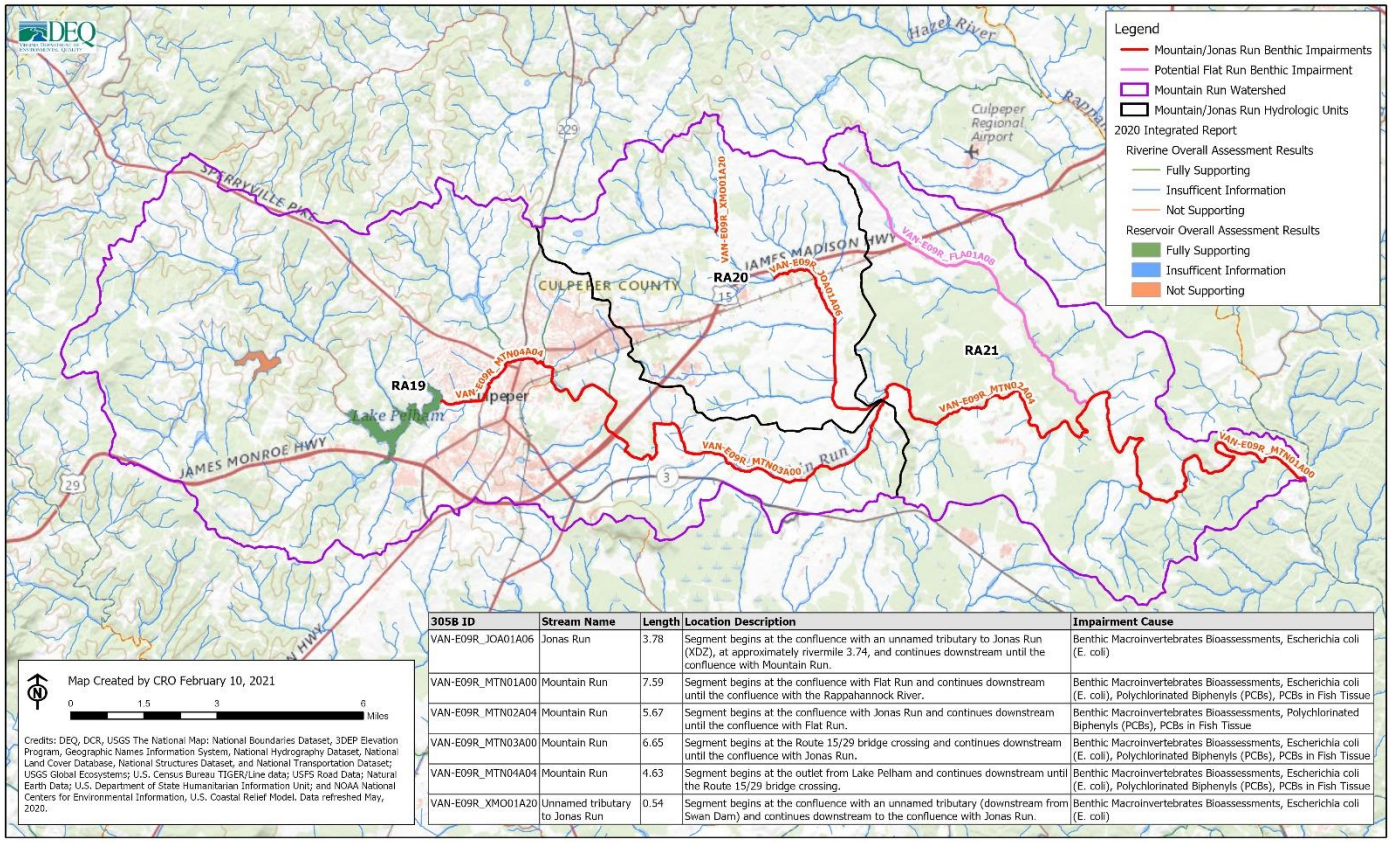
For VAN-E09R_MTN04A04, in addition to the benthic impairment, an observed effects for the aquatic life use is also noted based on sediment samples collected in 2006, when several consensus based probable effects concentration (PEC) sediment screening values were exceeded. These sediment parameters are in the family of polycyclic aromatic hydrocarbons (PAHs), which are normally a by-

product of combustion. PAHs in this area are likely legacy issues from prior industrial activities and possible source tracking and identification are beyond the scope of this project.

In the VAN-E09R_MTN03A00 AU an observed effect for chlordane is noted for the aquatic life use based on one exceedance in 2006 of the PEC sediment screening values at station 3-MTN018.83. Again, this exceedance is likely a legacy issues from prior industrial activities and possible source tracking and identification are beyond the scope of this project.

Impairments of the fish consumption use due to PCBs have also been noted in the watershed. These impairments are being addressed through a separate TMDL development process.

Mountain Run Watershed 2020 IR Benthic Assessment Results



305B ID	Stream Name	Length	Location Description	Impairment Cause
VAN-E09R_JOA01A06	Jonas Run	3.78	Segment begins at the confluence with an unnamed tributary to Jonas Run (XDZ), at approximately rivermile 3.74, and continues downstream until the confluence with Mountain Run.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli)
VAN-E09R_MTN01A00	Mountain Run	7.59	Segment begins at the confluence with Flat Run and continues downstream until the confluence with the Rappahannock River.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_MTN02A04	Mountain Run	5.67	Segment begins at the confluence with Jonas Run and continues downstream until the confluence with Flat Run.	Benthic Macroinvertebrates Bioassessments, Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_MTN03A00	Mountain Run	6.65	Segment begins at the Route 15/29 bridge crossing and continues downstream until the confluence with Jonas Run.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_MTN04A04	Mountain Run	4.63	Segment begins at the outlet from Lake Pelham and continues downstream until the Route 15/29 bridge crossing.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli), Polychlorinated Biphenyls (PCBs), PCBs in Fish Tissue
VAN-E09R_XMO01A20	Unnamed tributary to Jonas Run	0.54	Segment begins at the confluence with an unnamed tributary (downstream from Swan Dam) and continues downstream to the confluence with Jonas Run.	Benthic Macroinvertebrates Bioassessments, Escherichia coli (E. coli)

Figure 14-3. Impairment Listing for the Mountain Run Watershed

15.0 BENTHIC STRESSOR ANALYSIS APPROACH

Before an approach can be developed to address an impaired benthic macroinvertebrate community, the probable stressor(s) contributing to an unhealthy benthic community must be identified. A stressor can have direct effects on the organism itself, like dissolved metals or toxic chemicals, or alter habitat and resources that in turn result in a shift in the macroinvertebrate community.

The macroinvertebrate community at a given location is comprised of a suite of organisms that are adapted to the environmental conditions present at that location. As those environmental conditions are altered, organisms that are not adapted to those changes will be reduced in numbers or be extirpated, and

the macroinvertebrate community will shift to organisms that can withstand the new or changing conditions. The goal of the stressor analysis process is to apply a weight-of-evidence approach to define the probable stressor(s) that explain(s) the shift in the benthic macroinvertebrate community. Stressor analysis takes into account all available information including, but not limited to, water chemistry, physical habitat, qualitative habitat and sediment data. This study considered the analysis of the biological (Section 5.0 - Biological Data Analysis) and water quality chemistry (Section 6.0 - Water Chemistry Data Analysis) data. From these analyses, each candidate stressor are categorized as either a non-stressor, possible stressor, or probable stressor. Pollutants identified as probable stressors are those which are then considered to be addressed through either development of a TMDL or a plan that favors a "straight to implementation" approach. The probable stressors identified within are those proposed to be addressed in the Mountain Run, Muddy Run and Lower Hazel River Implementation Plan.

15.1 Candidate Stressors

The suite of candidate stressors typically analyzed in the benthic stressor analysis are those known to have effects on macroinvertebrates and are considered to be widespread and common stressors in Virginia. The candidate stressors were identified by DEQ based upon probabilistic monitoring data collected since 2005 throughout Virginia and supported by scientific literature. Additional candidates, on a waterbody-specific basis and in light of available resources, may be considered if there is potential for those to cause stress to the benthic community. Candidate stressors include both pollutants that can be targeted through TMDL development and additional contributing factors that can influence and stress benthic communities but that cannot be effectively targeted through TMDL development. This analysis will not result in the development of a TMDL but will instead identify stressors which can be mitigated through co-benefits of actions recommended in the Mountain Run, Muddy Run and Lower Hazel River Implementation Plan which address the previously developed bacteria TMDL.

Water quality data collected for the candidate stressors considered for this study were analyzed to identify if one or more of those parameters may be causing stress to the aquatic community. Candidate stressors were compared to numeric water quality criteria (Water Quality Standards, 9VAC25-260) and threshold stressor values, as applicable. The threshold stressor values were developed and published by DEQ (2017) in the "Stressor Analysis in Virginia: Data Collection and Stressor Thresholds" document. The candidate stressors considered in the benthic stressor analysis are shown in Table 2-1 and are identified as having water quality criteria and/or a stressor threshold.

Table 15-1. Candidate Stressors Analyzed

Candidate Stressors Considered					
Candidates with stressor thresholds[1,2]:	***pH***	***Dissolved Oxygen (DO)***	Total Phosphorous	Total Dissolved Solids (TDS)	Potassium
	Temperature	Specific Conductivity	Total Nitrogen	Sulfate	***Chloride***
	Sediment[3]	Sodium	Metal Cumulative Criterion Unit (Metals CCU)	***Individual Metals, Dissolved***	
Candidates without stressor thresholds[2]:	Turbidity	***Ammonia***	DO (Saturation)	Total Suspended Solids (TSS)	
Additional Contributing factors:	Underlying Geology	Land Disturbance	Degraded Riparian Buffer	Percent Imperviousness	

[1] Values published in "Stressor Analysis in Virginia: Data Collection and Stressor Thresholds" (DEQ, 2017)
[2] Parameters with water quality criteria denoted in bold, italicized text. When available, the value was also used in the analysis (Water Quality Standards, 9VAC25-260).
[3] Sediment was evaluated using Log Relative Bed Stability (LRBS) index and Habitat.

15.2 Contributing Factors

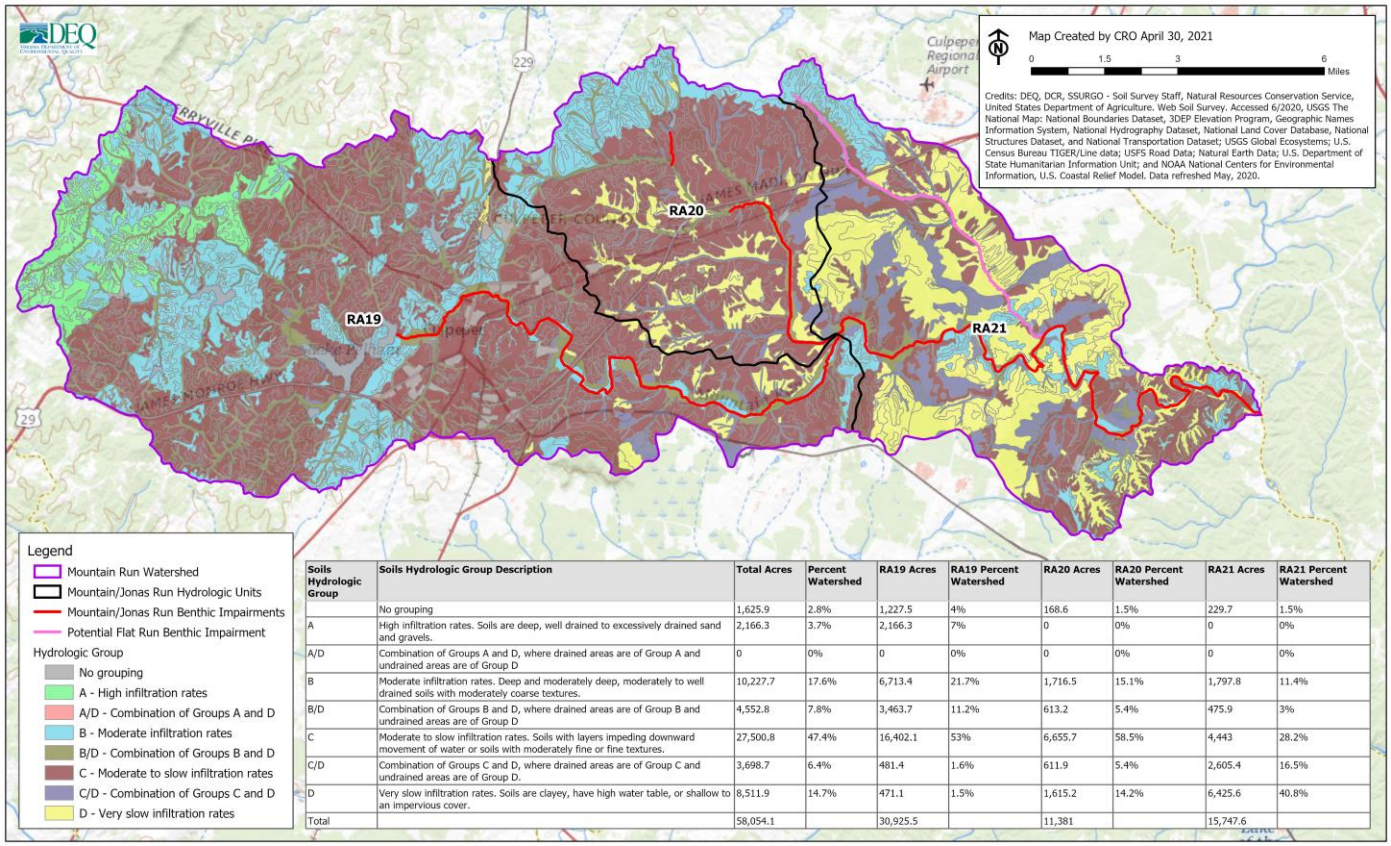
The benthic stressor analysis also considered factors that contribute to the impaired benthic macroinvertebrate community. These are watershed conditions that may exacerbate the impairment, but for which a TMDL cannot be individually developed. Examples of contributing factors can be degraded riparian buffer, hydrologic alternation such as dams or impoundments, current and/or historic land use practices, or the underlying geology. The additional contributing factors considered in this analysis are identified in Table 2-1. Again, it is believed that some additional contributing factors can be mitigated through co-benefits of actions recommended in the Mountain Run, Muddy Run and Lower Hazel River Implementation Plan.

16.0 WATERSHED CHARACTERIZATION

16.1 Soils

Hydrologic soil group composition in the Mountain Run watershed is identified in Figure 3-1 using the Soil Survey Geographic (SSURGO) database. These groups represent the infiltration characteristics of soils, where soils with high infiltration rates are represented by Group "A", and Group "D" represents soils with the slowest infiltration rates. Soils with slower infiltration rates are more susceptible to higher erosion rates because runoff will flow over the land quicker instead of infiltrating into the ground. Generally the soils in the western portion of the watershed have higher infiltration rates than those in the eastern portion of the watershed.

Mountain Run Watershed Soils Hydrologic Groups



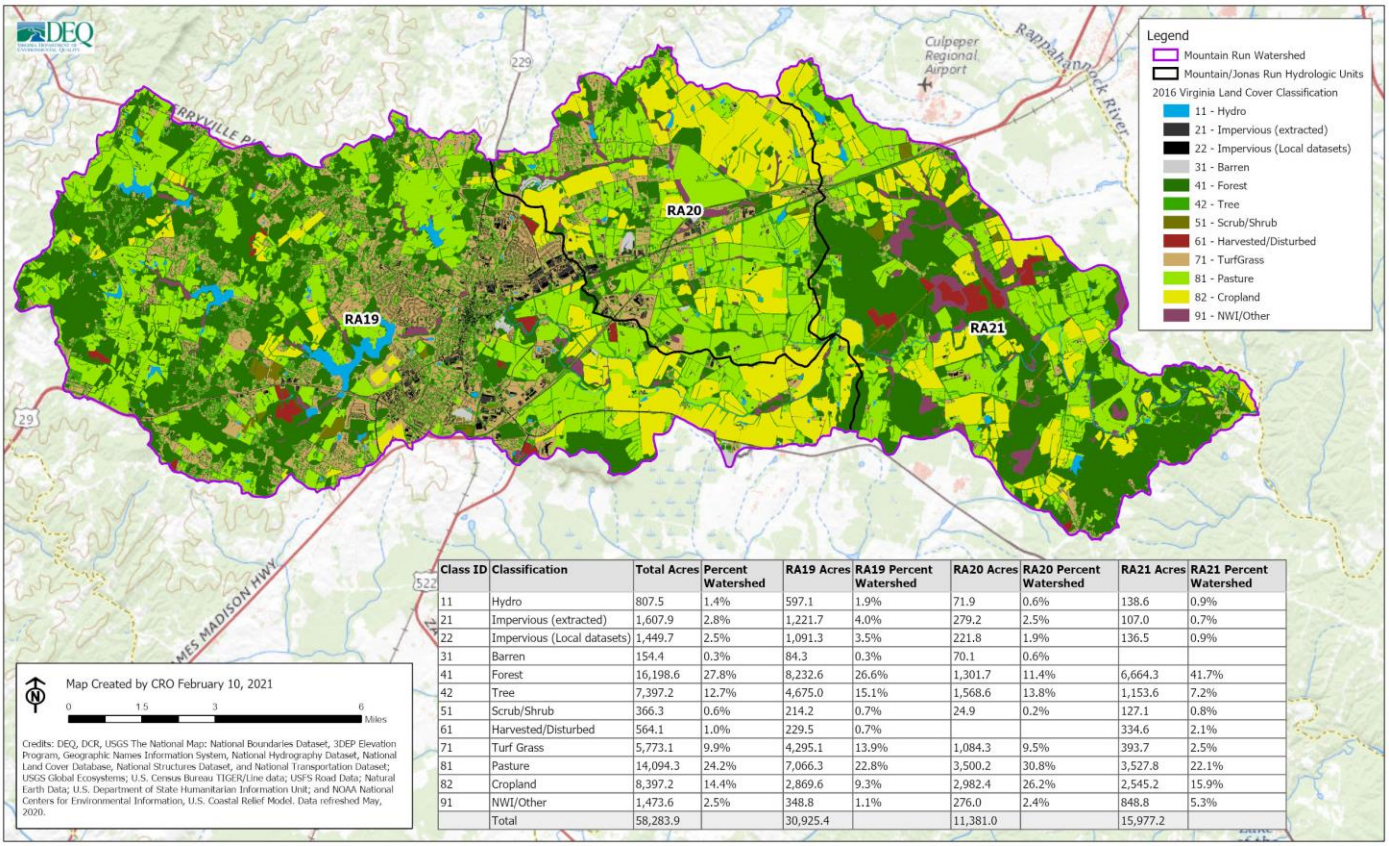
Soils Hydrologic Group	Soils Hydrologic Group Description	Total Acres	Percent Watershed	RA19 Acres	RA19 Percent Watershed	RA20 Acres	RA20 Percent Watershed	RA21 Acres	RA21 Percent Watershed
	No grouping	1,625.9	2.8%	1,227.5	4%	168.6	1.5%	229.7	1.5%
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.	2,166.3	3.7%	2,166.3	7%	0	0%	0	0%
A/D	Combination of Groups A and D, where drained areas are of Group A and undrained areas are of Group D	0	0%	0	0%	0	0%	0	0%
B	Moderate infiltration rates. Deep and moderately deep, moderately to well drained soils with moderately coarse textures.	10,227.7	17.6%	6,713.4	21.7%	1,716.5	15.1%	1,797.8	11.4%
B/D	Combination of Groups B and D, where drained areas are of Group B and undrained areas are of Group D	4,552.8	7.8%	3,463.7	11.2%	613.2	5.4%	475.9	3%
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.	27,500.8	47.4%	16,402.1	53%	6,655.7	58.5%	4,443	28.2%
C/D	Combination of Groups C and D, where drained areas are of Group C and undrained areas are of Group D.	3,698.7	6.4%	481.4	1.6%	611.9	5.4%	2,605.4	16.5%
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover.	8,511.9	14.7%	471.1	1.5%	1,615.2	14.2%	6,425.6	40.8%
Total		58,054.1		30,925.5		11,381		15,747.6	

Figure 16-1. Mountain Run Watershed Soil Hydrologic Groups

16.2 Land Use

The 2016 Virginia Land Cover Dataset (VGIN, 2017) was used to calculate land cover in the Mountain Run watershed (Figure 3-2). Overall, the watershed is approximately 40.5% forest/tree, 5.3% developed impervious, 11.8% developed pervious, 24.2% pasture/hay and 14.4% cropland. It is important to note that the three 12-digit hydrologic units that make up the watershed do have some significant differences in land cover. RA19 - Mountain Run (the furthest west and largest hydrologic unit) has more developed impervious land cover due to the Town of Culpeper, RA20 - Jonas Run (the central hydrologic unit) is dominated by pasture and cropland land cover, which make up 57% of the watershed, and, RA21 - Mountain Run-Flat Run (the eastern most hydrologic unit) is 48.9% forest/tree and 38% pasture/hay/cropland land use.

Mountain Run Watershed 2016 Virginia Land Cover Data



Class ID	Classification	Total Acres	Percent Watershed	RA19 Acres	RA19 Percent Watershed	RA20 Acres	RA20 Percent Watershed	RA21 Acres	RA21 Percent Watershed
11	Hydro	807.5	1.4%	597.1	1.9%	71.9	0.6%	138.6	0.9%
21	Impervious (extracted)	1,607.9	2.8%	1,221.7	4.0%	279.2	2.5%	107.0	0.7%
22	Impervious (Local datasets)	1,449.7	2.5%	1,091.3	3.5%	221.8	1.9%	136.5	0.9%
31	Barren	154.4	0.3%	84.3	0.3%	70.1	0.6%		
41	Forest	16,198.6	27.8%	8,232.6	26.6%	1,301.7	11.4%	6,664.3	41.7%
42	Tree	7,397.2	12.7%	4,675.0	15.1%	1,568.6	13.8%	1,153.6	7.2%
51	Scrub/Shrub	366.3	0.6%	214.2	0.7%	24.9	0.2%	127.1	0.8%
61	Harvested/Disturbed	564.1	1.0%	229.5	0.7%			334.6	2.1%
71	Turf Grass	5,773.1	9.9%	4,295.1	13.9%	1,084.3	9.5%	393.7	2.5%
81	Pasture	14,094.3	24.2%	7,066.3	22.8%	3,500.2	30.8%	3,527.8	22.1%
82	Cropland	8,397.2	14.4%	2,869.6	9.3%	2,982.4	26.2%	2,545.2	15.9%
91	NWI/Other	1,473.6	2.5%	348.8	1.1%	276.0	2.4%	848.8	5.3%
	Total	58,283.9		30,925.4		11,381.0		15,977.2	

Figure 16-2. 2016 Virginia Land Cover Data for Mountain Run Watershed

16.3 Underlying Ecoregions/Geology

Ecoregions denote area that are generally similar based on the type, quality, and quantity of environmental resources and can provide information to support decisions in the assessment and monitoring of watersheds. Ecoregions are defined at four levels with Level I being the most general (12 ecoregions in the continental United States) to Level IV being the most detailed (967 ecoregions in the conterminous United States).

The Mountain Run watershed lies largely in the Northern Piedmont Level III ecoregion; only the far eastern portion of the watershed near the confluence with the Rappahannock River falls in the Piedmont Level III ecoregion. These Level III ecoregions are used when comparing data specific to this BSA to other watersheds.

The Mountain Run watershed also partially falls within the Trap Rock and Conglomerates Uplands and Triassic Lowlands Level IV ecoregions. The underlying geology of these ecoregion is primarily sedimentary rock of the Triassic interspersed with magma intrusions of igneous diabase (trap rock) and heat-altered sedimentary rocks (Woods et al., 1999). This geology naturally produces higher conductivity and higher phosphorus levels in overlying streams than is typical in the rest of the Northern Piedmont Level III ecoregion (Porter et al., 2020). Figure 3-3 depicts the Level IV ecoregions surrounding and encompassing Mountain Run's watershed.

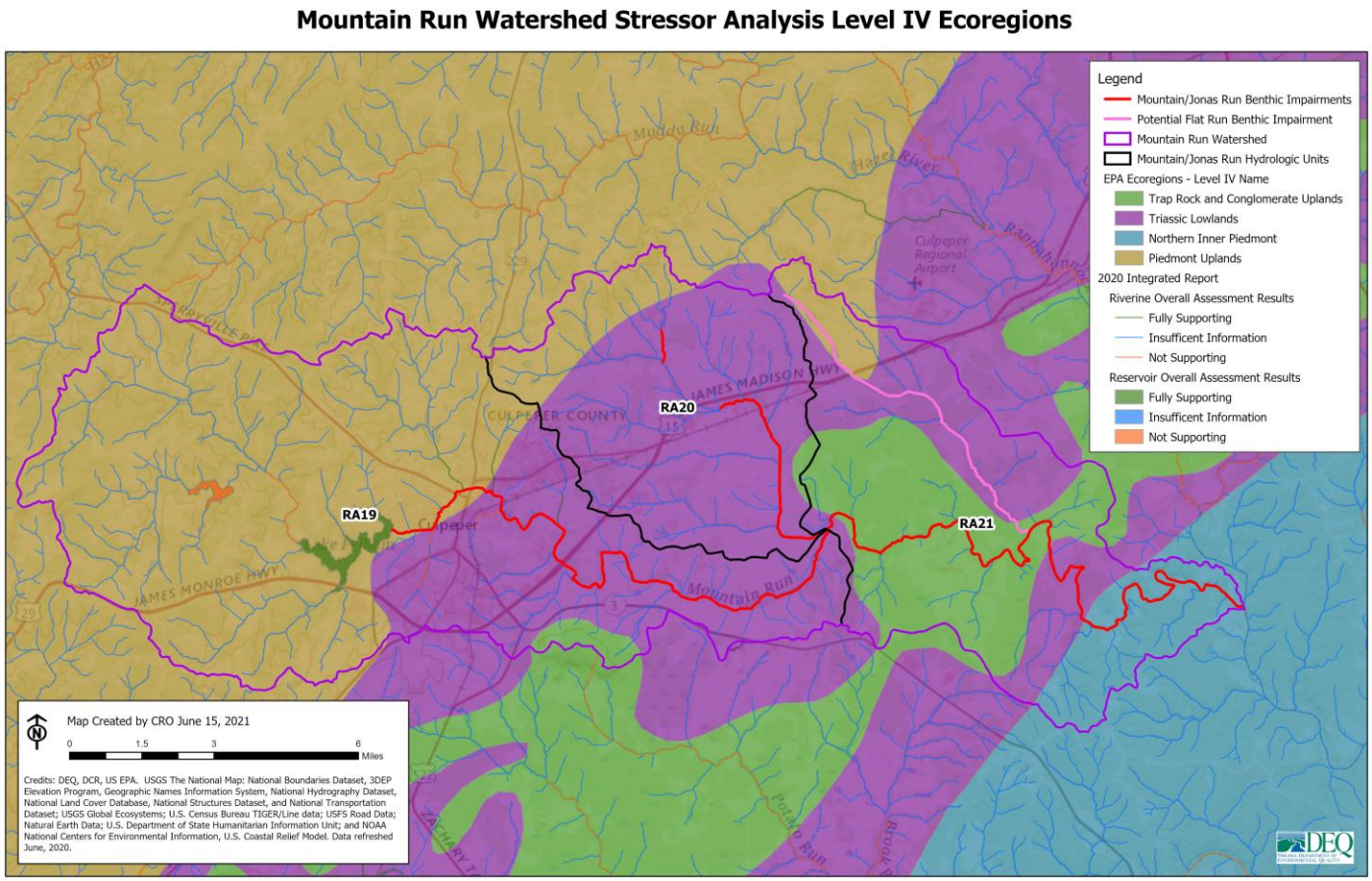


Figure 16-3. Mountain Run Watershed Area Level IV Ecoregions

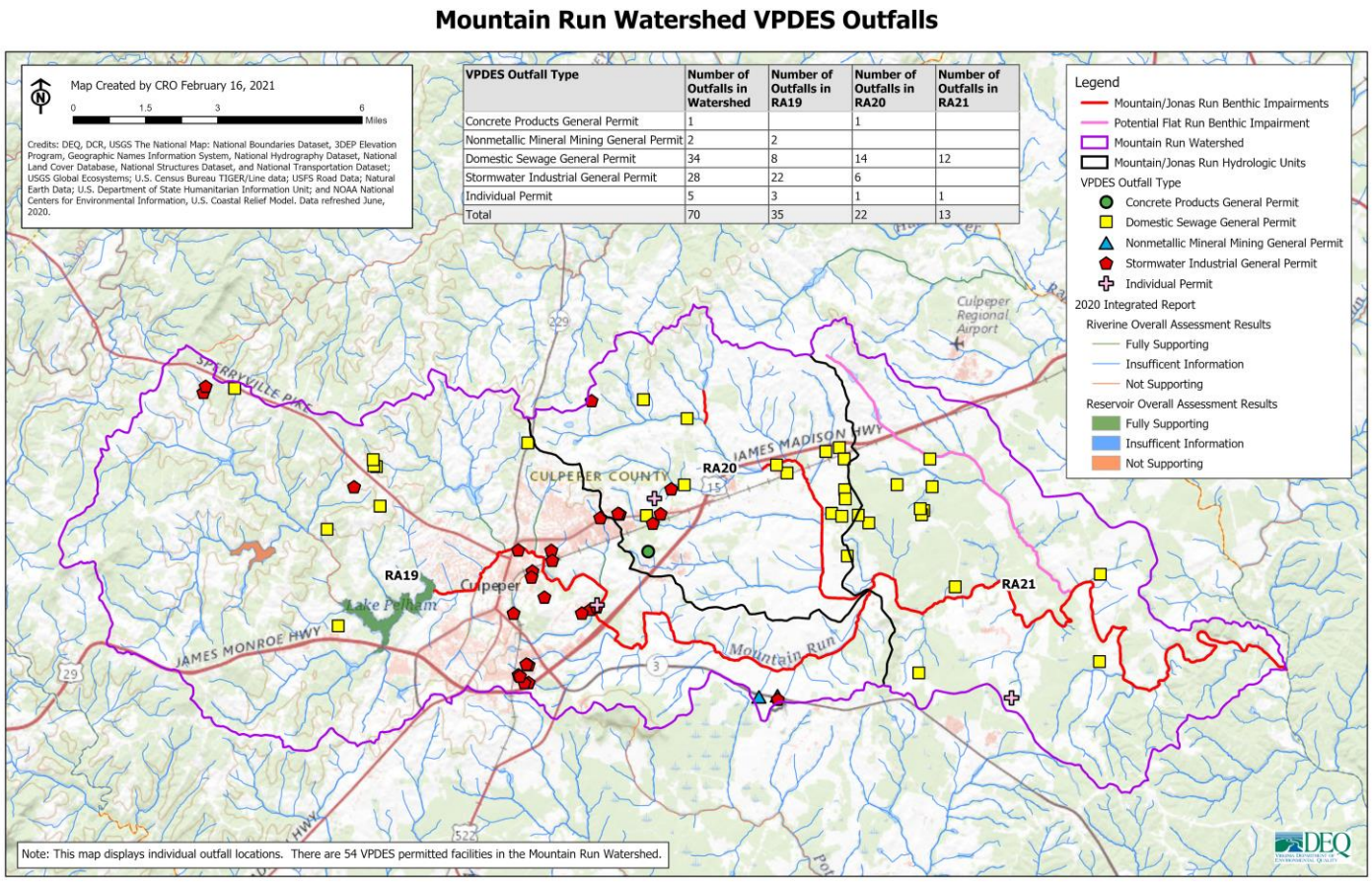
16.4 Virginia Pollution Discharge Elimination System (VPDES)

DEQ regulates discharges to state waters in accordance with federal and state laws and regulations. DEQ issues Virginia Pollutant Discharge Elimination System (VPDES) permits for point source discharges to surface waters. This includes discharges from municipal and industrial operations which may contain process wastewater water as well as certain types of stormwater. Stormwater which is exposed to industrial activity is regulated under the VPDES program, while Municipal Separate Storm Sewer Systems (MS4) are regulated under the Virginia Stormwater Management Program (VSMP). Under the VPDES and VSMP programs, there are both individual permits as well as general permits. General permits in Virginia are established as regulations, and are issued to categories of activities which have similar operations and nature of the pollutants discharged to surface waters. Discharge permits aim to ensure the Virginia WQS are maintained and protected. Permits may include effluent limits, monitoring requirements, and special conditions to address pollutants that have a reasonable potential to cause or contribute to an instream excursion of a water quality criteria. Facilities conduct monitoring to determine compliance with permit requirements.

As of March 2021, there are 54 VPDES permits with 70 outfalls in the watershed (Figure 3-4). These are largely made up of domestic sewage general permit outfalls (34) and stormwater industrial general permit (25) outfalls. The 3 VPDES individual permits (with 5 total outfalls) are detailed in the table below (Table 3-1).

Table 16-1. VPDES Individual Permits in the Mountain Run Watershed

VPDES Permit Number	Facility Name	Number of Outfalls
VA0059145	Culpeper Wood Preservers - Culpeper	1
VA0061590	Culpeper Wastewater Treatment Plant	3
VA0092452	Camp Red Arrow WWTP	1

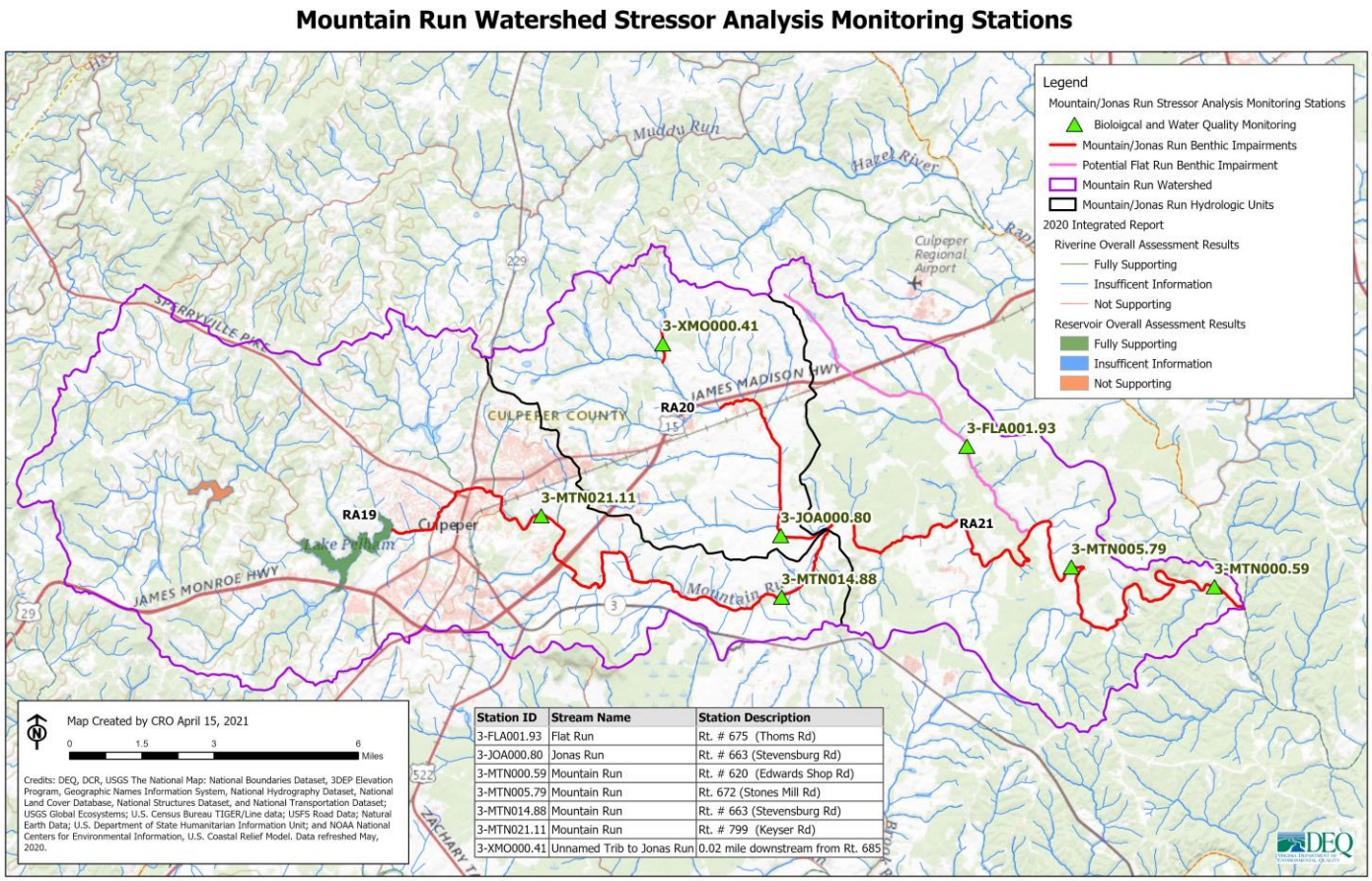


VPDES Outfall Type	Number of Outfalls in Watershed	Number of Outfalls in RA19	Number of Outfalls in RA20	Number of Outfalls in RA21
Concrete Products General Permit	1		1	
Nonmetallic Mineral Mining General Permit	2	2		
Domestic Sewage General Permit	34	8	14	12
Stormwater Industrial General Permit	28	22	6	
Individual Permit	5	3	1	1
Total	70	35	22	13

Figure 16-4. Location of VPDES Permitted Discharges in the Mountain Run Watershed

17.0 DEQ SAMPLE COLLECTION AND MONITORING STATIONS

DEQ biological and water quality monitoring data were examined in a 2015 to 2021 data window to investigate likely stressor(s) causing the impairment to the aquatic community as shown in Figure 4-1 below. While a larger data window exists for some of the stations only data since 2015 was considered to ensure the analysis reflected current stream conditions. For the purposes of the analysis of the stations and their data was reviewed in three groups. The four stations along the Mountain Run mainstem, from below Lake Pelham to just above the confluence with the Rappahannock River (stations 3-MTN021.11, 3-MTN014.88, 3-MTN005.79 and 3-MTN000.59), were evaluated as a group, the two stations in the Jonas Run watershed (3-JOA000.80 and 3-XMO000.41) were evaluated together, then the single station on Flat Run (3-FLA001.93) was evaluated independently. Table 4-1 details the stations and data windows used in the analysis.



Station ID	Stream Name	Station Description
3-FLA001.93	Flat Run	Rt. # 675 (Thoms Rd)
3-JOA000.80	Jonas Run	Rt. # 663 (Stevensburg Rd)
3-MTN000.59	Mountain Run	Rt. # 620 (Edwards Shop Rd)
3-MTN005.79	Mountain Run	Rt. 672 (Stones Mill Rd)
3-MTN014.88	Mountain Run	Rt. # 663 (Stevensburg Rd)
3-MTN021.11	Mountain Run	Rt. # 799 (Keyser Rd)
3-XMO000.41	Unnamed Trib to Jonas Run	0.02 mile downstream from Rt. 685

Figure 17-1. Location of Monitoring Stations in the Mountain Run Watershed

Table 17-1. Monitoring Stations and Data Windows for Mountain Run Watershed BSA

BSA Study Areas	Stream Name	DEQ Monitoring Station	Station Location	12-digit HUC	BSA Data Window
Mainstem Mountain Run	Mountain Run	3-MTN000.59	Rt. 620 (Edwards Shop Rd)	RA21	04/30/2015 - 02/22/2021
	Mountain Run	3-MTN005.79	Rt. 672 (Stones Mill Rd)	RA21	02/26/2018 - 09/30/2020
	Mountain Run	3-MTN014.88	Rt. 663 (Stevensburg Rd)	RA19	07/09/2015 - 09/30/2020
	Mountain Run	3-MTN021.11	Rt. 799 (Keyser Rd)	RA19	07/27/2015 - 09/30/2020
Jonas Run	Jonas Run	3-JOA000.80	Rt. 663 (Stevensburg Rd)	RA20	02/26/2018 - 09/24/2020
	Unnamed Tributary to Jonas Run	3-XMO000.41	0.02 mile downstream from Rt. 685	RA20	03/13/2018 - 10/30/2018
Flat Run	Flat Run	3-FLA001.93	Rt. 675 (Thoms Rd)	RA21	02/23/2018 - 09/24/2020

18.0 BIOLOGICAL DATA ANALYSIS

Benthic macroinvertebrate communities are commonly assessed to reflect water quality in a stream over periods of time, whereas ambient water samples only capture water quality at a specific point in time. DEQ samples these communities to identify stream stressors, both acute and chronic. Compounding stressors often result in decreased diversity, with pollutant tolerant organisms dominating the affected stream reach.

18.1 Virginia Stream Condition Index

DEQ evaluates biological communities using the VSCI to classify stream health. The VSCI, calculated using a variety of metrics, accounts for taxonomic richness and composition, evenness, tolerance, and trophic group of benthic macroinvertebrates (**Error! Reference source not found.**) (Burton and Gerritsen, 2003). An expected response to disturbance is applied to each metric (identified in **Error! Reference source not found.**) to return a VSCI score. These scores indicate the health of the stream; a VSCI score equal to or greater than 60 is considered non-impaired, and a score of less than 60 indicates an impaired community (DEQ, 2021).

Table 18-1. Metrics of the Virginia Stream Condition Index (VSCI)

Metric	Expected Response to Disturbance	Definition of Metric	Metric Measures…
Taxonomic Richness			
Total Taxa	Decrease	Total number taxa observed	Overall variety of macroinvertebrate assemblage
EPT Taxa	Decrease	Total number of *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) taxa (pollution-sensitive) observed	Prevalence of pollutant-sensitive mayflies, stoneflies, and caddis flies.
Taxonomic Composition			
% PT-H	Decrease	Percent individuals of *Plecoptera*, and *Trichoptera* (PT) taxa (pollution-sensitive) in samples excluding *Hydropsychidae* (pollution-tolerant)	Pollution-sensitive stoneflies and caddies flies without counting pollution-tolerant net-spinning caddis flies
% *Ephemeroptera*	Decrease	Percent individuals of *Ephemeroptera* taxa (pollution-sensitive)	Pollution-sensitive mayflies
% *Chironomidae*	Increase	Percent individuals of *Chironomidae* taxa (pollution-tolerant)	Pollution-tolerant midge larvae
Evenness			
% Two Dominant Taxa	Increase	Percent dominance of two most abundant taxa	Diversity of benthic community
Tolerance			
HBI (Family Level)	Increase	Hilsenhoff Biotic Index	Average tolerance to pollution of benthic community, weighted by abundance
Trophic Group			
% Scrapers	Decrease	% of scraper functional feeding group	Macroinvertebrates which graze on substrate- or periphyton-attached algae

18.1.1 Mainstem Mountain Run

Overall Mountain Run's VSCI score have largely been below the impairment threshold of 60 with a median value of 49.14 and an average value of 50.14 (Figure 5-1). Generally, the average of VSCI scores for all fall samples is slightly higher (57.21) compared to the average of all spring samples (43.06).

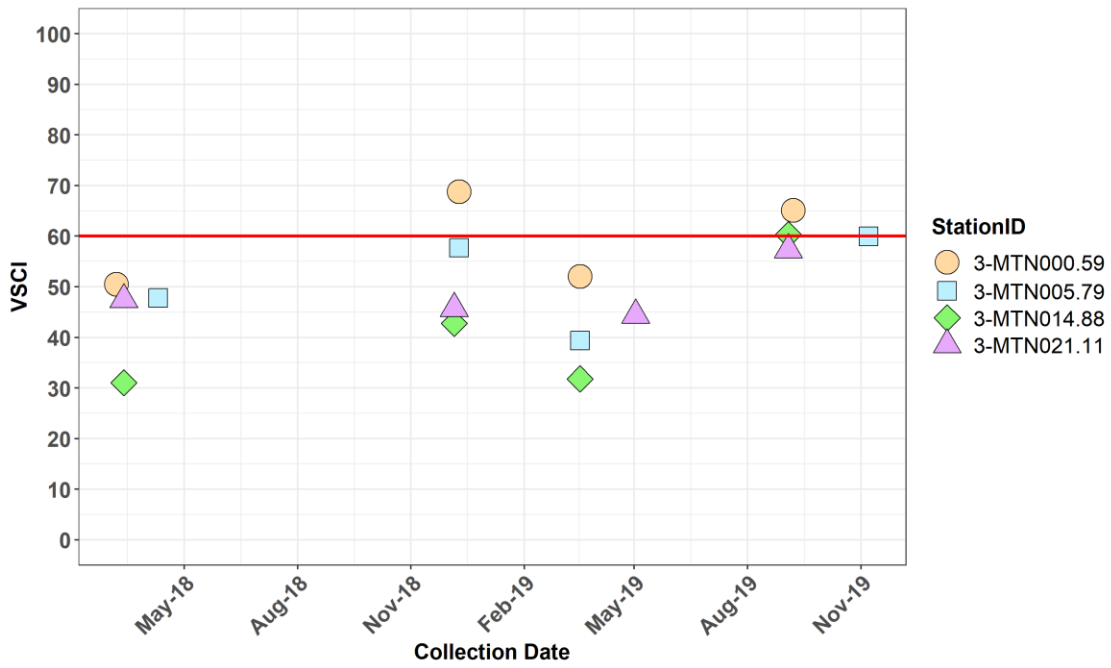


Figure 18-1. Virginia Stream Condition Index (VSCI) for Mountain Run

The VSCI scores for 3-MTN000.59, when both fall and spring samples are viewed together, have been below the impairment threshold with a median value of 58.6 and an average value of 59.13 (Table 5-2). On average, fall samples had a higher VSCI score (66.97) compared to spring samples (51.29). In the Metric Scores tables below the orange shaded values indicate the two lowest scores that are most likely driving low VSCI scores and the red VSCI scores are below the impairment threshold of 60.

Table 18-2. Metric Scores Used to Calculate the VSCI for 3-MTN000.59.

	% Ephem Score	% PT-H Score	% Chironomidae Score	Fam Richness Score	Fam EPT Score	Family %Scraper Score	Family %2 Domniant Score	Family %MFBI Score	VSCI
Spring 2018	7.42	10.21	90.00	63.64	54.55	45.81	64.37	68.05	50.50
Fall 2018	26.69	61.29	92.73	68.18	72.73	54.62	94.59	79.68	68.81
Spring 2019	19.28	7.66	80.91	59.09	63.64	49.33	68.31	68.45	52.08
Fall 2019	11.86	53.63	97.27	54.55	54.55	100.00	60.43	88.64	65.12

The VSCI scores for 3-MTN005.79 have been below the impairment threshold with a median value of 52.75 and an average value of 51.2 (Table 5-3). On average, fall samples had a higher VSCI score (58.83) compared to spring samples (43.58).

Table 18-3. Metric Scores Used to Calculate VSCI for 3-MTN005.79

	% Ephem Score	% PT-H Score	% Chironomidae Score	Fam Richness Score	Fam EPT Score	Family %Scraper Score	Family %2 Domniant Score	Family %MFBI Score	VSCI
Spring 2018	2.97	22.98	67.27	59.09	45.45	51.09	64.37	69.12	47.79
Fall 2018	14.83	7.66	95.45	81.82	36.36	65.19	93.27	67.11	57.71
Spring 2019	10.38	5.11	58.18	63.64	36.36	26.43	51.23	63.64	39.37
Fall 2019	23.73	28.09	100.00	63.64	54.55	77.52	55.18	76.87	59.95

The VSCI scores for 3-MTN014.88 have been below the impairment threshold with a median value of 37.3 and an average value of 41.48 (Table 5-4) with the exception of the Fall 2019 score. On average, fall samples had a higher VSCI score (51.55) compared to spring samples (31.42).

Table 18-4. Metric Scores Used to Calculate the VSCI for 3-MTN014.88

	% Ephem Score	% PT-H Score	% Chironomidae Score	Fam Richness Score	Fam EPT Score	Family %Scraper Score	Family %2 Domniant Score	Family %MFBI Score	VSCI
Spring 2018	0.00	7.66	35.45	50.00	27.27	38.76	24.96	64.17	31.03
Fall 2018	4.45	12.77	96.36	54.55	36.36	33.47	39.41	64.84	42.78
Spring 2019	1.48	2.55	56.36	40.91	27.27	26.43	36.78	62.70	31.81
Fall 2019	20.76	76.61	90.00	36.36	45.45	72.23	56.49	84.63	60.32

The VSCI scores for 3-MTN021.11 have been below the impairment threshold with a median value of 46.59 and an average value of 48.73 (Table 5-5). On average, fall samples had a higher VSCI score (51.51) compared to spring samples (45.95).

Table 18-5. Metric Scores Used to Calculate the VSCI for 3-MTN021.11

	% Ephem Score	% PT-H Score	% Chironomidae Score	Fam Richness Score	Fam EPT Score	Family %Scraper Score	Family %2 Domniant Score	Family %MFBI Score	VSCI
Spring 2018	17.80	5.11	69.09	54.55	27.27	65.19	74.88	65.91	47.47
Fall 2018	14.83	5.11	98.18	59.09	27.27	52.85	43.35	64.97	45.71
Spring 2019	16.31	5.11	90.91	40.91	27.27	45.81	59.12	69.92	44.42
Fall 2019	45.97	15.32	96.36	40.91	36.36	84.57	61.74	77.27	57.31

18.1.2 Jonas Run and the Unnamed Tributary to Jonas Run

The VSCI scores for Jonas Run and the unnamed tributary to Jonas Run have been below the impairment threshold with a median value of 39.72 and an average value of 43.18 (Figure 5-2). On average, fall samples had a higher VSCI score (52.2) compared to spring samples (34.15).

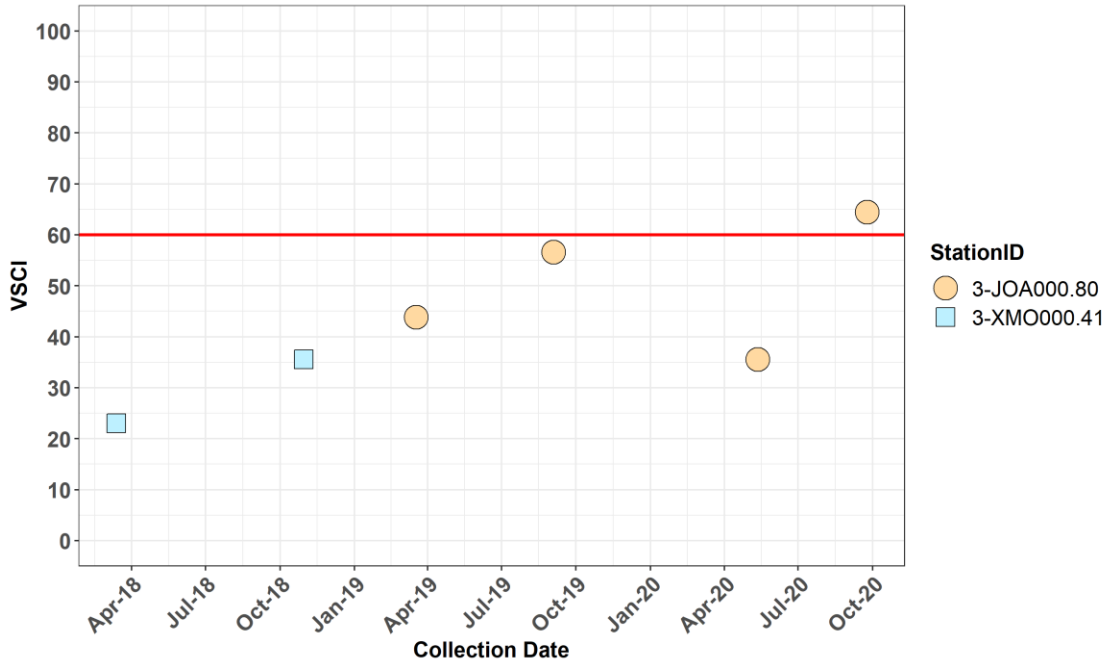


Figure 18-2. Virginia Stream Condition Index (VSCI) for Jonas Run and the Unnamed Tributary to Jonas Run

The VSCI scores for 3-JOA000.80 have been below the impairment threshold with a median value of 50.25 and an average value of 50.13 (Table 5-6), with the exception of the Fall 2020 score. On average, fall samples had a higher VSCI score (60.53) compared to spring samples (39.72).

Table 18-6. Metric Scores Used to Calculate the VSCI for 3-JOA000.80

	% Ephem Score	% PT-H Score	% Chironomidae Score	Fam Richness Score	Fam EPT Score	Family %Scraper Score	Family %2 Domniant Score	Family %MFBI Score	VSCI
Spring 2019	2.97	43.41	67.27	45.45	27.27	33.47	61.74	69.52	43.89
Fall 2019	4.45	53.63	85.45	45.45	36.36	100.00	44.67	82.75	56.60
Spring 2020	0.00	0.00	65.45	31.82	9.09	58.14	52.55	67.38	35.55
Fall 2020	23.73	91.93	94.55	40.91	36.36	82.80	57.80	87.70	64.47

The VSCI scores for the two sampling events at 3-XMO000.41 have been below the impairment threshold with a median value of 29.27 and an average value of 29.27 (Table 5-7). On average, fall samples had a higher VSCI score (35.54) compared to spring samples (23.01).

Table 18-7. Metric Scores Used to Calculate the VSCI for 3-XMO000.41

	% Ephem Score	% PT-H Score	% Chironomidae Score	Fam Richness Score	Fam EPT Score	Family %Scraper Score	Family %2 Domniant Score	Family %MFBI Score	VSCI
Spring 2018	1.48	0.00	34.55	36.36	9.09	21.14	19.71	61.76	23.01
Fall 2018	5.93	12.77	73.64	45.45	45.45	14.09	23.65	63.37	35.54

18.1.3 Flat Run

Flat Run's VSCI scores have consistently been below the impairment threshold with a median value of 40.67 and an average value of 39.17 (Figure 5-3). On average, fall samples had a slightly higher VSCI score (40.72) compared to spring samples (37.63).

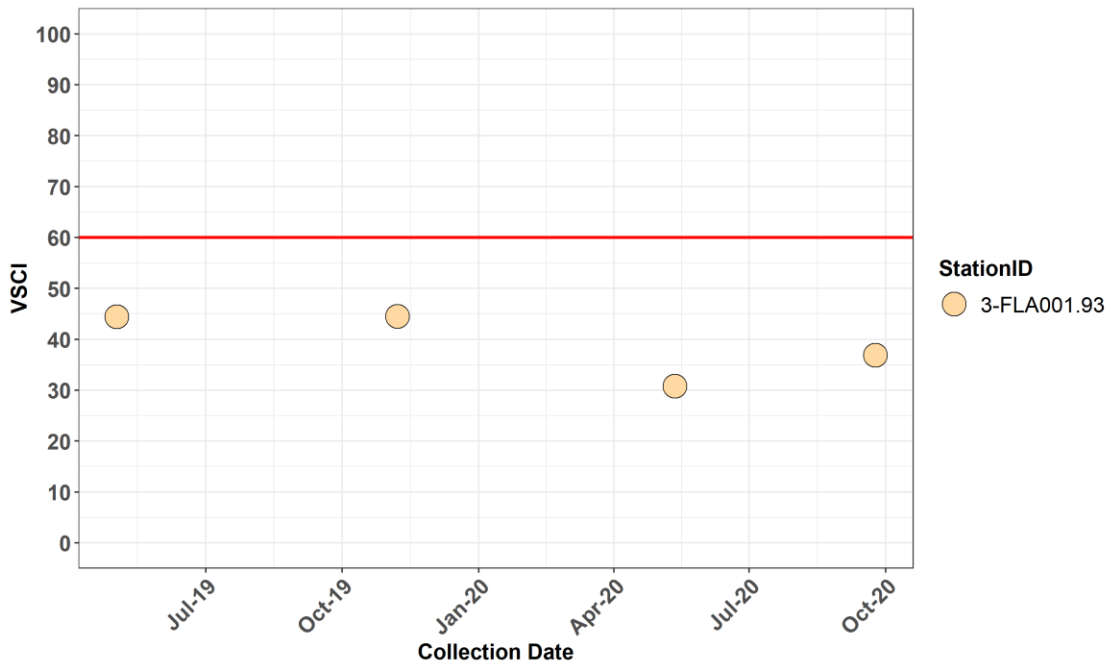


Figure 18-3. Virginia Stream Condition Index (VSCI) for Flat Run

The metrics used to calculate the VSCI scores for 3-FLA001.93 are shown in Table 5-8 below.

Table 18-8. Metric Scores Used to Calculate the VSCI for 3-FLA001.93

	% Ephem Score	% PT-H Score	% Chironomidae Score	Fam Richness Score	Fam EPT Score	Family %Scraper Score	Family %2 Domniant Score	Family %MFBI Score	VSCI
Spring 2019	22.25	0.00	85.45	54.55	27.27	28.19	74.88	62.83	**44.43**
Fall 2019	4.45	2.55	86.36	68.18	18.18	31.71	86.71	58.02	**44.52**
Spring 2020	0.00	0.00	78.18	40.91	0.00	7.05	70.94	49.60	**30.83**
Fall 2020	8.90	0.00	60.00	63.64	18.18	28.19	63.06	53.38	**36.92**

18.2 Biological Condition Gradient (BCG)

The Biological Condition Gradient (BCG) attribution identifies the relative tolerance and sensitivity for taxa commonly found throughout Virginia and surrounding sates (Tetra Tech, 2019). The attribution process uses data from several entities (DEQ, surrounding states within the region, counties, etc.) to assign a tolerance value to each taxon using a consensus-based process. The BCG Metric is an average of all stressor specific BCG attribution. The values range from 1 to 5, where 1 indicates that a taxon is highly sensitive to a given stressor pollutant or condition and 5 indicates that a taxon's population will increase in the presence of that stressor (e.g. more pollution tolerant). A value of 6 is used to indicate the species typically does not naturally occur in the locale or ecosystem. The letter accompanying the 6

attribution denotes intolerant, moderately tolerant, and tolerant characteristics in addition to the non-native status.

Table 5-9 - Table 5-15 display the BCG data for the 85th cumulative percentile of benthic macroinvertebrate community based upon number of individuals per taxa at the stations being considered in this analysis. The tables provide the response of the identified organism (rows) to the stressor indicator (columns); the taxon's assigned value is representative of their specific tolerance to 10 individual stressors. The six stations had averages of at least 4 for all of the stressors indicating pollution tolerant communities. Benthic taxa present also indicated increased tolerance for Specific Conductance, Sulfate, Nutrients, Total Habitat and Watershed % Impervious stressors at the stations.

18.2.1 Mainstem Mountain Run

Table 18-9. BCG attribution for 85th Cumulative Percentile of Benthic Macroinvertebrate Community Sampled at 3-MTN000.59

Genus Level	No. of Individuals	Functional Feeding Group	General Attribute[1]	Biological Condition Gradient (BCG) Attribute Assignments for Specific Stressors									
				DO	Acidity (pH[2])	Alkalinity (pH[2])	Specific Conduct-ance	Chloride	Sulfate	Nutrients[3]	Total Habitat Score	Relative Bed Stability	Watershed % Impervious
Cheumatopsyche	84	Filterer	5	4	3	4	5	4	4	5	4	4	5
Prosimulium	78	Filterer	3	4	4	4	3	4	4	3	3	4	2
Microcylloepus	75	Collector	4	3	3	4	4	3	4	4	3	4	4
Stenelmis	70	Scraper	4	4	4	4	5	4	4	4	5	4	5
Chironomidae	66	Collector	4	4	4	4	4	4	4	4	4	4	4
Simulium	65	Filterer	4	4	4	4	4	3	5	5	4	4	4
Taeniopteryx	62	Shredder	4	3	3	4	3	3	4	4	4	4	3
Maccaffertium	59	Scraper	4	4	4	4	3	3	3	4	4	4	4
Gammaridae	55	Collector	4	4	4	4	4	4	4	4	4	4	4
Gammarus	46	Collector	4	5	4	4	5	4	4	4	5	x	4
Hydrobiidae	18	Scraper	4	4	3	3	4	3	3	4	4	4	4
Optioservus	17	Scraper	4	3	3	4	4	4	5	4	4	4	3
TOTAL	695		**Rounded Average**	4	4	4	4	4	4	4	4	4	4

[1] Characterizes tolerance and other ecological attributes in relation to broad physical and chemical conditions. Lower values indicate greater sensitivity to pollution, higher values indicate greater tolerance to pollution.

[2] For pH, responses to acidity and alkalinity were considered independently.

[3] For nutrients, although Total Nitrogen (TN) and Total Phosphorous (TP) were analyzed separately, these were assessed as common responses for attribution assignment.

x - no attribute assigned for the genus/stressor

Table 18-10. BCG attribution for 85th Cumulative Percentile of Benthic Macroinvertebrate Community Sampled at 3-MTN005.79

Genus Level	No. of Individuals	Functional Feeding Group	General Attribute[1]	Biological Condition Gradient (BCG) Attribute Assignments for Specific Stressors									
				DO	Acidity (pH[2])	Alkalinity (pH[2])	Specific Conduct-ance	Chloride	Sulfate	Nutrients[3]	Total Habitat Score	Relative Bed Stability	Watershed % Impervious
Chironomidae	162	Collector	4	4	4	4	4	4	4	4	4	4	4
Gammarus	125	Collector	4	5	4	4	5	4	4	4	5	x	4
Simulium	90	Filterer	4	4	4	4	4	3	5	5	4	4	4
Stenelmis	82	Scraper	4	4	4	4	5	4	4	4	5	4	5
Maccaffertium	53	Scraper	4	4	4	4	3	3	3	4	4	4	4
Cheumatopsyche	40	Filterer	5	4	3	4	5	4	4	5	4	4	5
Hydrobiidae	23	Scraper	4	4	3	3	4	3	3	4	4	4	4
Prosimulium	23	Filterer	3	4	4	4	3	4	4	3	3	4	2
Microcylloepus	19	Collector	4	3	3	4	4	3	4	4	3	4	4
Hydropsyche	15	Filterer	4	3	3	x	5	4	5	5	4	4	5
Asellidae	13	Collector	5	5	5	2	4	4	4	4	5	4	4
Chimarra	13	Filterer	4	4	4	4	4	4	4	4	4	4	5
Psephenus	13	Scraper	4	3	3	4	4	3	4	3	3	3	3
Taeniopteryx	13	Shredder	4	3	3	4	3	3	4	4	4	4	3
TOTAL	684		**Rounded Average**	4	4	4	4	4	4	4	4	4	4

[1] Characterizes tolerance and other ecological attributes in relation to broad physical and chemical conditions. Lower values indicate greater sensitivity to pollution, higher values indicate greater tolerance to pollution.

[2] For pH, responses to acidity and alkalinity were considered independently.

[3] For nutrients, although Total Nitrogen (TN) and Total Phosphorous (TP) were analyzed separately, these were assessed as common responses for attribution assignment.

x - no attribute assigned for the genus/stressor

Table 18-11. BCG attribution for 85th Cumulative Percentile of Benthic Macroinvertebrate Community Sampled at 3-MTN014.88

Genus Level	No. of Individuals	Functional Feeding Group	General Attribute[1]	Biological Condition Gradient (BCG) Attribute Assignments for Specific Stressors									
				DO	Acidity (pH[2])	Alkalinity (pH[2])	Specific Conduct-ance	Chloride	Sulfate	Nutrients[3]	Total Habitat Score	Relative Bed Stability	Watershed % Impervious
Chironomidae	240	Collector	4	4	4	4	4	4	4	4	4	4	4
Stenelmis	144	Scraper	4	4	4	4	5	4	4	4	5	4	5
Cheumatopsyche	132	Filterer	5	4	3	4	5	4	4	5	4	4	5
Hydropsyche	77	Filterer	4	3	3	x	5	4	5	5	4	4	5
Chimarra	55	Filterer	4	4	4	4	4	4	4	4	4	4	5
Baetis	23	Collector	4	3	4	4	4	4	5	4	4	4	4
Tricladida	21	Collector	4	4	3	3	4	4	4	4	4	4	4
TOTAL	692		**Rounded Average**	4	4	4	4	4	4	4	4	4	5

[1] Characterizes tolerance and other ecological attributes in relation to broad physical and chemical conditions. Lower values indicate greater sensitivity to pollution, higher values indicate greater tolerance to pollution.

[2] For pH, responses to acidity and alkalinity were considered independently.

[3] For nutrients, although Total Nitrogen (TN) and Total Phosphorous (TP) were analyzed separately, these were assessed as common responses for attribution assignment.

x - no attribute assigned for the genus/stressor

Table 18-12. BCG attribution for 85th Cumulative Percentile of Benthic Macroinvertebrate Community Sampled at 3-MTN021.11

Genus Level	No. of Individuals	Functional Feeding Group	General Attribute[1]	Biological Condition Gradient (BCG) Attribute Assignments for Specific Stressors									
				DO	Acidity (pH[2])	Alkalinity (pH[2])	Specific Conduct-ance	Chloride	Sulfate	Nutrients[3]	Total Habitat Score	Relative Bed Stability	Watershed % Impervious
Hydropsyche	160	Filterer	4	3	3	x	5	4	5	5	4	4	5
Stenelmis	111	Scraper	4	4	4	4	5	4	4	4	5	4	5
Chironomidae	100	Collector	4	4	4	4	4	4	4	4	4	4	4
Cheumatopsyche	78	Filterer	5	4	3	4	5	4	4	5	4	4	5
Maccaffertium	71	Scraper	4	4	4	4	3	3	3	4	4	4	4
Baetis	49	Collector	4	3	4	4	4	4	5	4	4	4	4
Tricladida	40	Collector	4	4	3	3	4	4	4	4	4	4	4
Chimarra	33	Filterer	4	4	4	4	4	4	4	4	4	4	5
Hydropsychidae	30	Filterer	4	3	3	4	4	3	4	4	4	4	4
Simulium	26	Filterer	4	4	4	4	4	3	5	5	4	4	4
TOTAL	698		**Rounded Average**	4	4	4	4	4	4	4	4	4	4

[1] Characterizes tolerance and other ecological attributes in relation to broad physical and chemical conditions. Lower values indicate greater sensitivity to pollution, higher values indicate greater tolerance to pollution.

[2] For pH, responses to acidity and alkalinity were considered independently.

[3] For nutrients, although Total Nitrogen (TN) and Total Phosphorous (TP) were analyzed separately, these were assessed as common responses for attribution assignment.

x - no attribute assigned for the genus/stressor

18.2.2 Jonas Run and the Unnamed Tributary to Jonas Run

Table 18-13. BCG attribution for 85th Cumulative Percentile of Benthic Macroinvertebrate Community Sampled at 3-JOA000.80

Genus Level	No. of Individuals	Functional Feeding Group	General Attribute[1]	Biological Condition Gradient (BCG) Attribute Assignments for Specific Stressors									
				DO	Acidity (pH[2])	Alkalinity (pH[2])	Specific Conduct-ance	Chloride	Sulfate	Nutrients[3]	Total Habitat Score	Relative Bed Stability	Watershed % Impervious
Stenelmis	178	Scraper	4	4	4	4	5	4	4	4	5	4	5
Chironomidae	162	Collector	4	4	4	4	4	4	4	4	4	4	4
Chimarra	122	Filterer	4	4	4	4	4	4	4	4	4	4	5
Simulium	59	Filterer	4	4	4	4	4	3	5	5	4	4	4
Microcylloepus	42	Collector	4	3	3	4	4	3	4	4	3	4	4
Hydropsyche	37	Filterer	4	3	3	x	5	4	5	5	4	4	5
Psephenus	32	Scraper	4	3	3	4	4	3	4	3	3	3	3
Cheumatopsyche	31	Filterer	5	4	3	4	5	4	4	5	4	4	5
TOTAL	663		**Rounded Average**	4	4	4	4	4	4	4	4	4	4

[1] Characterizes tolerance and other ecological attributes in relation to broad physical and chemical conditions. Lower values indicate greater sensitivity to pollution, higher values indicate greater tolerance to pollution.

[2] For pH, responses to acidity and alkalinity were considered independently.

[3] For nutrients, although Total Nitrogen (TN) and Total Phosphorous (TP) were analyzed separately, these were assessed as common responses for attribution assignment.

x - no attribute assigned for the genus/stressor

Table 18-14. BCG attribution for 85th Cumulative Percentile of Benthic Macroinvertebrate Community Sampled at 3-XMO000.41

Genus Level	No. of Individuals	Functional Feeding Group	General Attribute[1]	Biological Condition Gradient (BCG) Attribute Assignments for Specific Stressors									
				DO	Acidity (pH[2])	Alkalinity (pH[2])	Specific Conduct-ance	Chloride	Sulfate	Nutrients[3]	Total Habitat Score	Relative Bed Stability	Watershed % Impervious
Chironomidae	179	Collector	4	4	4	4	4	4	4	4	4	4	4
Cheumatopsyche	57	Filterer	5	4	3	4	5	4	4	5	4	4	5
Hydropsyche	49	Filterer	4	3	3	x	5	4	5	5	4	4	5
Prosimulium	31	Filterer	3	4	4	4	3	4	4	3	3	4	2
Stenelmis	21	Scraper	4	4	4	4	5	4	4	4	5	4	5
Hydropsychidae	16	Filterer	4	3	3	4	4	3	4	4	4	4	4
TOTAL	353		**Rounded Average**	4	4	4	4	4	4	4	4	4	4

[1] Characterizes tolerance and other ecological attributes in relation to broad physical and chemical conditions. Lower values indicate greater sensitivity to pollution, higher values indicate greater tolerance to pollution.

[2] For pH, responses to acidity and alkalinity were considered independently.

[3] For nutrients, although Total Nitrogen (TN) and Total Phosphorous (TP) were analyzed separately, these were assessed as common responses for attribution assignment.

x - no attribute assigned for the genus/stressor

18.2.3 Flat Run

Table 18-15. BCG attribution for 85th Cumulative Percentile of Benthic Macroinvertebrate Community Sampled at 3-FLA001.93

Genus Level	No. of Individuals	Functional Feeding Group	General Attribute[1]	Biological Condition Gradient (BCG) Attribute Assignments for Specific Stressors									
				DO	Acidity (pH[2])	Alkalinity (pH[2])	Specific Conduct-ance	Chloride	Sulfate	Nutrients[3]	Total Habitat Score	Relative Bed Stability	Watershed % Impervious
Chironomidae	188	Collector	4	4	4	4	4	4	4	4	4	4	4
Asellidae	111	Collector	5	5	5	2	4	4	4	4	5	4	4
Simulium	64	Filterer	4	4	4	4	4	3	5	5	4	4	4
Cheumatopsyche	63	Filterer	5	4	3	4	5	4	4	5	4	4	5
Ceratopogoninae [4]	49	Predator	x	x	x	x	x	x	x	x	x	x	x
Caenis	40	Collector	4	4	3	4	4	4	4	4	4	5	5
Crangonyx	39	Collector	4	5	5	3	4	5	4	5	5	x	5
Physidae	29	Scraper	5	5	4	5	5	4	3	5	5	5	5
Stenelmis	29	Scraper	4	4	4	4	5	4	4	4	5	4	5
Corbicula	25	Filterer	6	4	3	4	5	4	4	5	5	4	5
Dubiraphia	25	Collector	4	4	3	3	4	4	4	4	4	4	4
TOTAL	662		**Rounded Average**	4	4	4	4	4	4	5	5	4	5

[1] Characterizes tolerance and other ecological attributes in relation to broad physical and chemical conditions. Lower values indicate greater sensitivity to pollution, higher values indicate greater tolerance to pollution.

[2] For pH, responses to acidity and alkalinity were considered independently.

[3] For nutrients, although Total Nitrogen (TN) and Total Phosphorous (TP) were analyzed separately, these were assessed as common responses for attribution assignment.

[4] BCG attribute assignments for specific stressors have not been established for this species

x - no attribute assigned for the genus/stressor

18.3 Total Habitat and Logged Relative Bed Stability Index

As a part of TMDL monitoring, DEQ conducted an assessment of the physical in the Mountain Run. First, as part of the Rapid Bioassessment Protocol (Barbour et al. 1999), a visual habitat assessment is performed at the time of each benthic sample collection to determine an overall total habitat score for the monitoring station. This assessment is comprised of a number of habitat components that include substrate, embeddedness, velocity, sediment, flow, channel alteration, riffles, bank stability, bank vegetation, and riparian vegetation. Each of these individual components are scored from 0 to 20, where 20 indicates optimal conditions and 0 indicates poor conditions. Scores between 0 and 5 are deemed very poor, 5 to 10 are marginal, 10 to 15 are suboptimal, and scores over 15 are considered optimal. The individual scores for each of these measures are then added for a total habitat score out of a possible 200. The total habitat score ranges from 0-200, where scores less than 100 indicate Poor habitat and scores greater than 150 indicate optimal habitat.

Table 18-16. Total Habitat Score Matrix

Habitat Conditions	Score Range
Optimal Habitat	200-150
Sub-Optimal Habitat	150-130
Marginal	130-100
Poor	100-0

Second, a more detailed physical habitat assessment of Mountain Run according to EPA methods for Quantifying Physical Habitat in Wadeable Streams (Kaufmann et al., 1999) was conducted on two occasions. This analysis is a type of siltation index that involves the measurement of channel dimensions and substrate composition at numerous transects within a 150 to 800 m stream reach surrounding the downstream benthic monitoring station. The outcome of this analysis is the calculation of a Logged Relative Bed Stability Index (LRBS). The LRBS is the ratio between the observed size distribution of in-stream sediments and the predicted sediment size distribution based on bankfull depth. The index was developed to differentiate between natural and anthropogenic sediment deposition in a watershed.

LRBS values near zero indicate that the stream is stable. Large negative values indicate that the stream is unstable and depositing excess sediment. Large positive numbers, while less common, indicate that the stream is unstable and sediment starved. LRBS scores less than -1.0 are considered sub-optimal, while scores greater than -0.5 are considered optimal.

18.3.1 Mainstem Mountain Run

18.3.1.1 *Total Habitat*

Along Mountain Run samples for total habitat used in this analysis were collected between 2018 and 2019. Total habitat measurements ranged from 107 - 137 with a median value of 124.5 and an average value of 123.12 (n=16) (Figure 5-4).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median total habitat were 119.75 and 118 respectively (n=4).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for total habitat were 126.5 and 125.5 respectively (n=4).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median total habitat were 121 and 121.5 respectively (n=4).

At the upstream most monitoring station, 3-MTN021.11, the average and median total habitat were 125.25 and 124, respectively (n=4).

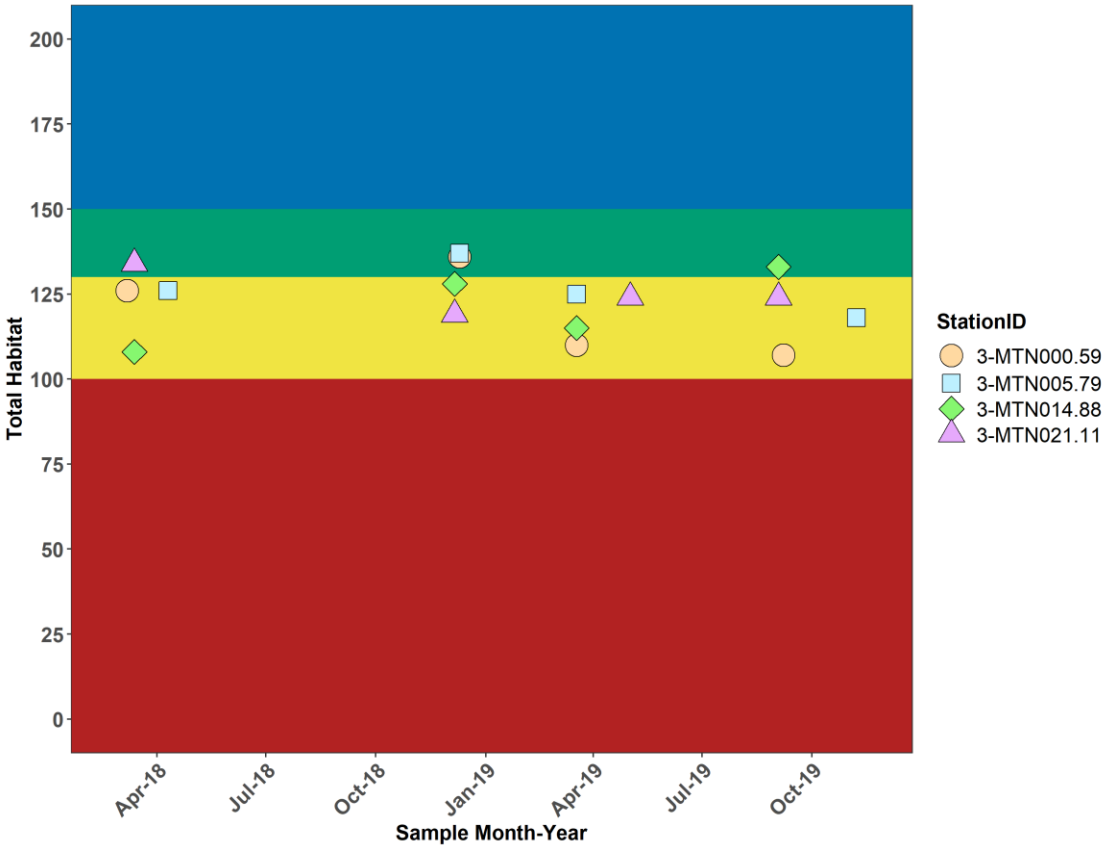


Figure 18-4. Total Habitat Measurements in Mountain Run

Further analysis of the individual metrics that make up the qualitative total habitat score are visible in the heat maps below (Table 5.17 - Table 5.20) for Mountain Run stations.

Table 18-17. Qualitative Habitat Measurements Taken during Biological Monitoring at 3-MTN000.59

Station ID	Date	Channel Alteration	Bank Stability	Bank Vegetation	Embeddedness	Flow	Riffles	Riparian Vegetation	Sediment	Substrate	Velocity	Total Habitat
3-MTN000.59	2018-03-07	16	6	10	14	16	13	10	11	14	16	126
3-MTN000.59	2018-12-10	19	7	11	12	20	13	13	12	13	16	136
3-MTN000.59	2019-03-18	18	5	10	11	18	7	8	7	10	16	110
3-MTN000.59	2019-09-07	18	6	9	10	15	9	7	7	10	16	107

At station 3-MTN000.59 the median scores for the bank stability, bank vegetation, riparian vegetation and sediment metrics all were 10 or below indicating marginal conditions. None of the median scores were at or below 5 which would indication poor conditions for those metrics. The bank stability and sediment metrics can give evidence of sediment impairment. Low scores for banks stability, bank vegetation, and riparian vegetation generally indicate that the riparian corridor is highly impacted and provides conditions that favor erosion of the banks and instability of the stream channel.

Table 18-18. Qualitative Habitat Measurements Taken during Biological Monitoring at 3-MTN005.79

Station ID	Date	Channel Alteration	Bank Stability	Bank Vegetation	Embeddedness	Flow	Riffles	Riparian Vegetation	Sediment	Substrate	Velocity	Total Habitat
3-MTN005.79	2018-04-10	16	9	15	12	16	15	7	9	11	16	126
3-MTN005.79	2018-12-10	18	6	16	12	20	14	10	11	12	18	137
3-MTN005.79	2019-03-18	18	6	16	11	18	14	8	8	10	16	125
3-MTN005.79	2019-11-07	18	5	11	10	16	13	9	8	11	17	118

The bank stability, riparian vegetation and sediment metrics median scores were 10 or below indicating marginal conditions at station 3-MTN005.79. None of the median scores were at or below 5 which would indicate poor conditions for those metrics. These metrics again indicate the riparian corridor is impacted and conditions that favor erosion of the banks and instability of the stream channel are present.

Table 18-19. Qualitative Habitat Measurements Taken during Biological Monitoring at 3-MTN014.88

Station ID	Date	Channel Alteration	Bank Stability	Bank Vegetation	Embeddedness	Flow	Riffles	Riparian Vegetation	Sediment	Substrate	Velocity	Total Habitat
3-MTN014.88	2018-03-13	10	7	11	10	19	11	8	6	10	16	108
3-MTN014.88	2018-12-06	15	8	13	10	19	13	11	10	10	19	128
3-MTN014.88	2019-03-18	13	11	11	9	18	15	6	6	8	18	115
3-MTN014.88	2019-09-03	13	13	13	14	16	15	6	14	13	16	133

For station 3-MTN014.88 the bank stability, embeddedness, riparian vegetation, sediment and substrate metrics median values were 10 or below indicating marginal conditions with none of those metrics at or below 5 which would indicate poor conditions for those metrics. The embeddedness, sediment and substrate metrics are instream indicators of deposited sediment.

Table 18-20. Qualitative Habitat Measurements Taken during Biological Monitoring at 3-MTN021.11

Station ID	Date	Channel Alteration	Bank Stability	Bank Vegetation	Embeddedness	Flow	Riffles	Riparian Vegetation	Sediment	Substrate	Velocity	Total Habitat
3-MTN021.11	2018-03-13	19	10	13	12	16	14	8	10	14	18	134
3-MTN021.11	2018-12-06	18	8	15	6	18	16	8	10	10	10	119
3-MTN021.11	2019-05-02	19	11	13	5	19	16	8	11	6	16	124
3-MTN021.11	2019-09-03	16	12	10	12	15	16	7	14	12	10	124

For 3-MTN021.11 only the median scores for embeddedness and riparian vegetation were 10 or below but above 5 indicating marginal conditions for those metrics.

18.3.1.2*LRBS*

A single set of quantitative habitat data was collected along Mountain Run at station 3-MTN021.11. This data was used to calculate the LRBS index, percent fines, and embeddedness. This Mountain Run station had a LRBS score of -0.25 (Figure 5-5).

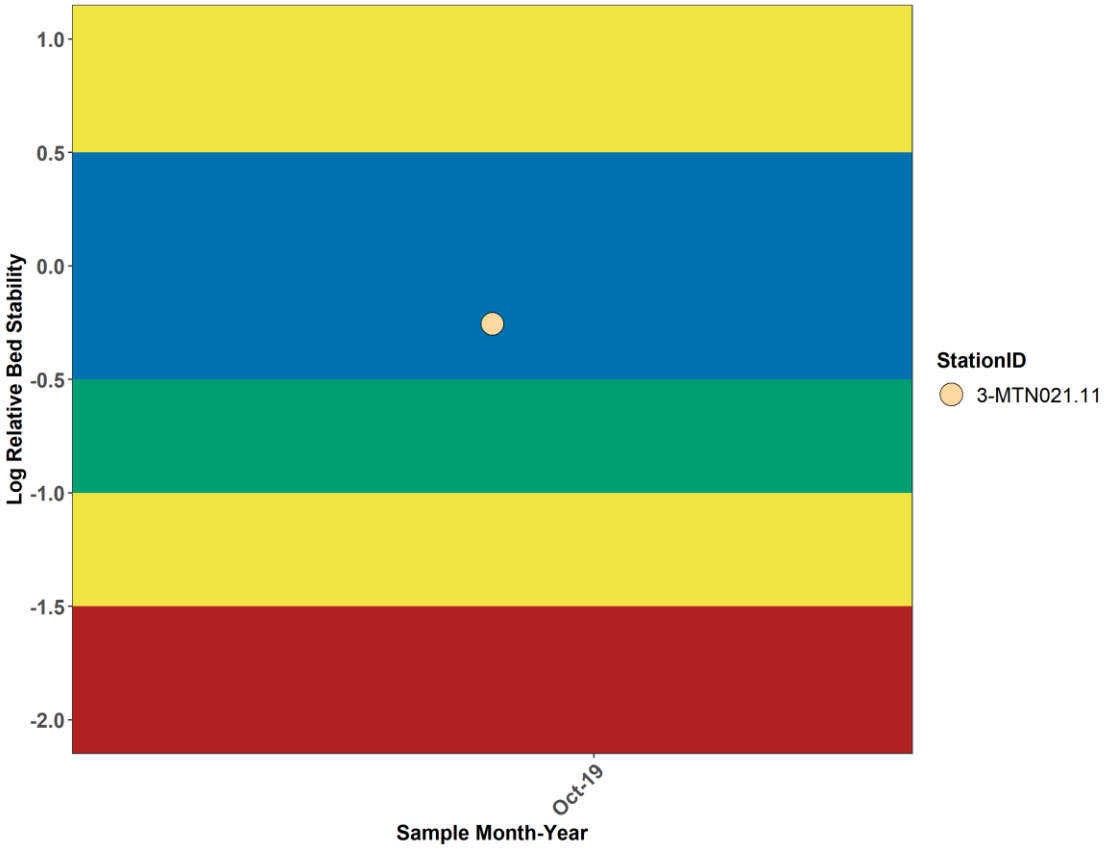


Figure 18-5. LRBS Measurements in Mountain Run

The individual metrics collected and used to calculate the LRBS score provides additional information on the characteristics of the channel substrate. Table 5-21 provides the individual metrics that comprise the LRBS score for 3-MTN021.11.

Table 18-21. LRBS Individual Metrics for 3-MTN021.11

LRBS Metrics	Value
LRBS	-0.25
LRBS Percentile[1] (Northern Piedmont / Statewide)	70th / 71st
Geometric Mean of the Particle Substrate (logged)	1.01
Particle Substrate Percentile[1]	54th / 58th
Slope	0.28
Slope Percentile[1]	26th / 21st
% Sands and Fines	22%
Percentile Sands and Fines[1]	20th / 25th
% Boulders, Cobbles, Gravel	70%
Percentile Boulders, Cobbles, Gravel[1]	91st / 86th
% Hardpan	5%
% Concrete or Asphalt	2%
Average Embeddedness	55%
Percentile Embeddedness	35th / 39th
Streambank incision depth (m)	1.96

[1] Based on DEQ Probabilistic Monitoring data

18.3.2 Jonas Run and the Unnamed Tributary to Jonas Run

18.3.2.1 *Total Habitat*

In Jonas Run and the unnamed tributary to Jonas Run samples for total habitat used in this analysis were collected between 2018 and 2020. Total habitat measurements from 97 - 128 with a median value of 105 and an average value of 110.67 (n=6) (Figure 5-6).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median total habitat were 115.5 and 116 respectively (n=4).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median total habitat were 101 and 101 respectively (n=2).

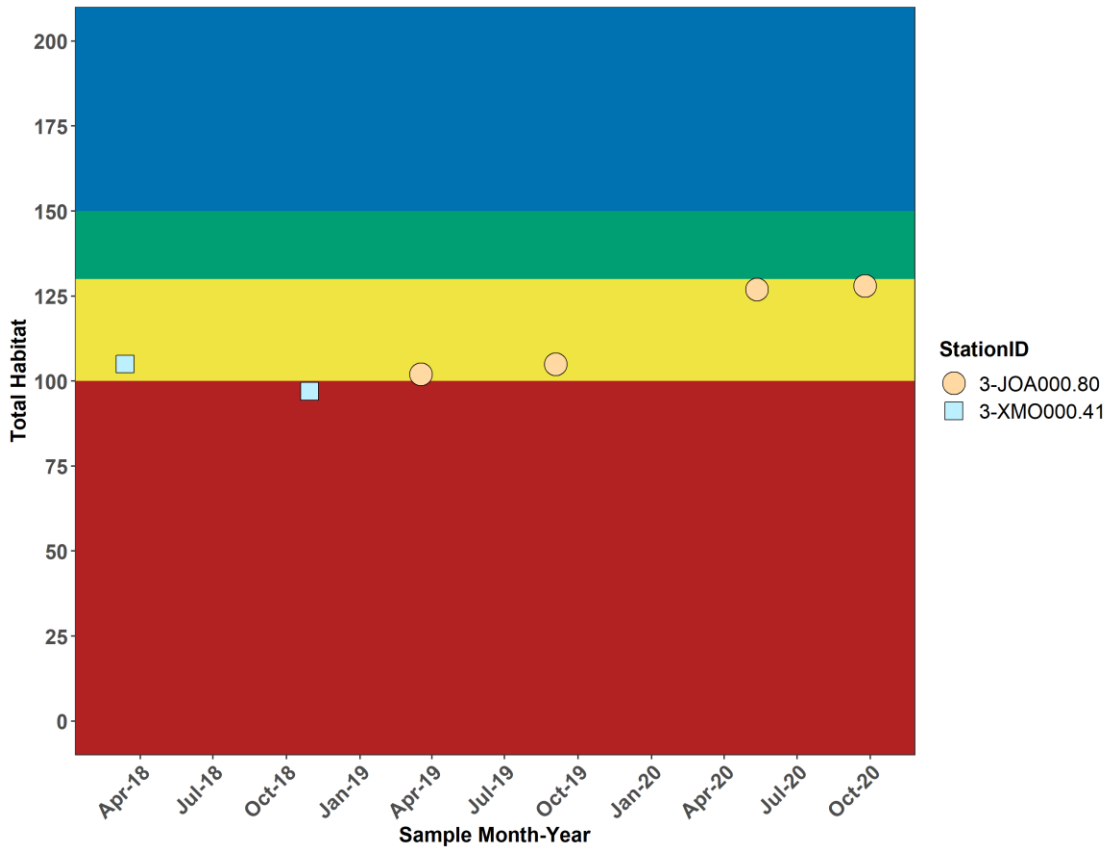


Figure 18-6. Total Habitat Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

Further analysis of the individual metrics (scored 1-20) that make up the qualitative total habitat score are visible in the heat maps below (Table 5.22 and Table 5.23) for Jonas Run and the unnamed tributary to Jonas Run stations. Darker colors indicate lower habitat metric scores.

Table 18-22. Qualitative Habitat Measurements Taken during Biological Monitoring 3-JOA000.80

Station ID	Date	Channel Alteration	Bank Stability	Bank Vegetation	Embeddedness	Flow	Riffles	Riparian Vegetation	Sediment	Substrate	Velocity	Total Habitat
3-JOA000.80	2019-03-18	17	6	11	7	18	12	7	7	7	10	102
3-JOA000.80	2019-09-03	16	6	11	11	17	10	4	11	9	10	105
3-JOA000.80	2020-05-12	15	12	13	12	17	10	8	12	13	15	127
3-JOA000.80	2020-09-24	15	10	14	13	20	8	7	13	14	14	128

The bank stability, riffles and riparian vegetation metrics median scores were 10 or below indicating marginal conditions at station 3-JOA000.80. None of the median scores were at or below 5 which would indicate poor conditions for those metrics. The bank stability and riparian vegetation metrics again indicate the riparian corridor is impacted and conditions that favor erosion of the banks and instability of the stream channel are present.

Table 18-23. Qualitative Habitat Measurements Taken during Biological Monitoring 3-XMO000.41

Station ID	Date	Channel Alteration	Bank Stability	Bank Vegetation	Embeddedness	Flow	Riffles	Riparian Vegetation	Sediment	Substrate	Velocity	Total Habitat
3-XMO000.41	2018-03-13	13	16	16	7	16	8	7	6	5	11	105
3-XMO000.41	2018-10-30	13	6	8	7	20	12	6	5	7	13	97

For station 3-XMO000.41 the median scores for the embeddedness, riffles, riparian vegetation, sediment and substrate metrics all were 10 or below indicating marginal conditions. None of the median scores were at or below 5 which would indication poor conditions for those metrics although the median score for sediment was 5.5. Low scores for embeddedness, sediment, and substrate generally imply excess sediment deposition.

18.3.2.2 *LRBS*

A single set of quantitative habitat data was collected along the unnamed tributary to Jonas Run at station 3-XMO000.41. This data was used to calculate the LRBS index, percent fines, and embeddedness. The unnamed tributary to Jonas Run had a LRBS score of 0.42 (Figure 5-7).

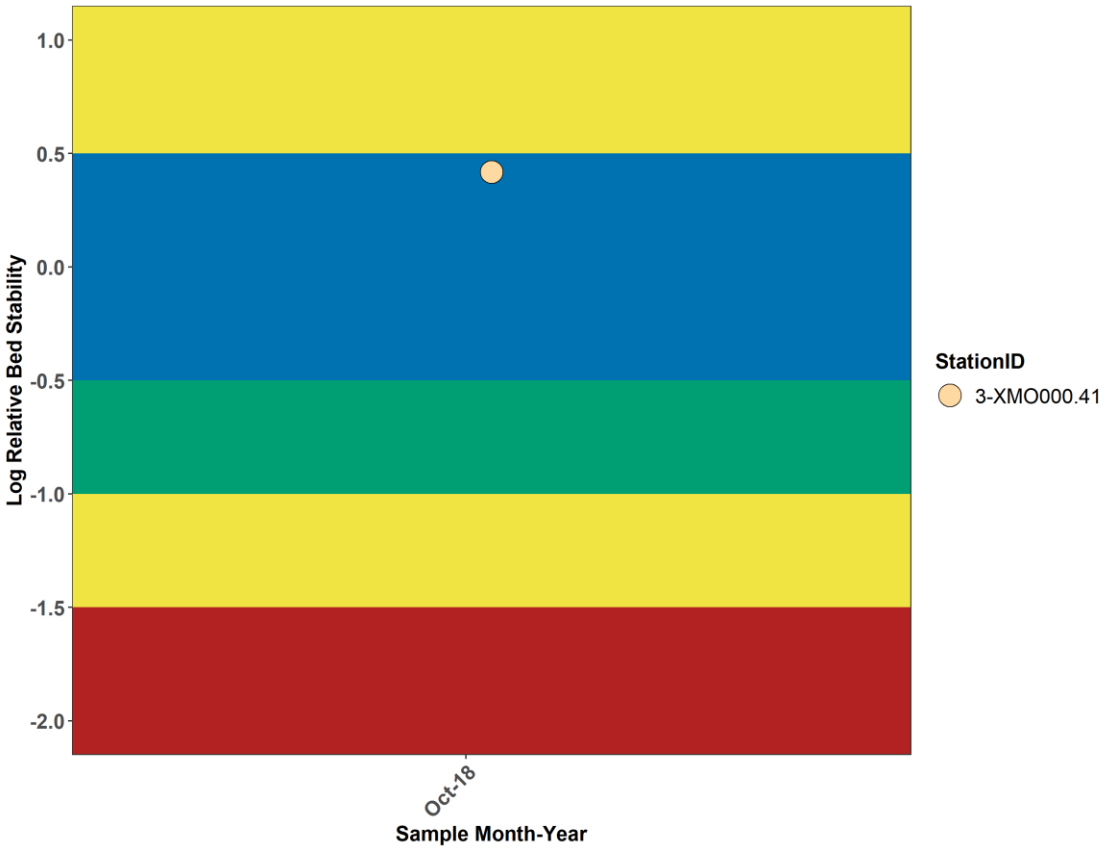


Figure 18-7. LRBS Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The individual metrics collected and used to calculate the LRBS score provides additional information on the characteristics of the channel substrate. Table 5-24 provides the individual metrics that comprise the LRBS score for 3-XMO000.41.

Table 18-24. LRBS Individual Metrics for 3-XMO000.41

LRBS Metrics	Value
LRBS	0.42
LRBS Percentile[1] (Northern Piedmont / Statewide)	93rd / 95th
Geometric Mean of the Particle Substrate (logged)	1.55
Particle Substrate Percentile[1]	83rd / 77th
Slope	0.84
Slope Percentile[1]	63rd / 53rd
% Sands and Fines	12%
Percentile Sands and Fines[1]	12th / 14th
% Boulders, Cobbles, Gravel	43%
Percentile Boulders, Cobbles, Gravel[1]	52nd / 49th
% Hardpan	30%
% Concrete or Asphalt	8%
Average Embeddedness	38%
Percentile Embeddedness	18th / 21st
Streambank incision depth (m)	2.10

[1] Based on DEQ Probabilistic Monitoring data

18.3.3 Flat Run

18.3.3.1 *Total Habitat*

In the potentially impaired portions of Flat Run samples for total habitat used in this analysis were collected between 2019 and 2020. Total habitat measurements along Flat Run ranged from 58 - 98 with a median value of 73 and an average value of 75.5 (n=4) (Figure 5-8).

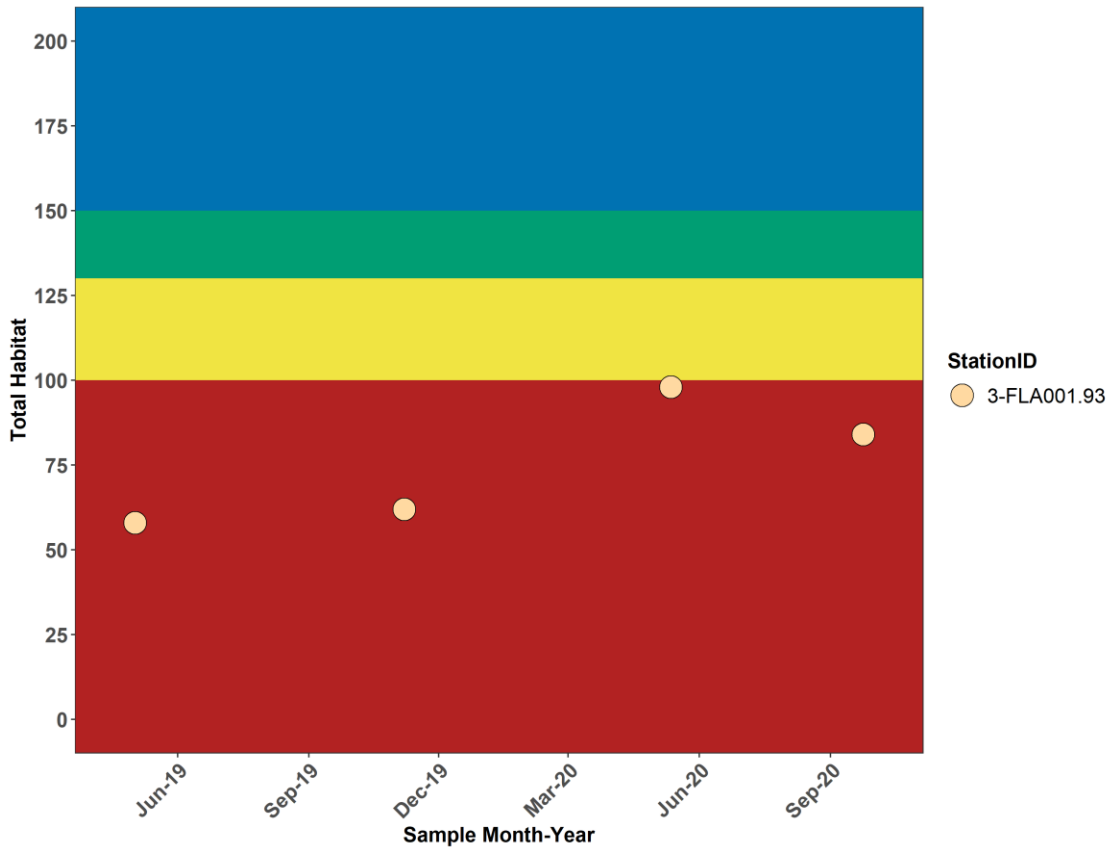


Figure 18-8. Total Habitat Measurements in Flat Run

Further analysis of the individual metrics (scored 1-20) that make up the qualitative total habitat score are visible in the heat map below (Table 5-25) for the Flat Run station. Darker colors indicate lower habitat metric scores.

Table 18-25. Qualitative Habitat Measurements Taken during Biological Monitoring 3-FLA001.93

Station ID	Date	Channel Alteration	Bank Stability	Bank Vegetation	Embeddedness	Flow	Riffles	Riparian Vegetation	Sediment	Substrate	Velocity	Total Habitat
3-FLA001.93	2019-05-02	11	5	8	1	16	0	5	1	1	10	58
3-FLA001.93	2019-11-07	13	5	7	1	16	1	5	1	2	11	62
3-FLA001.93	2020-05-12	14	12	11	3	17	6	10	11	6	8	98
3-FLA001.93	2020-09-24	14	12	11	2	20	3	10	3	4	5	84

At station 3-FLA001.93 the median scores for the bank stability, bank vegetation, riparian vegetation and velocity metrics all were 10 or below but greater than 5 indicating marginal conditions. Median metric scores for embeddedness, riffles, sediment and substrate were all below 5 indicating poor condition. These score indicate that the riparian corridor is highly impacted, provides conditions that favor erosion of the banks and instability of the stream channel and that excess sediment deposition is present.

18.3.3.2 *LRBS*

No quantitative habitat data was collected along Flat Run. This data is necessary to allow VADEQ to calculate the LRBS index, percent fines, and embeddedness.

19.0 WATER CHEMISTRY DATA ANALYSIS

Water quality data collected for the candidate stressors were analyzed to identify if one or more of those parameters may be causing stress to the aquatic community. To help identify potential for stress, freshwater aquatic life water quality criteria were compared to observed values for parameters with numeric criteria. Another evaluation compared parameters, as applicable, to threshold stressor values developed and published by DEQ (2017) in the "Stressor Analysis in Virginia: Data Collection and Stressor Thresholds" document.

Stressor thresholds or concentration/measured ranges linked to probable stress to aquatic life were developed using data collected through DEQ's Freshwater Probabilistic Monitoring Program (Table 6-1). The stressor thresholds are not derived from literature values and are not intended to replace water quality criteria or define TMDL endpoints. Rather, they were derived from empirical data collected using a probabilistic sampling design. The probabilistic approach minimizes bias because it is a statistically designed study and sample sites are selected randomly across a geographical area. The probabilistic monitoring dataset allowed DEQ to determine thresholds ranging from no stress to aquatic life to high probability of stress to aquatic life for the following parameters: dissolved oxygen, pH, total phosphorus, total nitrogen, ionic strength (specific conductivity, TDS, and sulfate, chloride, sodium, and potassium), dissolved metals cumulative criterion unit, total habitat and relative bed stability.

The stress categories were developed by analyzing benthic macroinvertebrate community responses (represented by VSCI scores) through a variety of peer-reviewed statistical techniques: relative risk, relative extent, conditional probability and quantile regression. The results were interpreted into stress categories. "No Stress" to aquatic life means that a parameter range reflects an undisturbed, or background, condition in Virginia. "Low Probability" represents a benthic macroinvertebrate community response that is slightly above background conditions but unlikely to cause a major community shift. The next category is "Medium Probability" and means there is evidence of harm causing a possible shift in benthic communities with changes noticeably above background conditions. The "High Probability" threshold corresponds to values that are among the highest in the Commonwealth and result in degradation of the benthic community (DEQ, 2017).

Table 19-1. Definitions of the Probabilities of Stress to Aquatic Life

Probability of Stress to Aquatic Life	Definition
High Probability	Values that are the highest in Virginia, resulting in degradation of the benthic community.
Medium Probability	Noticeable evidence of harm causing a possible shift in benthic communities, changes noticeably above background conditions.
Low Probability	Slightly above background conditions, but unlikely to cause a major benthic community shift.
No Probability	Background conditions.

19.1 pH

Benthic macroinvertebrates require a specific pH range to thrive in aquatic systems. The Virginia WQS establish allowable criteria for pH as between 6.0 and 9.0 standard units in Class III nontidal waters (9VAC25-260-50).

19.1.1 Mainstem Mountain Run

In the impaired portion of Mountain Run samples for pH used in this analysis were collected between 2015 and 2020. pH measurements along Mountain Run ranged from 6.59 - 8.65 with a median value of 7.29 and an average value of 7.34 (n=120) (Figure 6-1).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median pH were 7.28 and 7.28 respectively (n=55).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for pH were 7.42 and 7.4 respectively (n=21).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median pH were 7.42 and 7.41 respectively (n=23).

At the upstream most monitoring station, 3-MTN021.11, the average and median pH were 7.33 and 7.29, respectively (n=21).

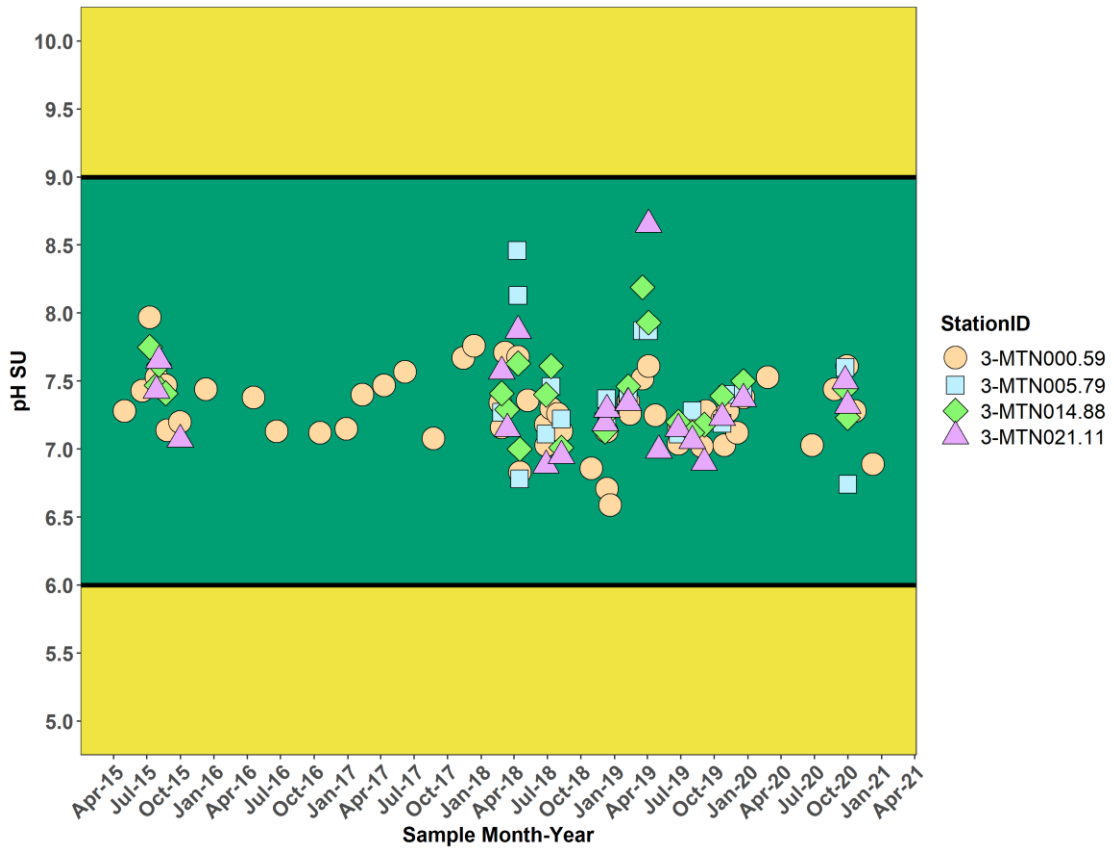


Figure 19-1. pH Measurements in Mountain Run

All pH measurements fell into the low probability of stress to aquatic life range and the water quality criteria range, 6.0 SU – 9.0 SU (Figure 6-1). The black lines in Figure 6-1 represent the minimum and maximum water quality criteria for pH, 6.0 SU and 9.0 SU.

19.1.2 Jonas Run and the Unnamed Tributary to Jonas Run

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for pH used in this analysis were collected between 2018 and 2020. pH measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 6.52 - 9.02 with a median value of 7.55 and an average value of 7.64 (n=20) (Figure 6-2).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median pH were 7.75 and 7.69 respectively (n=18).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median pH were 6.66 and 6.66 respectively (n=2).

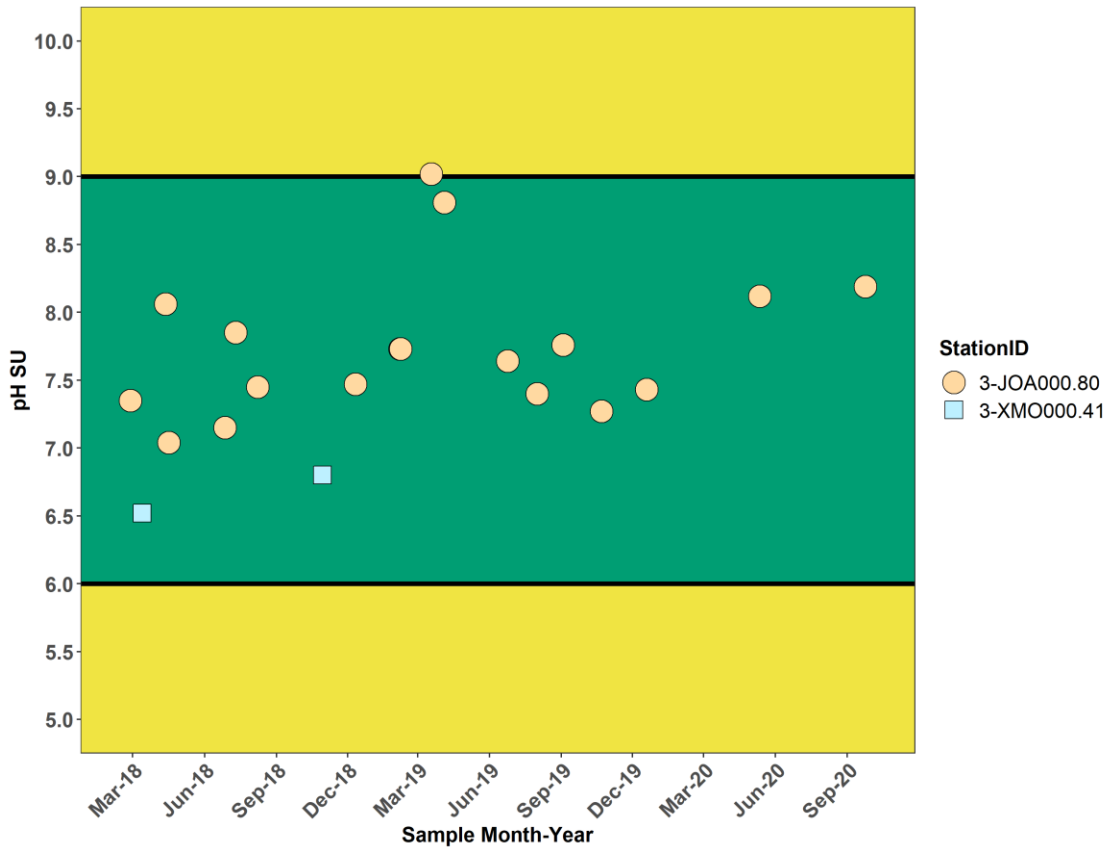


Figure 19-2. pH Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

All pH measurements except one value fell into the low probability of stress to aquatic life range and the water quality criteria range, 6.0 SU – 9.0 SU (Figure 6-2). The black lines in Figure 6-2 represent the minimum and maximum water quality criteria for pH, 6.0 SU and 9.0 SU. For 3-JOA000.80 the pH value was 9.02 on 3/18/2019.

19.1.3 Flat Run

In the potentially impaired portion of Flat Run samples for pH used in this analysis were collected between 2018 and 2020. pH measurements along Flat Run ranged from 6.49 - 7.64 with a median value of and an average value of 7.12 (n=16) (Figure 6-3).

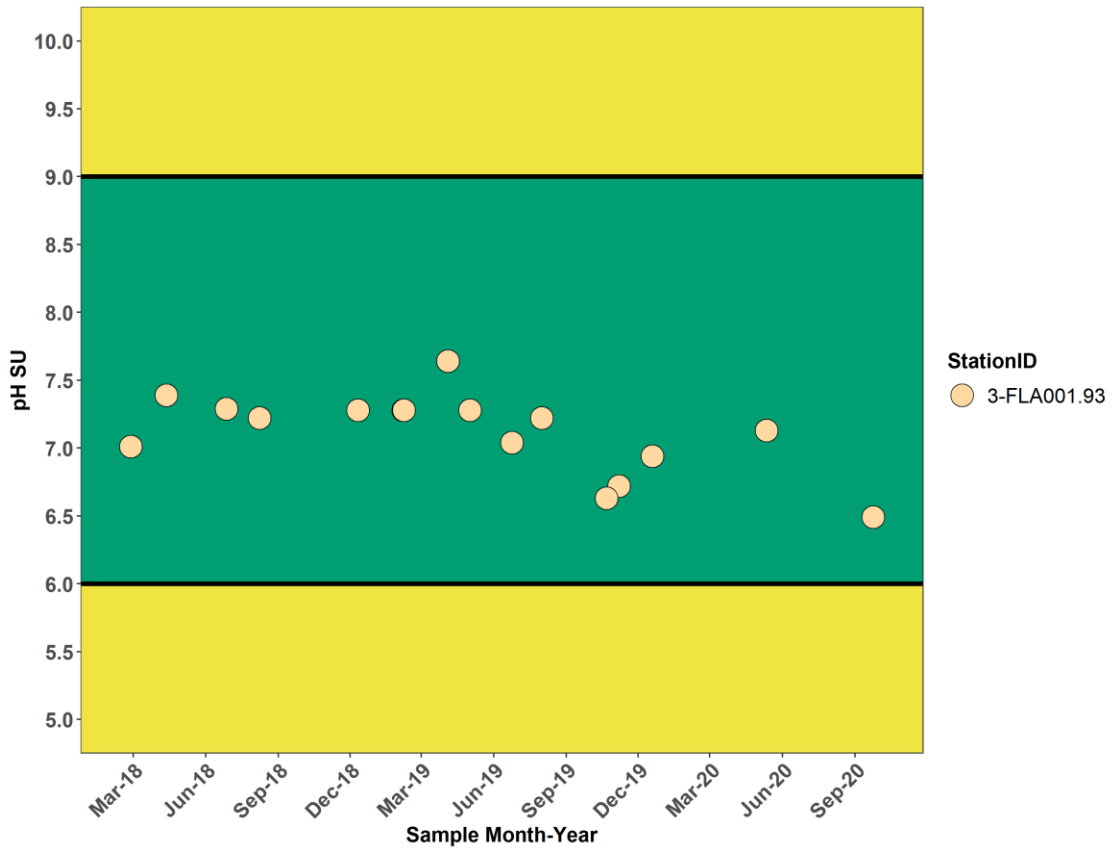


Figure 19-3. pH Measurements in Flat Run

All pH measurements fell into the low probability of stress to aquatic life range and the water quality criteria range, 6.0 SU – 9.0 SU (Figure 6-3). The black lines in Figure 6-3 represent the minimum and maximum water quality criteria for pH, 6.0 SU and 9.0 SU.

19.2 Dissolved Oxygen

Most organisms require oxygen to sustain life. The amount of oxygen available to aquatic organisms is called dissolved oxygen (DO). Sensitive aquatic organisms require high levels of DO, while more tolerant organisms can withstand lower levels. The Virginia WQS establish a minimum DO of 4 mg/L and a minimum daily average DO of 5 mg/L in Class III nontidal waters (9VAC25-260-50).

19.2.1 Mainstem Mountain Run

In the impaired portion of Mountain Run samples for Dissolved Oxygen (DO) used in this analysis were collected between 2015 and 2020. DO measurements along Mountain Run ranged from 4.11 - 14.44 with a median value of 9.22 and an average value of 9.81 (n=124) (Figure 6-4).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median DO were 9.54 and 9.16 respectively (n=56).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for DO were 10.24 and 10.64 respectively (n=22).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median DO were 9.64 and 9.01 respectively (n=24).

At the upstream most monitoring station, 3-MTN021.11, the average and median DO were 10.24 and 9.22, respectively (n=22).

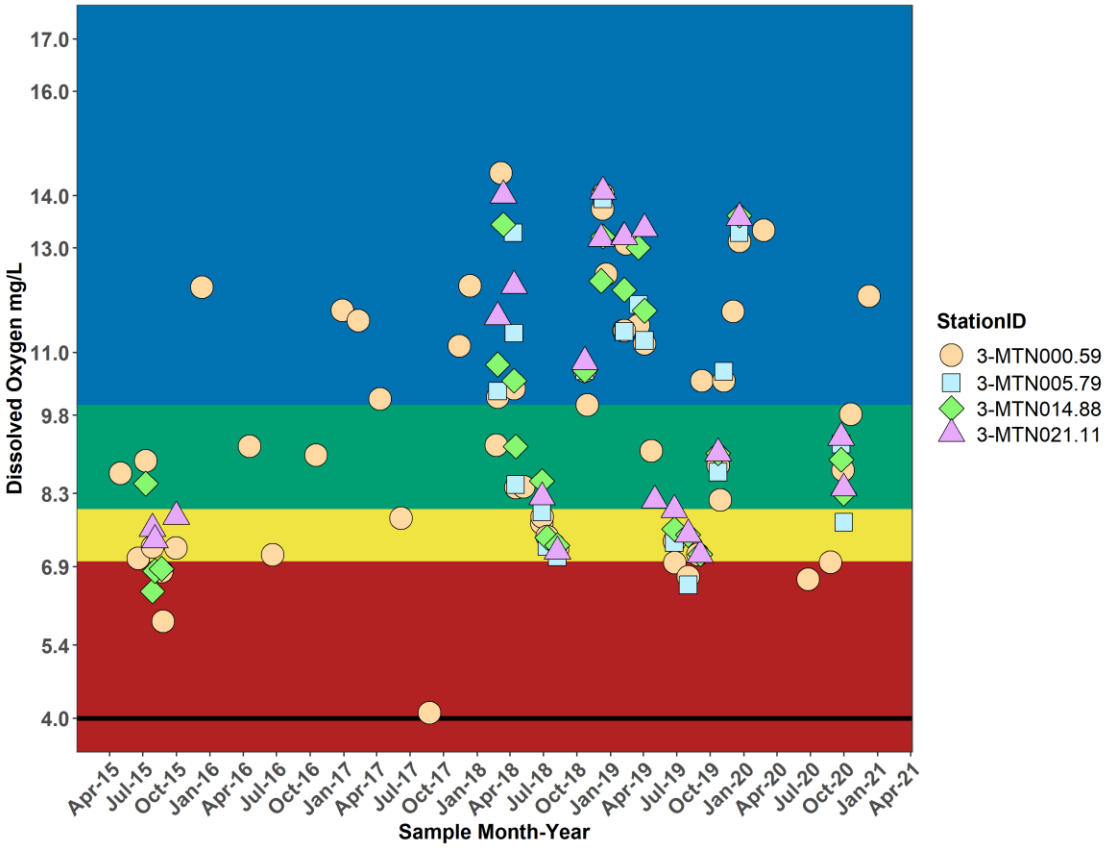


Figure 19-4. DO Measurements in Mountain Run

The black line at 4.0 mg/L shown in Figure 6-4 represents the water quality criterion for DO. All data measured were above the water quality criteria for DO, 4.0 mg/L. The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating no probability of stress.

19.2.2 Jonas Run and the Unnamed Tributary to Jonas Run

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for Dissolved Oxygen (DO) used in this analysis were collected between 2018 and 2020. DO measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 6.12 - 15.31 with a median value of 11.8 and an average value of 11.21 (n=21) (Figure 6-5).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median DO were 11.18 and 11.8 respectively (n=19).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median DO were 11.54 and 11.54 respectively (n=2).

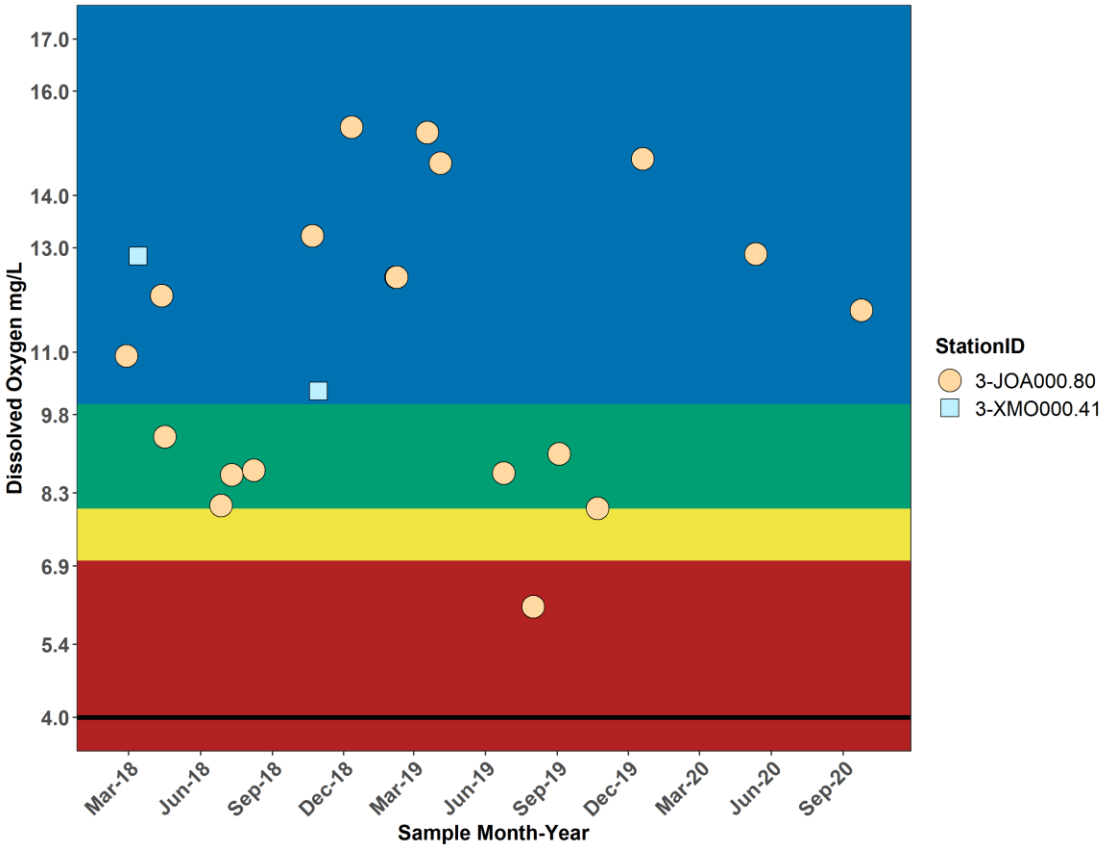


Figure 19-5. DO Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The black line at 4.0 mg/L shown in Figure 6-5 represents the water quality criterion for DO. All data measured were above the water quality criteria for DO, 4.0 mg/L. The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating no probability of stress.

19.2.3 Flat Run

In the potentially impaired portions of Flat Run samples for Dissolved Oxygen (DO) used in this analysis were collected between 2018 and 2020. DO measurements along Flat Run ranged from 4.07 - 13.72 with a median value of 8.62 and an average value of 9.01 (n=17) (Figure 6-6).

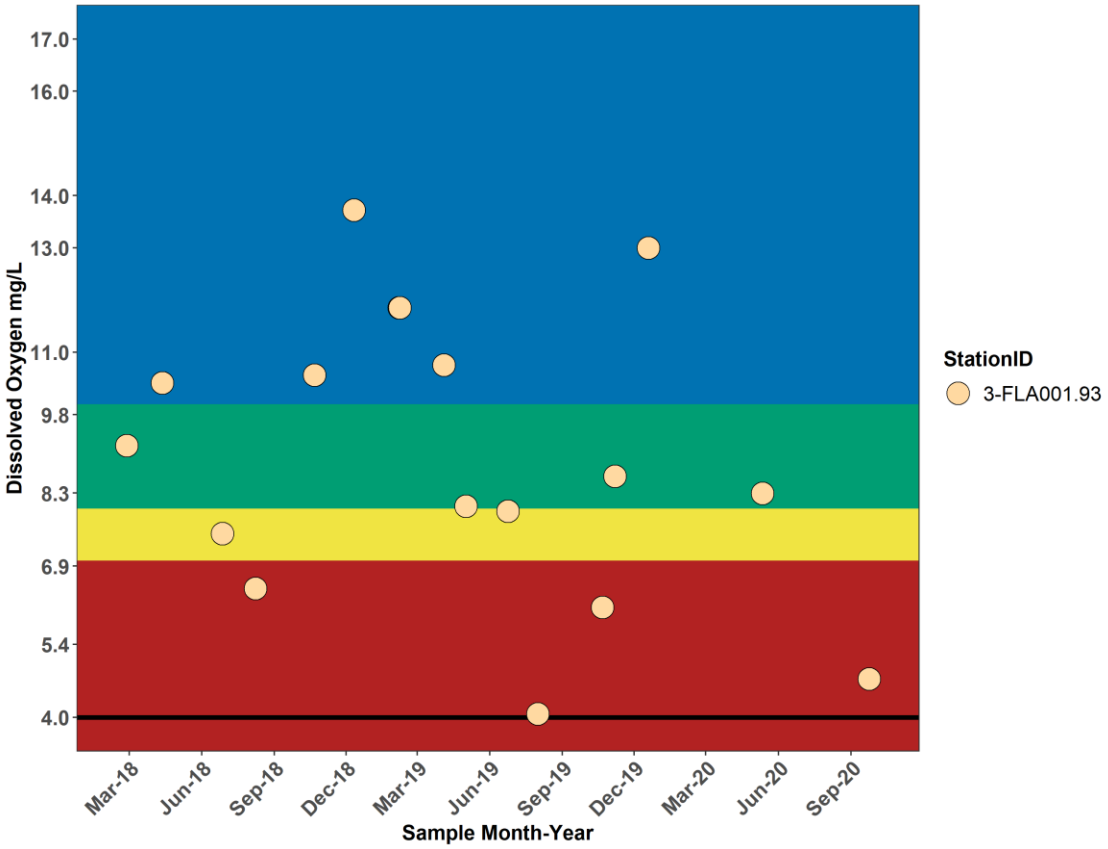


Figure 19-6. DO Measurements in Flat Run

The black line at 4.0 mg/L shown in Figure 6-6 represents the water quality criterion for DO. All data measured were above the water quality criteria for DO, 4.0 mg/L. The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating a low probability of stress.

19.3 Total Nitrogen

Total nitrogen is an essential resource for aquatic plants and animals, yet excess nitrogen can over fertilize algae resulting in eutrophication of streams or lakes. Humans may alter natural nitrogen levels through poor agricultural practices, mismanagement of waste, and combustion of fossil fuels. In Virginia, there are no numeric water quality criteria for total nitrogen in free flowing streams.

19.3.1 Mainstem Mountain Run

In the impaired portion of Mountain Run samples for Total Nitrogen (TN) used in this analysis were collected between 2015 and 2020. TN measurements along Mountain Run ranged from 0.31 - 2.41 with a median value of 1.22 and an average value of 1.24 (n=91) (Figure 6-7).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median TN were 1.24 and 1.25 respectively (n=46).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for TN were 1.35 and 1.28 respectively (n=15).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median TN were 1.31 and 1.19 respectively (n=14).

At the upstream most monitoring station, 3-MTN021.11, the average and median TN were 1.08 and 1.02, respectively (n=16).

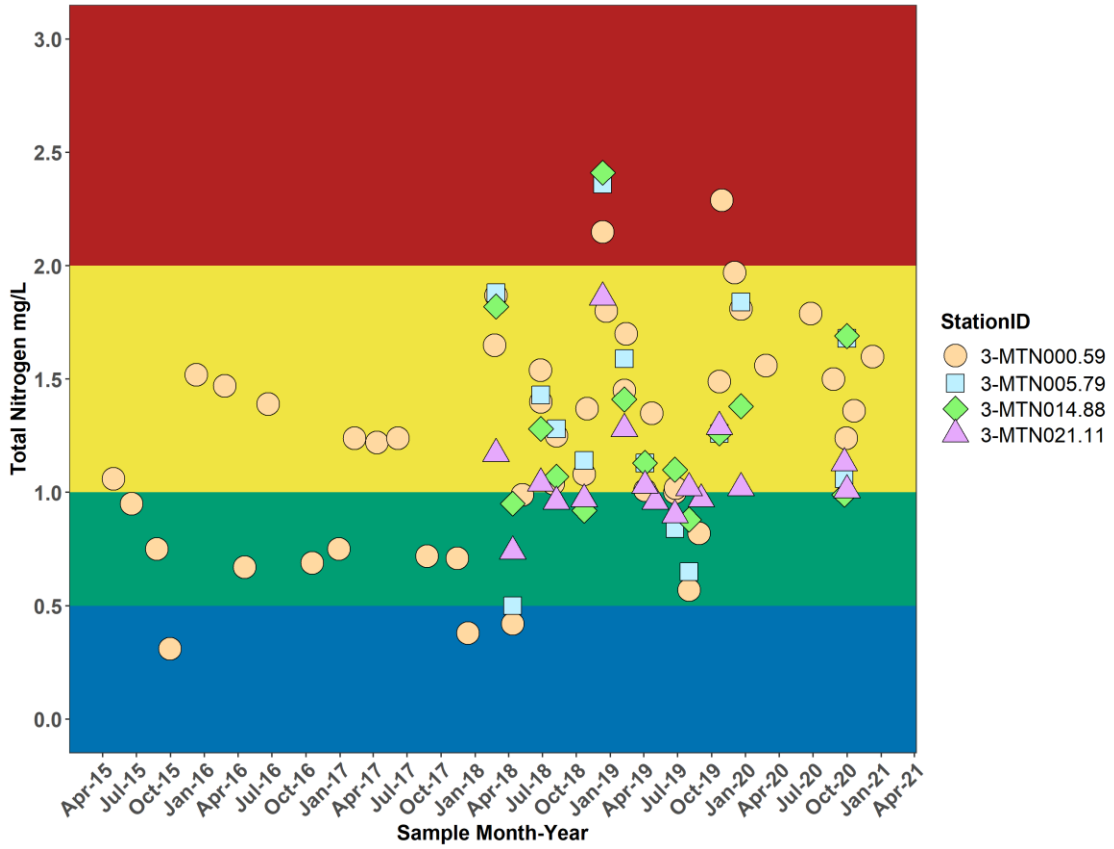


Figure 19-7. Total Nitrogen Measurements in Mountain Run

The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating medium probability of stress. While Virginia has not established water quality criteria for nutrients, USEPA has published recommended criteria based on ecoregion (USEPA, 2000a). For the Northern Piedmont ecoregion in which most of the Mountain Run watershed is located, the recommended criterion for nitrogen is 0.69 mg/L. Median nitrogen levels for Mountain Run are above this value, indicating that nitrogen levels may be elevated.

19.3.2 Jonas Run and the Unnamed Tributary to Jonas Run

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for Total Nitrogen (TN) used in this analysis were collected between 2018 and 2019. TN measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 0.51 - 3.13 with a median value of 1.94 and an average value of 1.88 (n=14) (Figure 6-8).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median TN were 1.88 and 1.94 respectively (n=12).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median TN were 1.92 and 1.92 respectively (n=2).

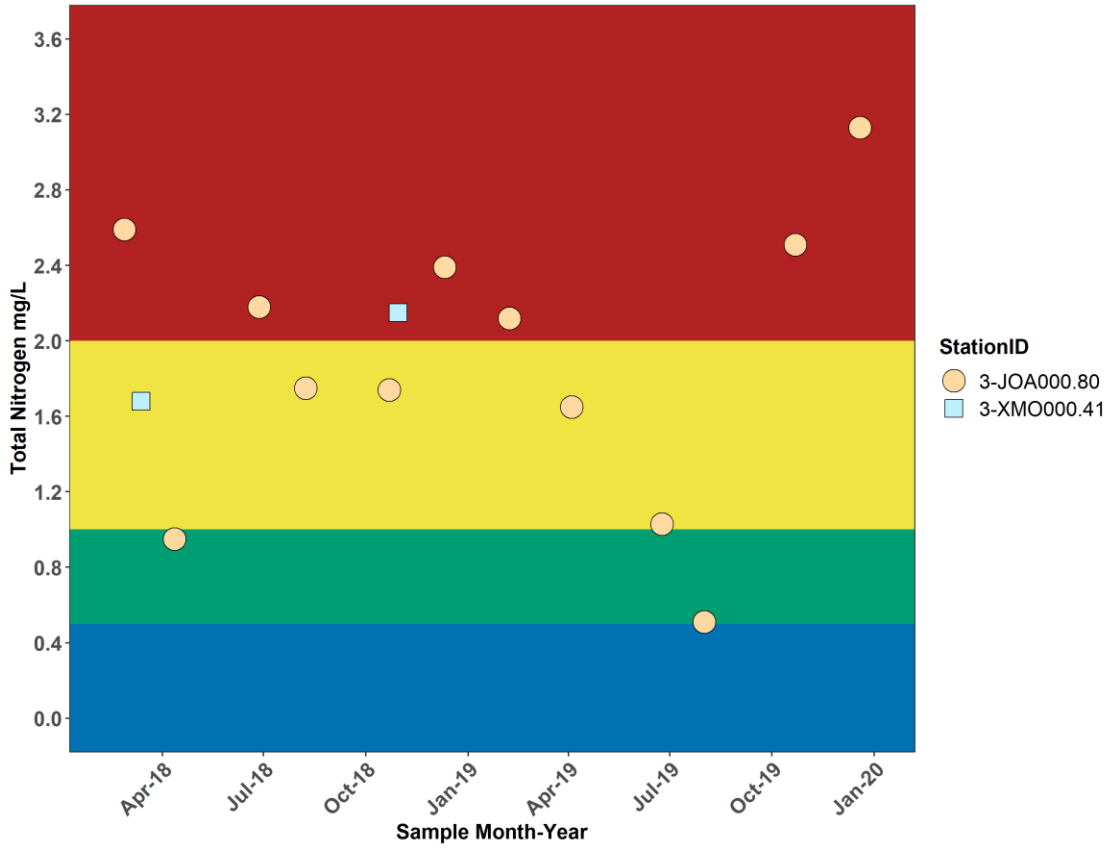


Figure 19-8. Total Nitrogen Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The data measured ranged from low probability of stress to high probability of stress, with the average and median values indicating medium probability of stress. While Virginia has not established water quality criteria for nutrients, USEPA has published recommended criteria based on ecoregion (USEPA, 2000a). For the Northern Piedmont ecoregion in which most of the Mountain Run watershed is located, the recommended criterion for nitrogen is 0.69 mg/L. Median nitrogen levels for Jonas Run and the unnamed tributary to Jonas Run are above this value, indicating that nitrogen levels may be elevated.

19.3.3 Flat Run

In the potentially impaired portions of Flat Run samples for Total Nitrogen (TN) used in this analysis were collected between 2018 and 2019. TN measurements along Flat Run ranged from 0.59 - 1.85 with a median value of 1.44 and an average value of 1.33 (n=12) (Figure 6-9).

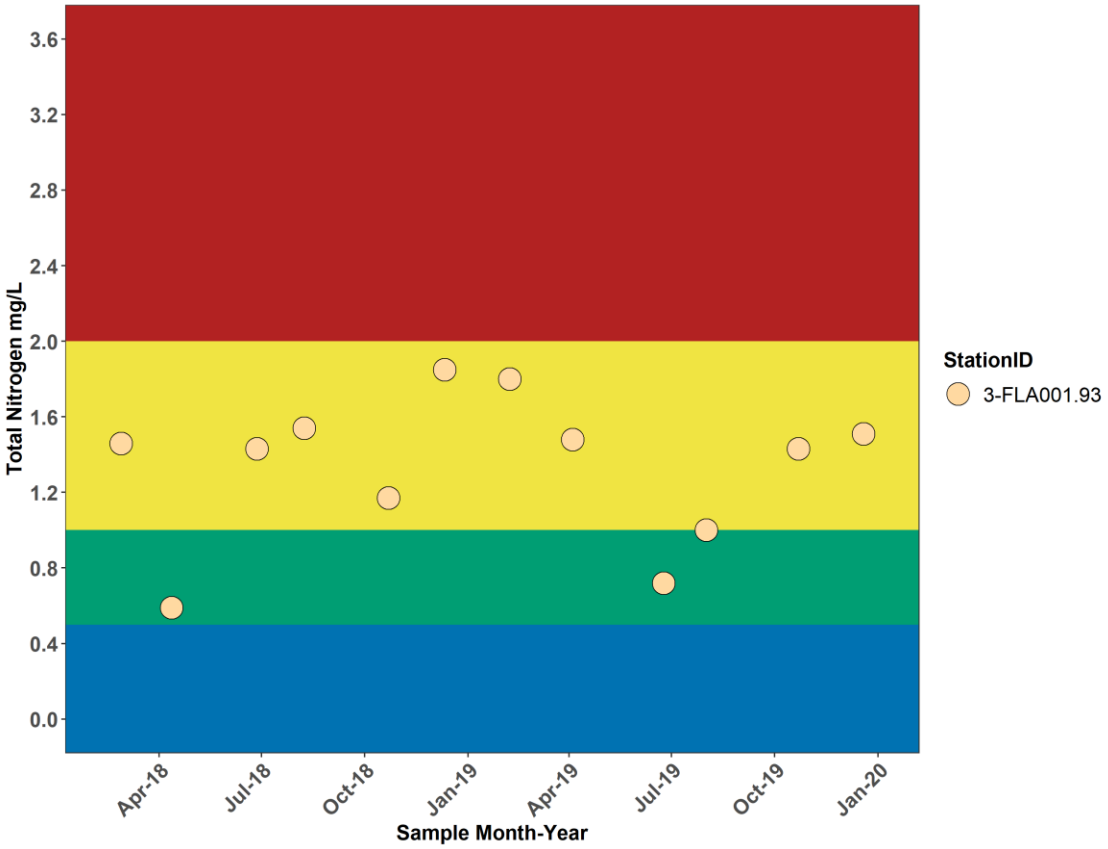


Figure 19-9. Total Nitrogen Measurements in Flat Run

The data measured ranged from low probability of stress to medium probability of stress, with the average and median values indicating medium probability of stress. While Virginia has not established water quality criteria for nutrients, USEPA has published recommended criteria based on ecoregion (USEPA, 2000a). For the Northern Piedmont ecoregion in which most of the Mountain Run watershed is located, the recommended criterion for nitrogen is 0.69 mg/L. Median nitrogen levels for Flat Run are above this value, indicating that nitrogen levels may be elevated.

19.4 Total Phosphorus

Elevated levels of total phosphorus can stimulate algal production and shift aquatic communities. Phosphorus is often the limiting nutrient in aquatic communities, meaning that biota may have a stronger response to phosphorus additions than nitrogen additions (Schindler, 1977). Generally, values above the typical nitrogen to phosphorous ratio of 7.5 seen in algae indicate that phosphorous is the limiting nutrient.

19.4.1 Mainstem Mountain Run

In the impaired portion of Mountain Run samples for Total Phosphorus (TP) used in this analysis were collected between 2015 and 2020. TP measurements along Mountain Run ranged from 0.02 - 0.51 with a median value of 0.05 and an average value of 0.07 (n=96) (Figure 6-10).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median TP were 0.07 and 0.06 respectively (n=47).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for TP were 0.08 and 0.05 respectively (n=15).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median TP were 0.06 and 0.04 respectively (n=16).

At the upstream most monitoring station, 3-MTN021.11, the average and median TP were 0.05 and 0.04, respectively (n=18).

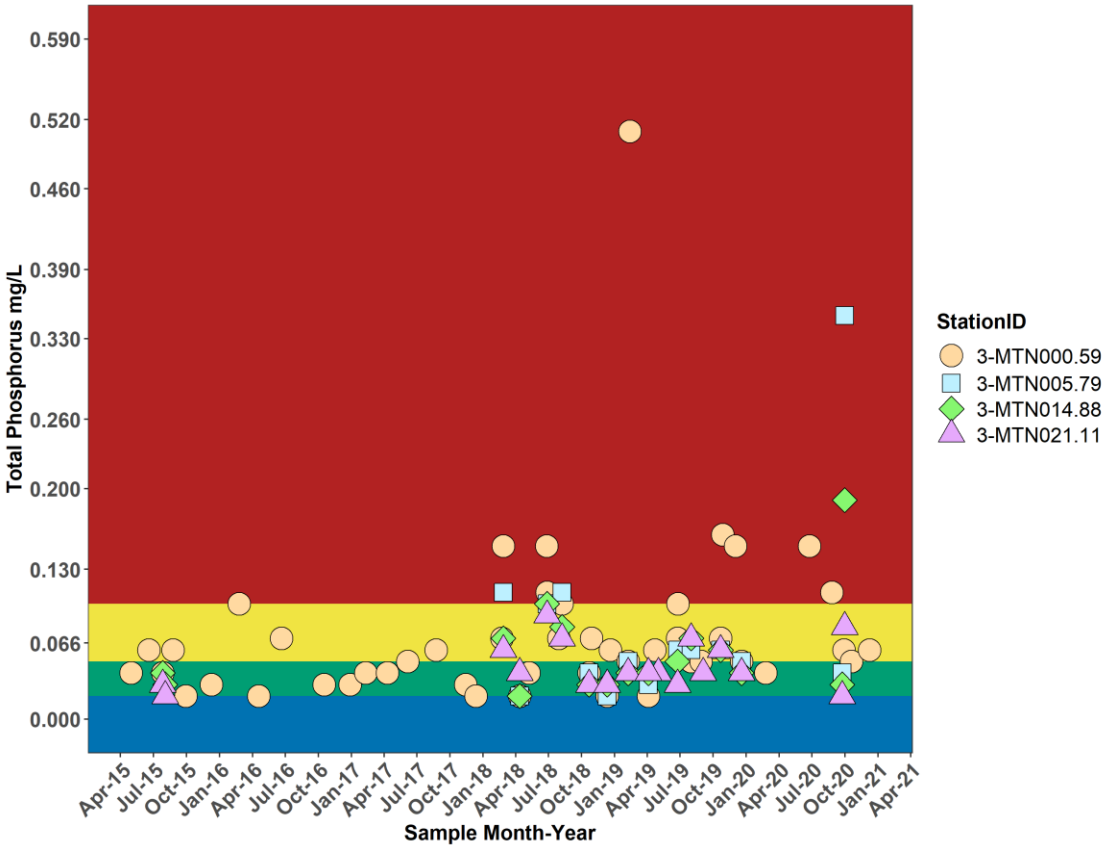


Figure 19-10. Total Phosphorus Measurements in Mountain Run

In Mountain Run, the ratio of average total nitrogen concentration of 1.24 mg/L to the average total phosphorous concentration of 0.07 mg/L is 18:1. This indicates that phosphorus is likely the limiting nutrient. While Virginia has not established water quality criteria for nutrients, USEPA has published recommended criteria based on ecoregion (USEPA, 2000a). For the Northern Piedmont ecoregion in which most of the Mountain Run watershed is located, the recommended criterion is 0.04 mg/L. Median phosphorus levels for Mountain Run are above this value, indicating that phosphorus levels may be elevated.

19.4.2 Jonas Run and the Unnamed Tributary to Jonas Run

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for Total Phosphorus (TP) used in this analysis were collected between 2018 and 2019. TP measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 0.01 - 0.09 with a median value of 0.04 and an average value of 0.04 (n=14) (Figure 6-11).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median TP were 0.04 and 0.03 respectively (n=12).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median TP were 0.06 and 0.06 respectively (n=2).

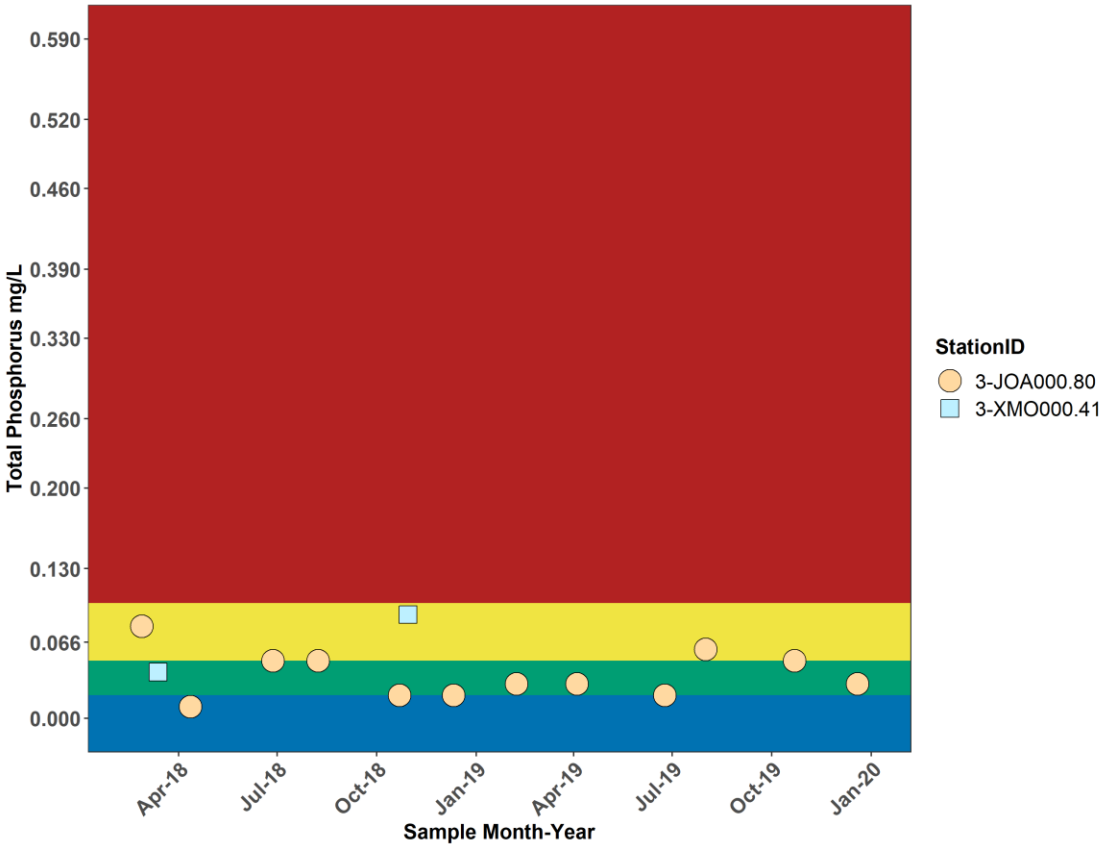


Figure 19-11. Total Phosphorus Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

For Jonas Run and the unnamed tributary to Jonas Run, the ratio of average total nitrogen concentration of 1.88 mg/L to the average total phosphorous concentration of 0.04 mg/L is 47:1. This indicates that phosphorus is likely the limiting nutrient. While Virginia has not established water quality criteria for nutrients, USEPA has published recommended criteria based on ecoregion (USEPA, 2000a). For the Northern Piedmont ecoregion in which the Jonas Run watershed is located, the recommended criterion is 0.04 mg/L. Median phosphorus levels for Jonas Run and the unnamed tributary to Jonas Run are equal to this value, indicating that phosphorus levels are not elevated.

19.4.3 Flat Run

In the potentially impaired portions of Flat Run samples for Total Phosphorus (TP) used in this analysis were collected between 2018 and 2019. TP measurements along Flat Run ranged from 0.03 - 0.24 with a median value of 0.09 and an average value of 0.1 (n=12) (Figure 6-12).

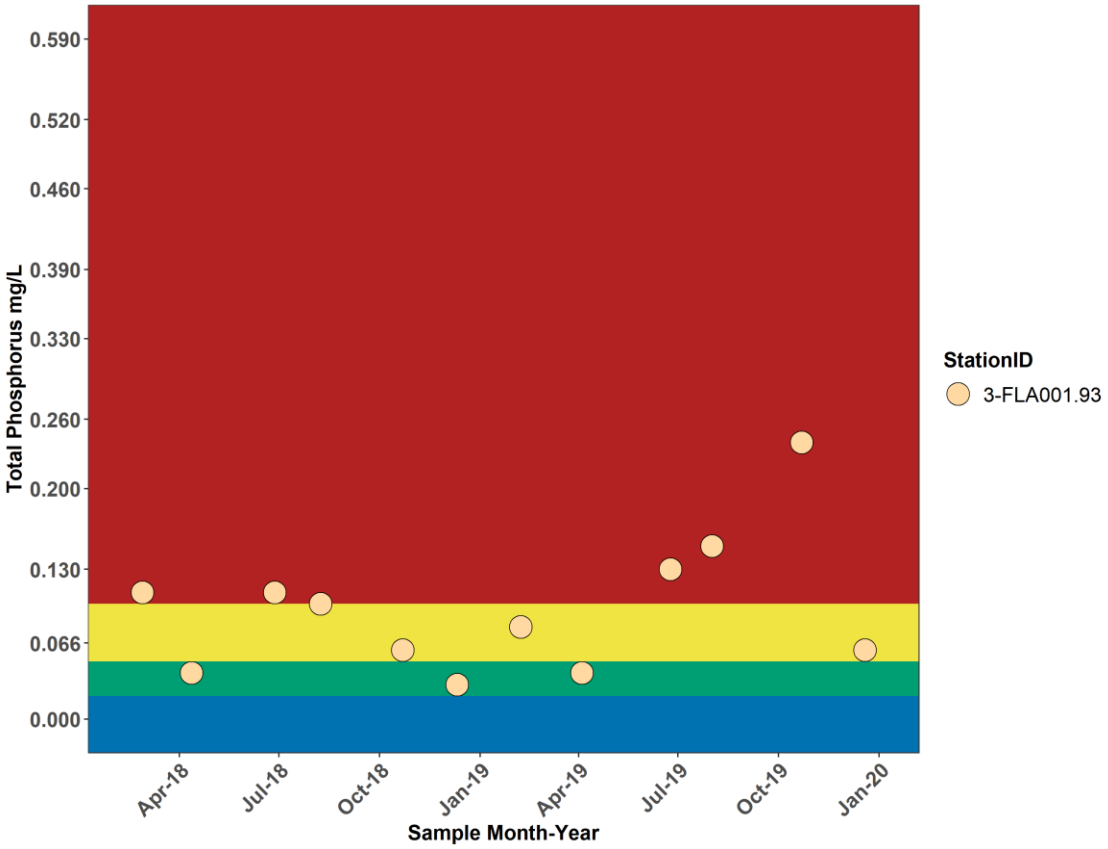


Figure 19-12. Total Phosphorus Measurements in Flat Run

For Flat Run, the ratio of average total nitrogen concentration of 1.33 mg/L to the average total phosphorous concentration of 0.1 mg/L is 13:1. This indicates that phosphorus is likely the limiting nutrient. While Virginia has not established water quality criteria for nutrients, USEPA has published recommended criteria based on ecoregion (USEPA, 2000a). For the Northern Piedmont ecoregion in which the Flat Run watershed is located, the recommended criterion is 0.04 mg/L. Median phosphorus levels for Flat Run are significantly above this value, indicating that phosphorus levels are elevated.

19.5 Ammonia

Values for ammonia were compared against the water quality criteria. Stressor thresholds have not been developed for ammonia. Because the water quality criteria for ammonia is dependent on instream pH and temperature, the aquatic life criterion for each monitoring event was calculated using the instream pH and temperature for the corresponding monitoring event. A comparison of the ammonia results with the criteria shows no excursions of the acute nor the chronic criterions. Table 6.2 - Table 6.4 detail this data.

19.5.1 Mainstem Mountain Run

Table 19-2. Ammonia Measurements Collected from Mountain Run from July 2015 – September 2020

Station ID	Monitoring Date	Total Ammonia (mg/L)	Acute Criteria (mg/L)	Chronic Criteria (mg/L)
3-MTN000.59	7/27/2015	0.02 [a]	5.77	0.975
3-MTN000.59	2/26/2018	0.61	32.20	3.309
3-MTN000.59	4/12/2018	0.01 [a]	15.58	2.223
3-MTN000.59	6/27/2018	0.04	13.44	1.604
3-MTN000.59	8/8/2018	0.02 [a]	9.30	1.243
3-MTN000.59	10/22/2018 [c]	0.01 [a]	-	-
3-MTN000.59	12/11/2018	0.02 [a]	46.23	4.746
3-MTN000.59	2/7/2019	0.01 [a]	25.63	3.307
3-MTN000.59	4/4/2019	0.008 [b]	17.48	2.439
3-MTN000.59	6/24/2019	0.03 [a]	13.67	1.631
3-MTN000.59	8/1/2019	0.02 [a]	10.60	1.404
3-MTN000.59	10/22/2019	0.05	21.65	2.470
3-MTN000.59	12/19/2019	0.014 [b]	24.63	3.547
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3-MTN005.79	7/27/2015	0.02 [a]	5.51	0.941
3-MTN005.79	8/3/2015	0.02 [a]	5.43	0.953
3-MTN005.79	2/26/2018	0.07	28.38	3.124
3-MTN005.79	4/12/2018	0.01 [a]	6.57	1.162
3-MTN005.79	6/27/2018	0.05	12.45	1.550
3-MTN005.79	8/8/2018	0.02 [a]	8.51	1.195
3-MTN005.79	10/22/2018 [c]	0.01 [a]	-	-
3-MTN005.79	12/11/2018	0.02 [a]	29.42	3.890
3-MTN005.79	2/7/2019	0.02 [a]	23.96	3.183
3-MTN005.79	4/4/2019	0.008 [b]	10.62	1.678
3-MTN005.79	6/24/2019	0.03 [a]	11.96	1.502
3-MTN005.79	8/1/2019	0.03 [a]	8.91	1.264
3-MTN005.79	10/22/2019	0.08	21.98	2.475
3-MTN005.79	12/19/2019	0.014 [b]	22.97	3.415
3-MTN005.79	9/23/2020	0.014 [b]	12.85	1.851
3-MTN005.79	9/30/2020	0.04	26.67	2.528
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3-MTN014.88	7/27/2015	0.03 [a]	6.40	1.038

Station ID	Monitoring Date	Total Ammonia (mg/L)	Acute Criteria (mg/L)	Chronic Criteria (mg/L)
3-MTN014.88	8/3/2015	0.03 [a]	5.90	1.016
3-MTN014.88	2/26/2018	0.06	23.63	2.820
3-MTN014.88	4/12/2018	0.02 [a]	15.86	2.197
3-MTN014.88	6/27/2018	0.08	9.37	1.367
3-MTN014.88	8/8/2018	0.05	10.22	1.288
3-MTN014.88	10/22/2018 [c]	0.01 [a]	-	-
3-MTN014.88	12/11/2018	0.04	28.72	3.844
3-MTN014.88	2/7/2019	0.01 [a]	22.01	3.194
3-MTN014.88	4/4/2019	0.008 [b]	8.70	1.445
3-MTN014.88	6/24/2019	0.04	10.89	1.439
3-MTN014.88	8/1/2019	0.02 [a]	10.89	1.401
3-MTN014.88	10/22/2019	0.28	15.90	2.055
3-MTN014.88	12/19/2019	0.02 [a]	20.75	3.222
3-MTN014.88	9/23/2020	0.014 [b]	16.00	2.098
3-MTN014.88	9/30/2020	0.05	16.59	2.015
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3-MTN021.11	7/27/2015	0.02 [a]	6.94	1.092
3-MTN021.11	8/3/2015	0.02 [a]	5.90	1.023
3-MTN021.11	2/26/2018	0.03 [a]	18.38	2.427
3-MTN021.11	4/12/2018	0.01 [a]	10.28	1.636
3-MTN021.11	6/27/2018	0.11	14.25	1.607
3-MTN021.11	8/8/2018	0.1	10.02	1.247
3-MTN021.11	10/22/2018 [c]	0.03 [a]	-	-
3-MTN021.11	12/11/2018	0.07	27.69	3.773
3-MTN021.11	2/7/2019	0.02 [a]	25.97	3.650
3-MTN021.11	4/4/2019	0.008 [b]	2.19	0.455
3-MTN021.11	5/2/2019	0.08	19.24	2.095
3-MTN021.11	6/24/2019	0.04	10.07	1.331
3-MTN021.11	8/1/2019	0.01 [a]	9.58	1.244
3-MTN021.11	9/3/2019	0.02 [a]	13.50	1.550
3-MTN021.11	10/22/2019	0.45	19.50	2.285
3-MTN021.11	12/19/2019	0.05	24.96	3.573
3-MTN021.11	9/23/2020	0.014 [b]	13.09	1.828
3-MTN021.11	9/30/2020	0.05	12.99	1.717

[a] Analyte detected above the method detection level but below the method quantification limit.

Station ID	Monitoring Date	Total Ammonia (mg/L)	Acute Criteria (mg/L)	Chronic Criteria (mg/L)

[b] Material analyzed for, but not detected. Value is the limit of detection.

[c] pH and temperature data were not collected so acute/chronic criteria cannot be calculated

19.5.2 Jonas Run and the Unnamed Tributary to Jonas Run

Table 19-3. Ammonia Measurements Collected from Jonas Run and the Unnamed Tributary to Jonas Run from February 2018 – December 2019

Station ID	Monitoring Date	Total Ammonia (mg/L)	Acute Criteria (mg/L)	Chronic Criteria (mg/L)
3-JOA000.80	2/26/2018	0.03 [a]	25.63	3.089
3-JOA000.80	4/12/2018	0.01 [a]	7.82	1.338
3-JOA000.80	6/27/2018	0.04	11.82	1.508
3-JOA000.80	8/8/2018	0.01 [a]	6.68	1.067
3-JOA000.80	10/22/2018 [c]	0.008 [b]	-	-
3-JOA000.80	12/11/2018	0.01 [a]	21.69	3.305
3-JOA000.80	2/7/2019	0.01 [a]	14.31	2.248
3-JOA000.80	4/4/2019	0.008 [b]	1.81	0.377
3-JOA000.80	6/24/2019	0.03 [a]	5.45	0.960
3-JOA000.80	8/1/2019	0.02 [a]	8.44	1.259
3-JOA000.80	10/22/2019	0.014 [b]	20.52	2.409
3-JOA000.80	12/19/2019	0.014 [b]	22.97	3.415
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3-XMO000.41	3/13/2018	0.05	50.54	4.908
3-XMO000.41	10/30/2018	0.03 [a]	42.65	3.694

[a] Analyte detected above the method detection level but below the method quantification limit.

[b] Material analyzed for, but not detected. Value is the limit of detection.

[c] pH and temperature data were not collected so acute/chronic criteria cannot be calculated

19.5.3 Flat Run

Table 19-4. Ammonia Measurements Collected from Flat Run from February 2018 – December 2019

Station ID	Monitoring Date	Total Ammonia (mg/L)	Acute Criteria (mg/L)	Chronic Criteria (mg/L)
3-FLA001.93	2/26/2018	0.05	37.31	3.702
3-FLA001.93	4/12/2018	0.06	23.53	2.788
3-FLA001.93	6/27/2018	0.03 [a]	9.73	1.358
3-FLA001.93	8/8/2018	0.01 [a]	8.84	1.231
3-FLA001.93	10/22/2018 [c]	0.01 [a]	-	-
3-FLA001.93	12/11/2018	0.03 [a]	28.03	3.797
3-FLA001.93	2/7/2019	0.14	28.03	3.620
3-FLA001.93	4/4/2019	0.01 [a]	15.71	2.186
3-FLA001.93	6/24/2019	0.03	12.01	1.474
3-FLA001.93	8/1/2019	0.1 [a]	10.53	1.411
3-FLA001.93	10/22/2019	0.03 [a]	34.60	3.025
3-FLA001.93	12/19/2019	0.014 [b]	39.59	4.458

[a] Analyte detected above the method detection level but below the method quantification limit.

[b] Material analyzed for, but not detected. Value is the limit of detection.

[c] pH and temperature data were not collected so acute/chronic criteria cannot be calculated

19.6 Specific Conductivity

Specific conductance is a measure of how well water can conduct an electrical current based on the amount of ions in water. Regional geology has great bearing on the ions in a water body. Therefore, water flowing through materials that easily dissolve into their ionic constituents will most likely have a higher conductivity. Human activities can increase natural ionization; for example of surface mining and the application of salts in winter to melt ice on paved surfaces can lead to an increased amount of ions in water.

Measurements of conductivity are typically converted to specific conductance (or specific conductivity) at a standard temperature (25ºC) because conductivity changes with temperature. This allows conductivity measurements made at different temperatures to be compared on a common basis. All data presented in this section represents specific conductivity converted to the 25ºC standard, however, the term conductivity may be used to generally refer to the data. While conductivity is a direct measure of electrical conductance, it is an indirect measure of the collective influence of dissolved ions in the water. It is this property of the water that has greater meaning for the analysis of stressors in Mountain Run. As the sum of all dissolved ions in a water increases, so too does the conductivity. It is the chemical action of these ions (both individually and collectively) and not necessarily the conductive property of the water that produces toxic effects on freshwater organisms if above certain thresholds.

19.6.1 Mainstem Mountain Run

In the impaired portion of Mountain Run, samples for specific conductivity used in this analysis were collected between 2015 and 2020. Specific conductivity measurements along Mountain Run ranged from 74 - 552 with a median value of 196.5 and an average value of 215.68 (n=124) (Figure 6-13).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median specific conductivity were 221.95 and 200.5 respectively (n=56).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median specific conductivity were 219.55 and 206 respectively (n=22).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median specific conductivity were 270.42 and 246 respectively (n=24).

At the upstream most monitoring station, 3-MTN021.11, the average and median specific conductivity were 136.14 and 122, respectively (n=22).

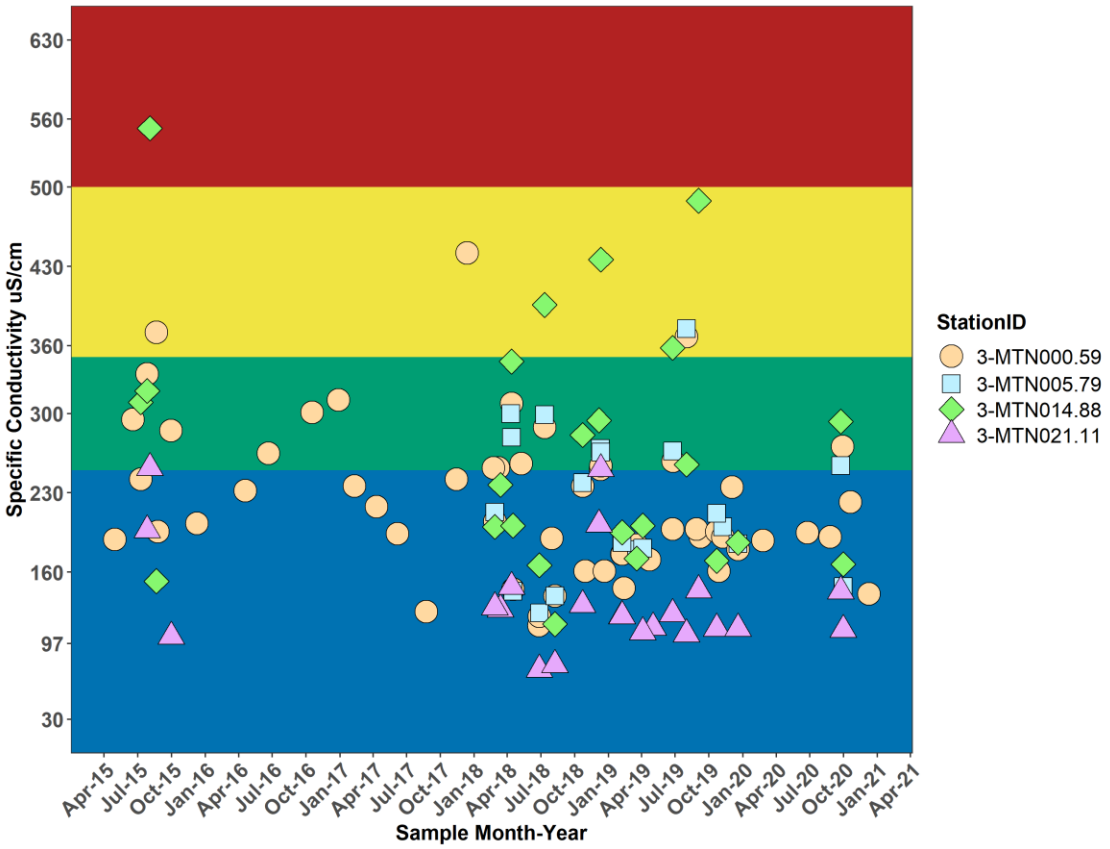

Figure 19-13. Specific Conductivity Measurements in Mountain Run

The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating no probability of stress.

19.6.2 Jonas Run and the Unnamed Tributary to Jonas Run

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for specific conductivity used in this analysis were collected between 2018 and 2020. Specific conductivity measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 112 - 296 with a median value of 182 and an average value of 194.05 (n=21) (Figure 6-14).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median specific conductivity were 200.42 and 190 respectively (n=19).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median specific conductivity were 133.5 and 133.5 respectively (n=2).

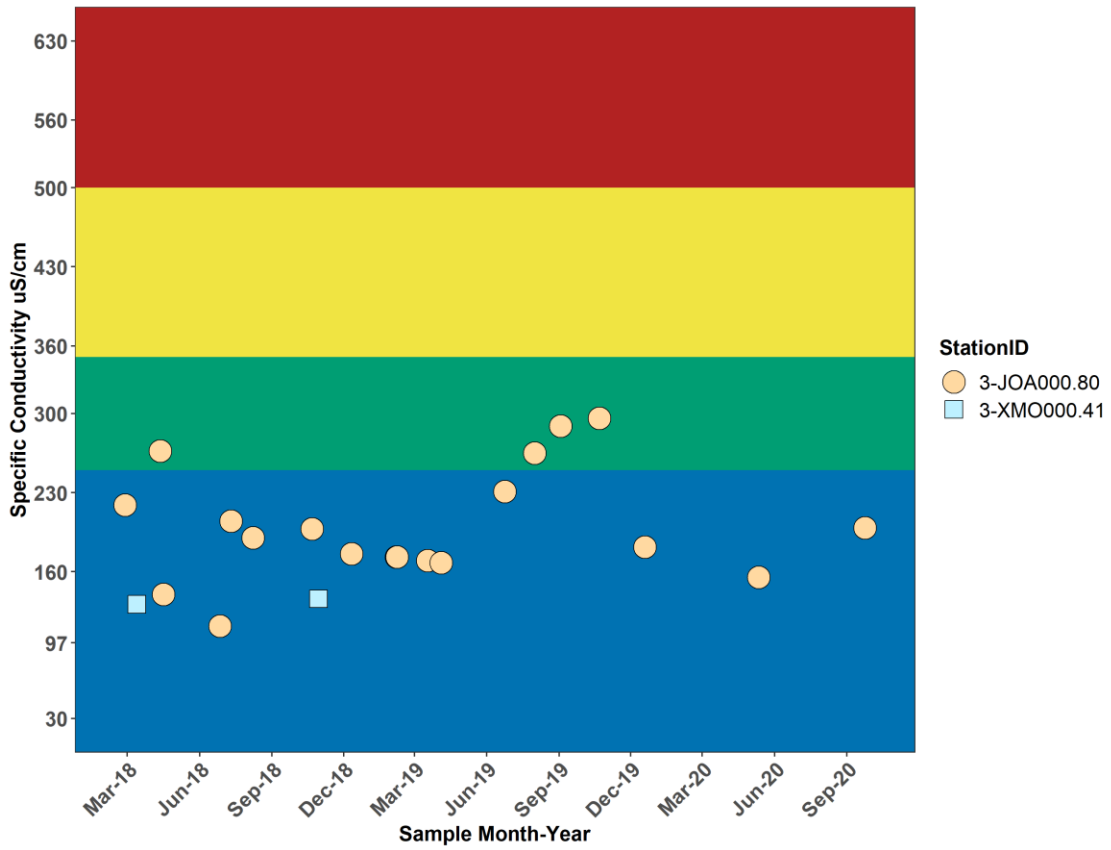

Figure 19-14. Specific Conductivity Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The data measured ranged from no probability of stress to low probability of stress, with the average and median values indicating no probability of stress.

19.6.3 Flat Run

In the potentially impaired portions of Flat Run samples for specific conductivity used in this analysis were collected between 2018 and 2020. Specific conductivity measurements along Flat Run ranged from 164 - 425 with a median value of 212 and an average value of 241.41 (n=17) (Figure 6-15).

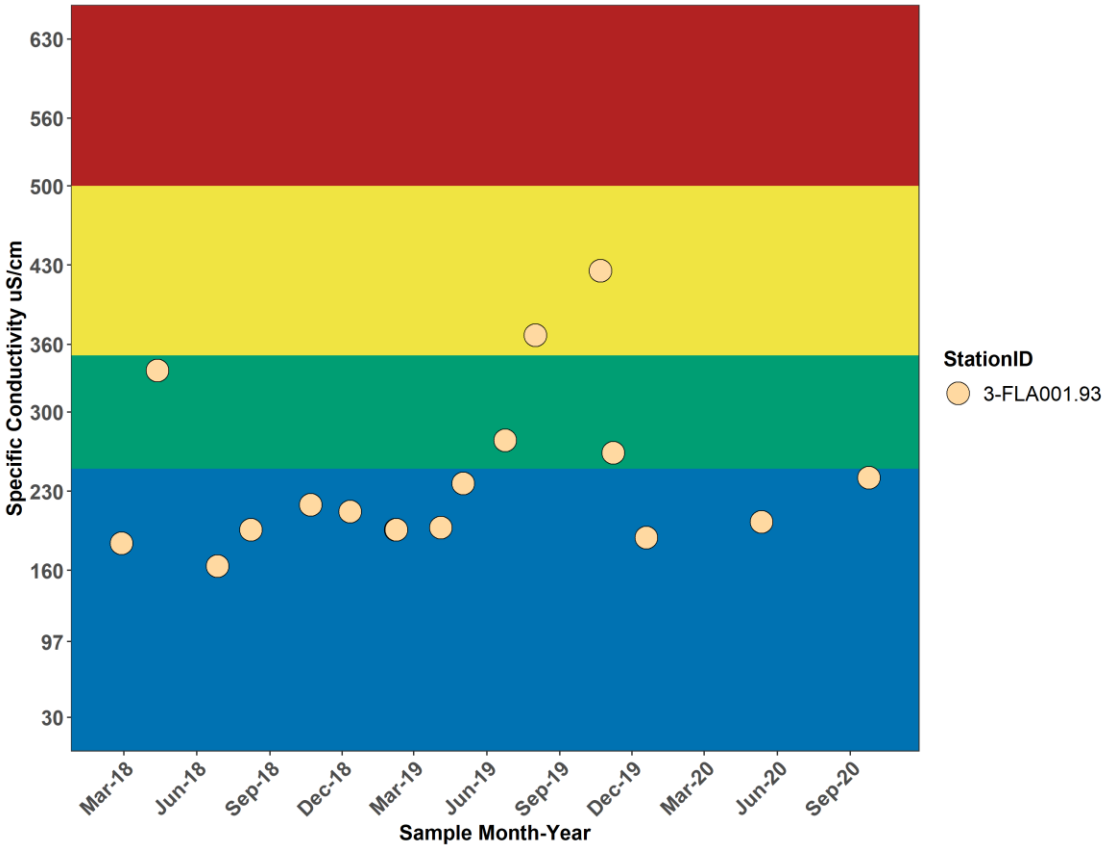

Figure 19-15. Specific Conductivity Measurements in Flat Run

The data measured ranged from no probability of stress to medium probability of stress, with the average and median values indicating no probability of stress.

19.7 Total Dissolved Solids

Total dissolved solids (TDS) is a measurement of the concentration of dissolved ions in a waterbody. Although there are no water quality standards for TDS, EPA Secondary Regulations establish a (non-enforceable) TDS level of 500 mg/L for aesthetic and corrosion prevention purposes (40 CFR §141.208). Although a TDS level of above 350 mg/L is considered to have a high probability of aquatic stress in Virginia, there are streams with naturally high levels of TDS from underlying geology. However, analyzing a suite of ions that are associated with anthropogenic activities, like sulfate, chloride, sodium, and potassium, can help to understand the cause(s) for elevated TDS concentrations.

19.7.1 Mainstem Mountain Run

In the impaired portion of Mountain Run samples for Total Dissolved Solids (TDS) used in this analysis were collected between 2018 and 2020. TDS measurements along Mountain Run ranged from 60 - 251 with a median value of 112 and an average value of 123.59 (n=56) (Figure 6-16).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median TDS were 134.5 and 122 respectively (n=12).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for TDS were 137.33 and 134 respectively (n=15).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median TDS were 145.64 and 124 respectively (n=14).

At the upstream most monitoring station, 3-MTN021.11, the average and median TDS were 80.53 and 75, respectively (n=15).

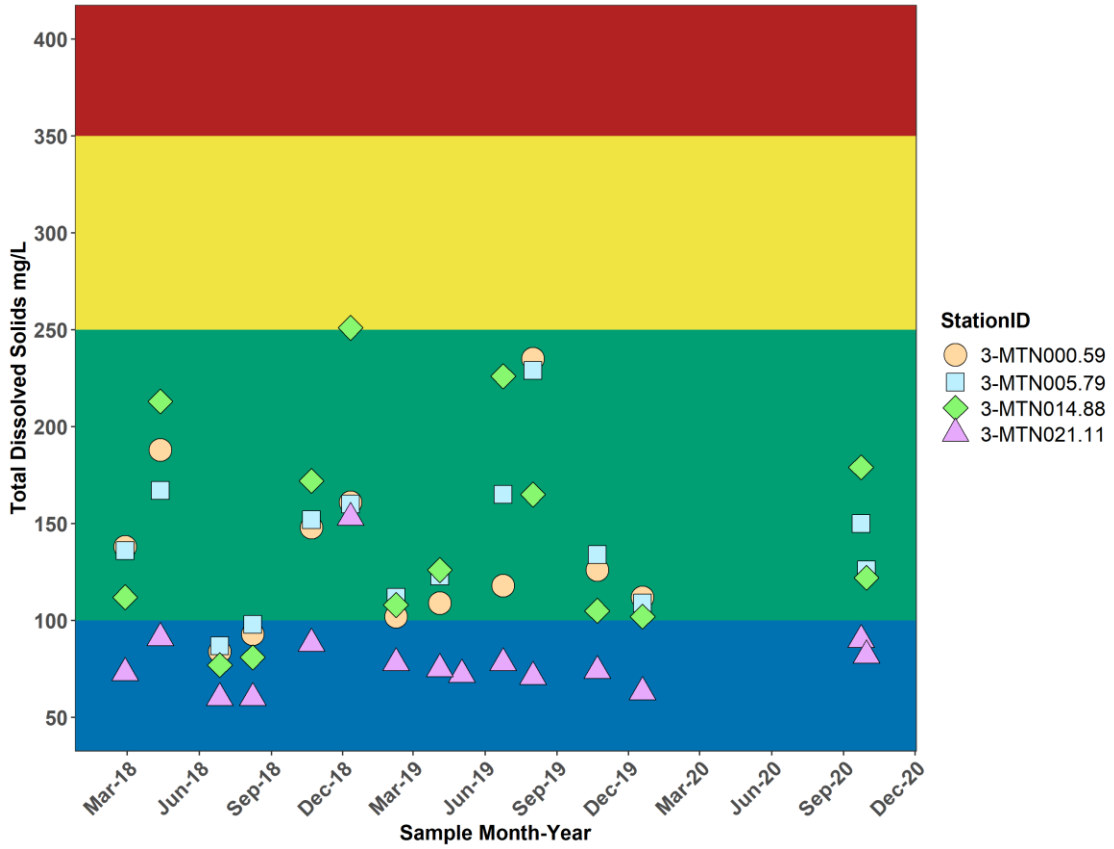

Figure 19-16. Total Dissolved Solids Measurements in Mountain Run

The data measured ranged from no probability of stress to medium probability of stress, with the average and median values indicating low probability of stress.

19.7.2 Jonas Run and the Unnamed Tributary to Jonas Run

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for Total Dissolved Solids (TDS) used in this analysis were collected between 2018 and 2019. TDS measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 67 - 190 with a median value of 121 and an average value of 125.31 (n=13) (Figure 6-17).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median TDS were 130.17 and 123.5 respectively (n=12).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median TDS were 67 and 67 respectively (n=1).

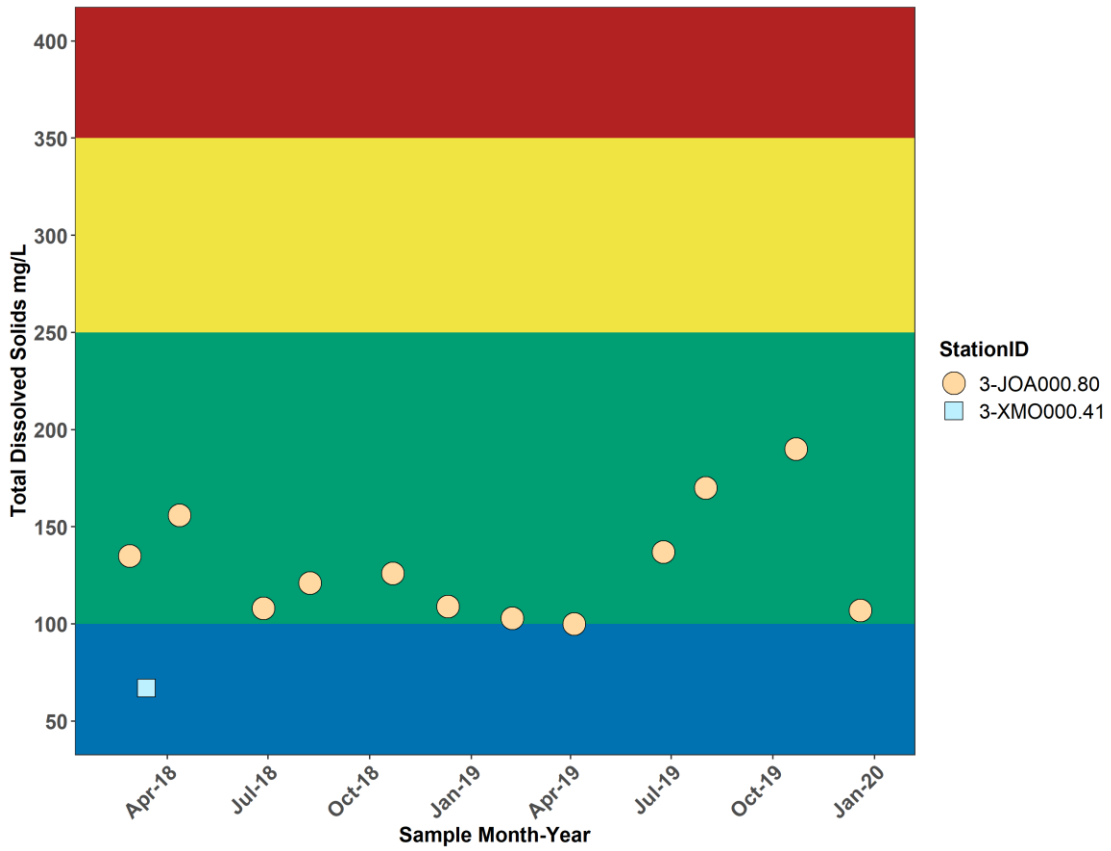

Figure 19-17. Total Dissolved Solids Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The data measured ranged from no probability of stress to low probability of stress, with the average and median values indicating low probability of stress.

19.7.3 Flat Run

In the potentially impaired portions of Flat Run samples for Total Dissolved Solids (TDS) used in this analysis were collected between 2018 and 2019. TDS measurements along Flat Run ranged from 108 - 288 with a median value of 134 and an average value of 162.17 (n=12) (Figure 6-18).

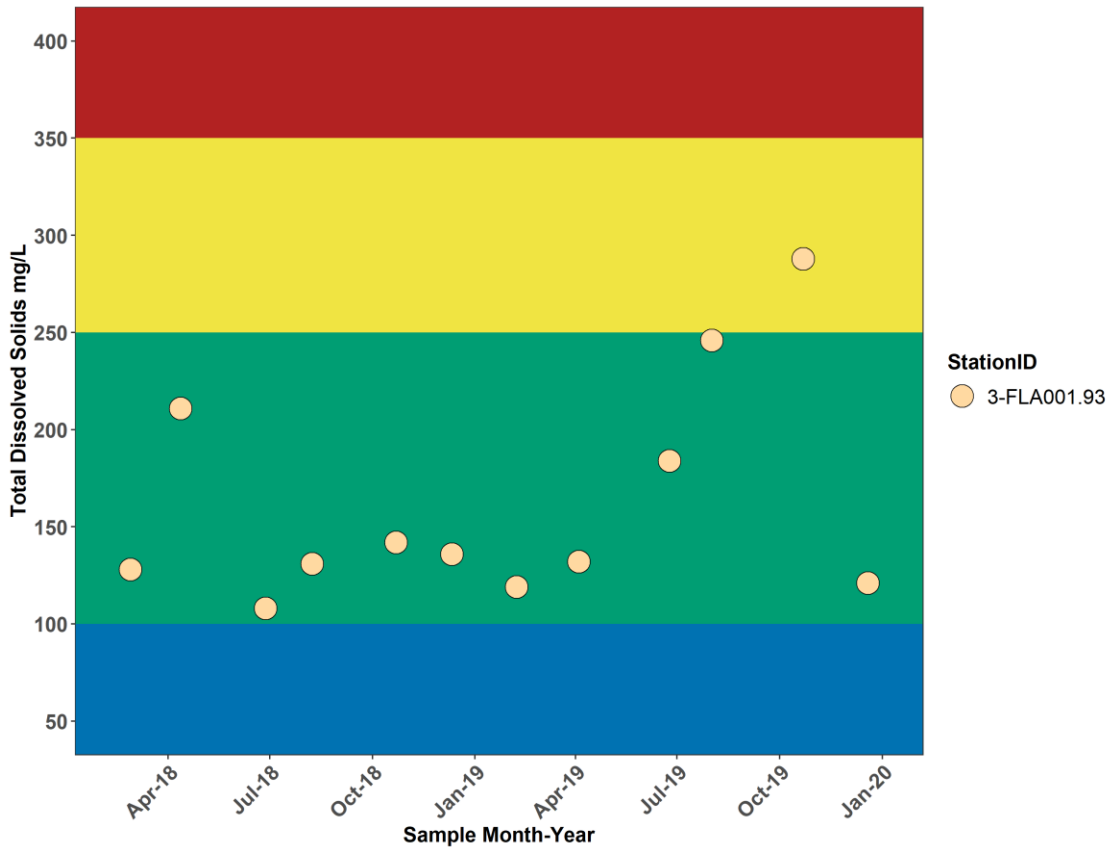

Figure 19-18. Total Dissolved Solids Measurements in Flat Run

The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating no probability of stress.

19.8 Dissolved Ions

A suite of ions associated with anthropogenic activities were analyzed. These are sulfate, chloride, sodium, and potassium.

19.8.1 Sulfate

19.8.1.1 *Mainstem Mountain Run*

In the impaired portion of Mountain Run samples for sulfate used in this analysis were collected between 2018 and 2020. Sulfate measurements along Mountain Run ranged from 2.26 - 72.4 with a median value of 18.1 and an average value of 21.17 (n=71) (Figure 6-19).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median sulfate values were 23.89 and 18.7 respectively (n=27).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for sulfate values were 24.8 and 20.8 respectively (n=15).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median sulfate values were 29.15 and 19.7 respectively (n=14).

At the upstream most monitoring station, 3-MTN021.11, the average and median sulfate were 5.19 and 4.86, respectively (n=15).

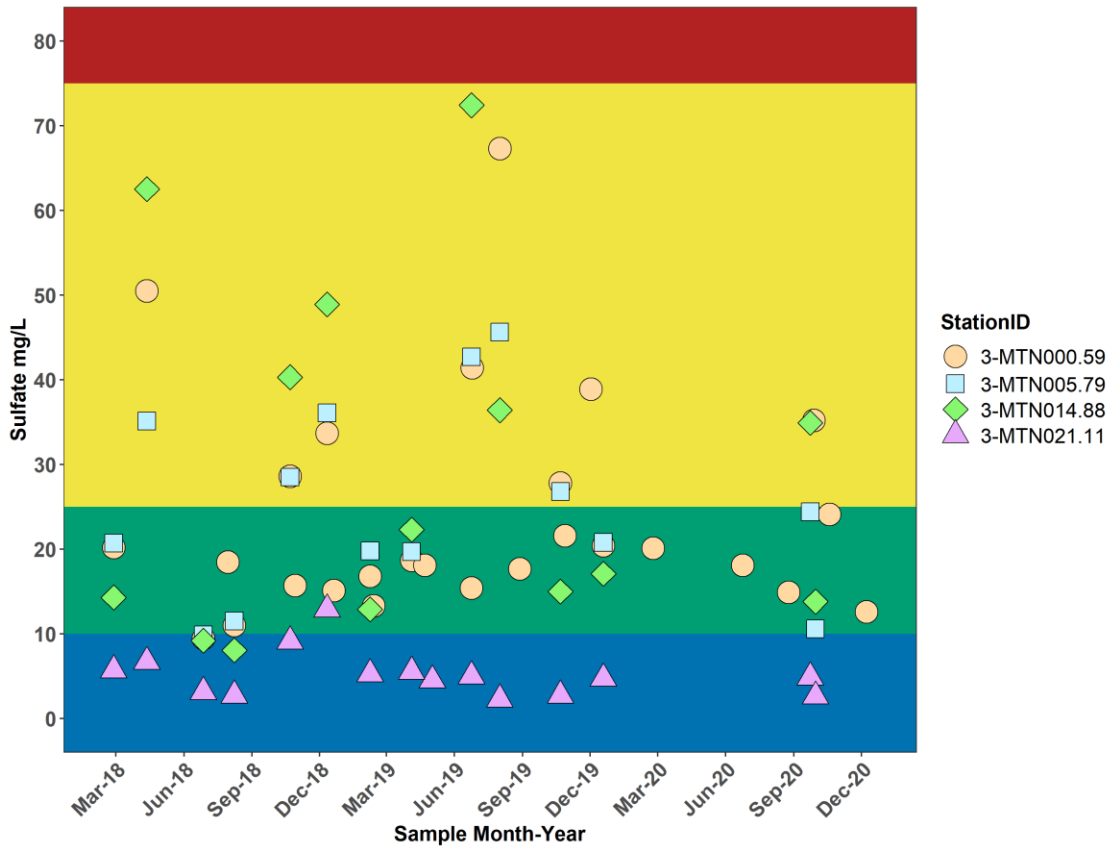

Figure 19-19. Sulfate Measurements in Mountain Run

The data measured ranged from no probability of stress to medium probability of stress, with the average and median values indicating low probability of stress.

19.8.1.2 *Jonas Run and the Unnamed Tributary to Jonas Run*

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for Sulfate used in this analysis were collected between 2018 and 2019. Sulfate measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 7.22 - 49.4 with a median value of 16.3 and an average value of 19.46 (n=13) (Figure 6-20).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median sulfate values were 20.48 and 16.95 respectively (n=12).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median sulfate values were 7.22 and 7.22 respectively (n=1).

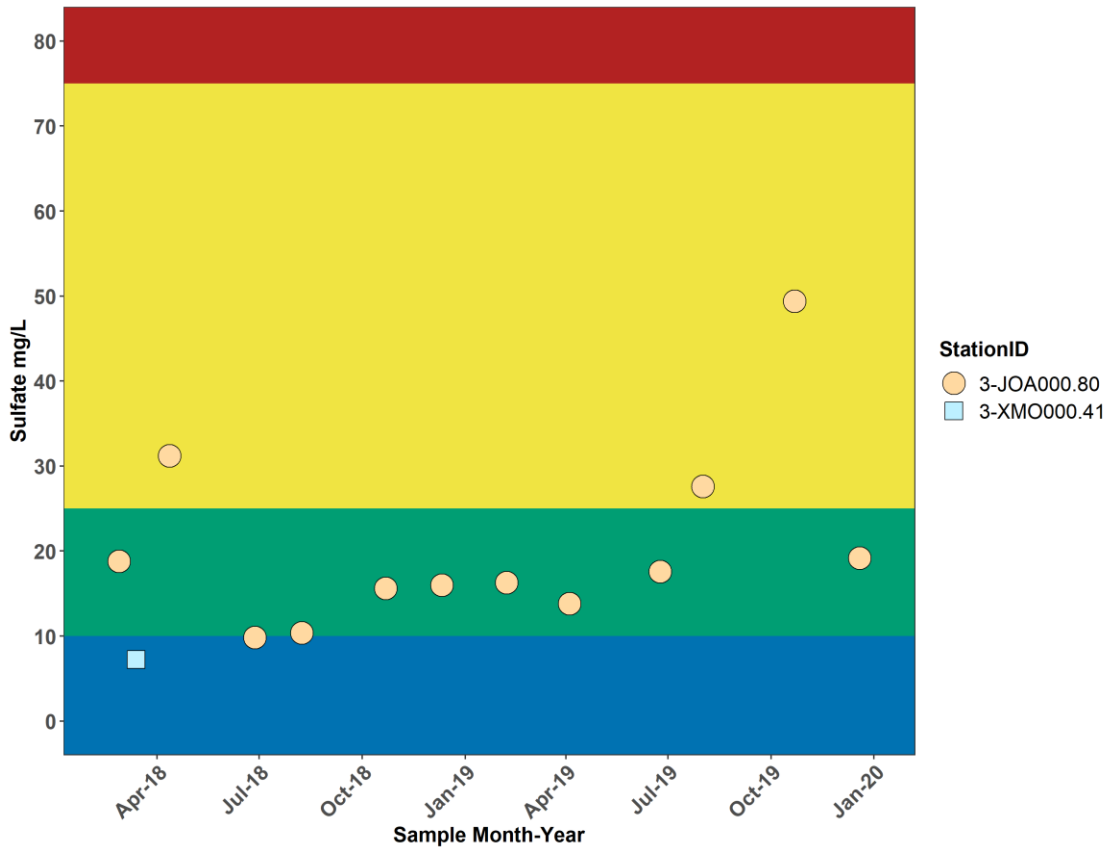

Figure 19-20. Sulfate Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The data measured ranged from no probability of stress to medium probability of stress, with the average and median values indicating low probability of stress.

19.8.1.3 *Flat Run*

In the potentially impaired portions of Flat Run samples for sulfate used in this analysis were collected between 2018 and 2019. Sulfate measurements along Flat Run ranged from 9.85 - 126 with a median value of 26.3 and an average value of 37.49 (n=12) (Figure 6-21).

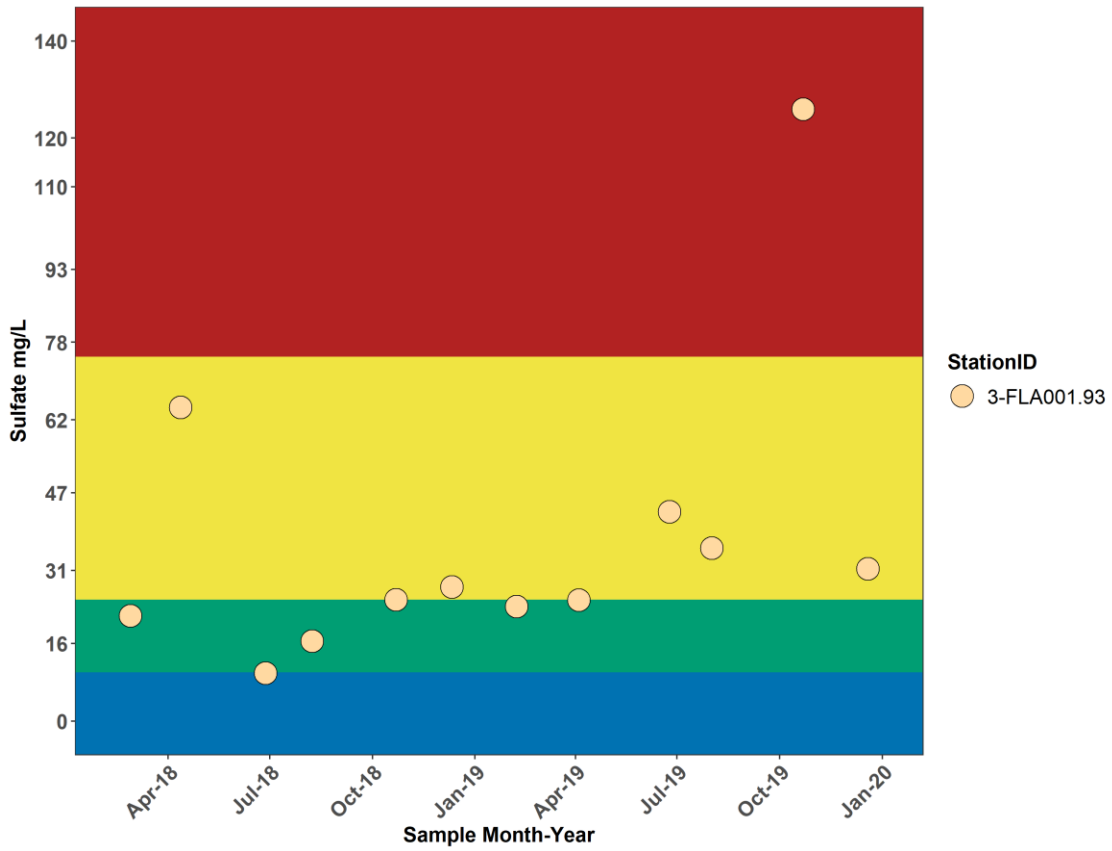

Figure 19-21. Sulfate Measurements in Flat Run

The data measured ranged from low probability of stress to high probability of stress, with the average and median values indicating medium probability of stress.

19.8.2 Chloride

19.8.2.1 *Mainstem Mountain Run*

In the impaired portion of Mountain Run samples for chloride used in this analysis were collected between 2018 and 2020. Chloride measurements along Mountain Run ranged from 6.25 - 67.6 with a median value of 17.8 and an average value of 19.6 (n=71) (Figure 6-22).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median chloride values were 17.87 and 16.9 respectively (n=27).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for chloride values were 21 and 19.6 respectively (n=15).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median chloride values were 26.34 and 25.95 respectively (n=14).

At the upstream most monitoring station, 3-MTN021.11, the average and median chloride values were 15.02 and 13.3, respectively (n=15).

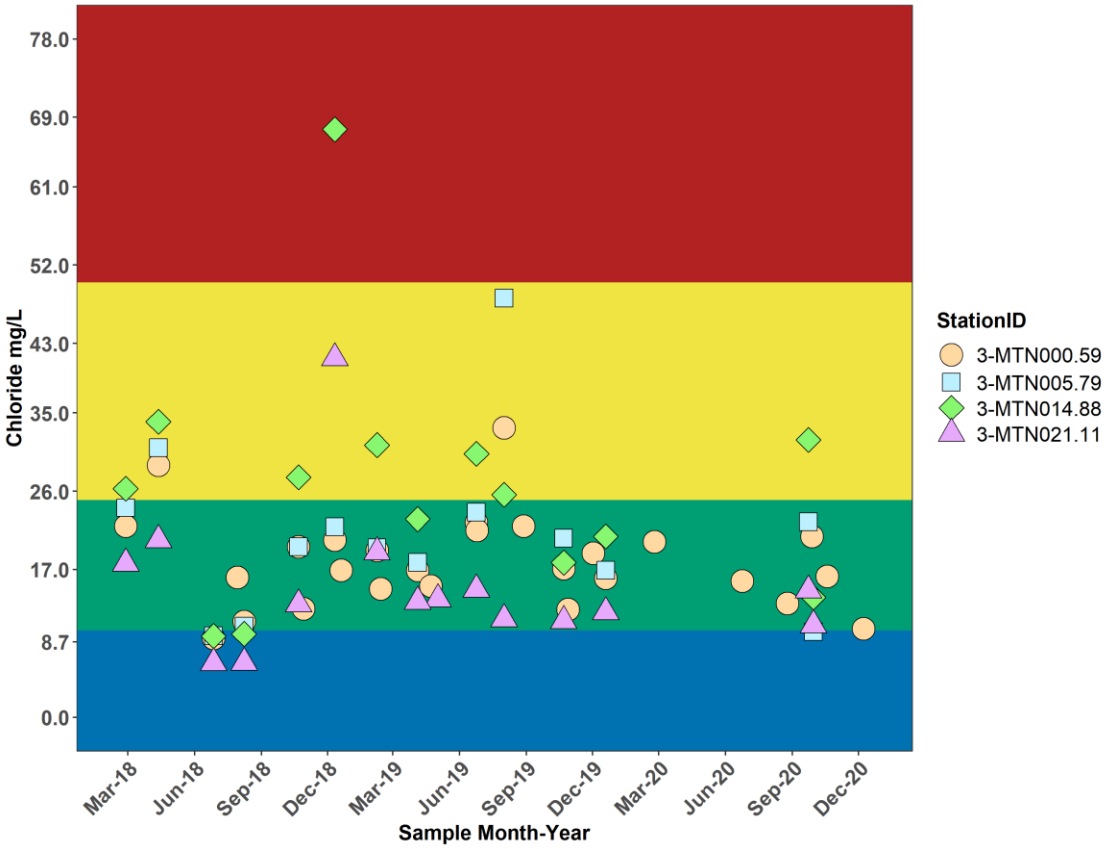

Figure 19-22. Chloride Measurements in Mountain Run

The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating low probability of stress.

19.8.2.2 *Jonas Run and the Unnamed Tributary to Jonas Run*

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for chloride used in this analysis were collected between 2018 and 2019. Chloride measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 10.7 - 24.6 with a median value of 12.8 and an average value of 14.82 (n=13) (Figure 6-23).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median chloride values were 15.11 and 13.25 respectively (n=12).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median chloride values were 11.4 and 11.4 respectively (n=1).

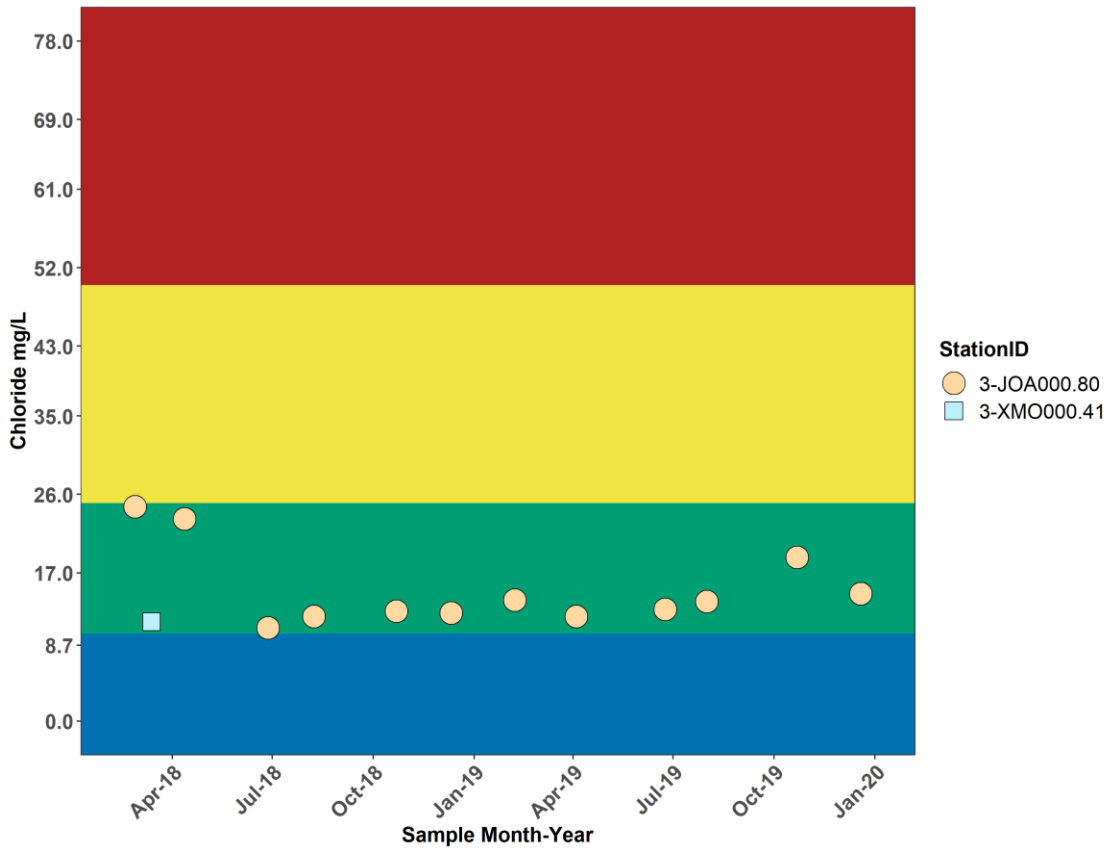

Figure 19-23. Chloride Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

All data measured, including the average and median values, indicate low probability of stress.

19.8.2.3 *Flat Run*

In the potentially impaired portions of Flat Run samples for chloride used in this analysis were collected between 2018 and 2019. Chloride measurements along Flat Run ranged from 9.53 - 21.4 with a median value of 11.65 and an average value of 13.84 (n=12) (Figure 6-24).

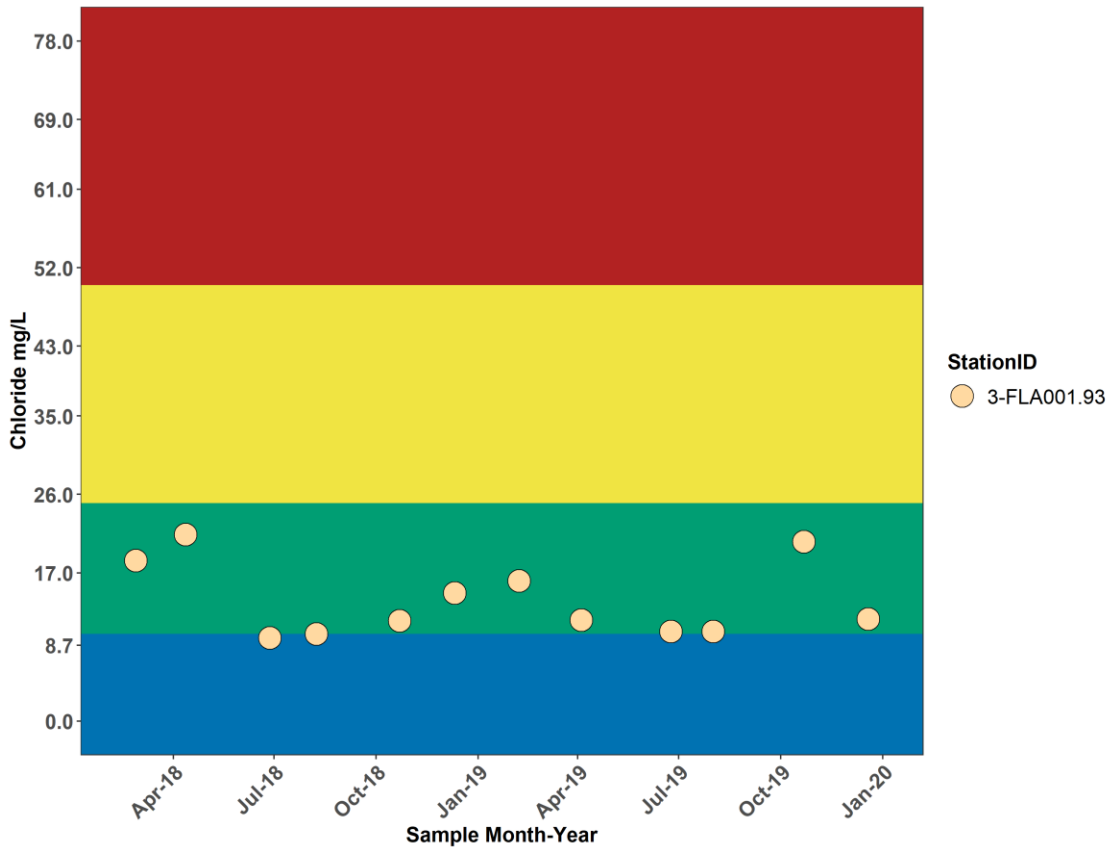

Figure 19-24. Chloride Measurements in Flat Run

The data measured ranged from no probability of stress to low probability of stress, with the average and median values indicating low probability of stress.

19.8.3 Potassium

19.8.3.1 *Mainstem Mountain Run*

In the impaired portion of Mountain Run samples for potassium used in this analysis were collected between 2018 and 2020. Potassium measurements along Mountain Run ranged from 1.77 - 5.55 with a median value of 3.26 and an average value of 3.36 (n=72) (Figure 6-25).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median potassium values were 3.5 and 3.43 respectively (n=27).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for potassium values were 3.52 and 3.39 respectively (n=15).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median potassium values were 3.73 and 3.84 respectively (n=14).

At the upstream most monitoring station, 3-MTN021.11, the average and median potassium values were 2.64 and 2.83, respectively (n=16).

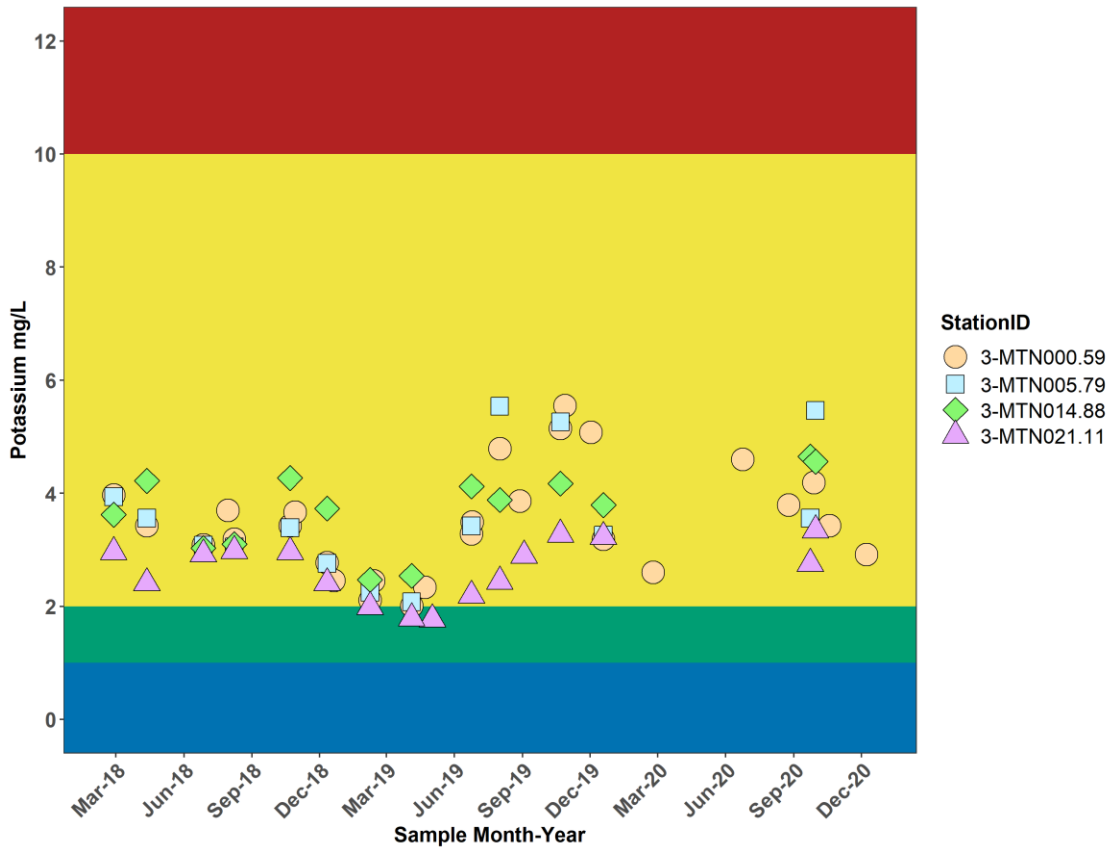

Figure 19-25. Potassium Measurements in Mountain Run

The data measured ranged from low probability of stress to medium probability of stress, with the average and median values indicating medium probability of stress.

19.8.3.2 *Jonas Run and the Unnamed Tributary to Jonas Run*

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for potassium used in this analysis were collected between 2018 and 2019. Potassium measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 1.38 - 5.95 with a median value of 2.14 and an average value of 2.45 (n=13) (Figure 6-26).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median potassium values were 2.51 and 2.17 respectively (n=12).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median potassium values were 1.7 and 1.7 respectively (n=1).

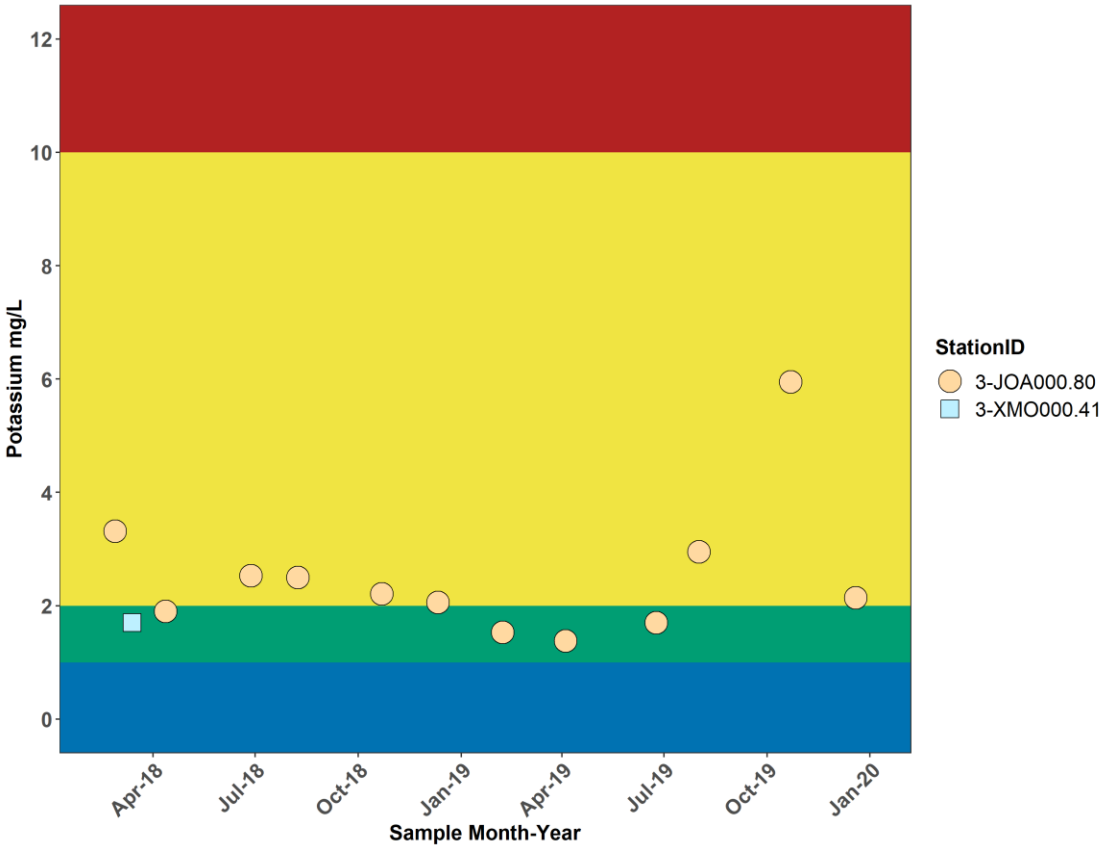

Figure 19-26. Potassium Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The data measured ranged from low probability of stress to medium probability of stress, with the average and median values indicating medium probability of stress.

19.8.3.3 *Flat Run*

In the potentially impaired portions of Flat Run samples for potassium used in this analysis were collected between 2018 and 2019. Potassium measurements along Flat Run ranged from 1.54 - 10.3 with a median value of 2.44 and an average value of 3.11 (n=12) (Figure 6-27).

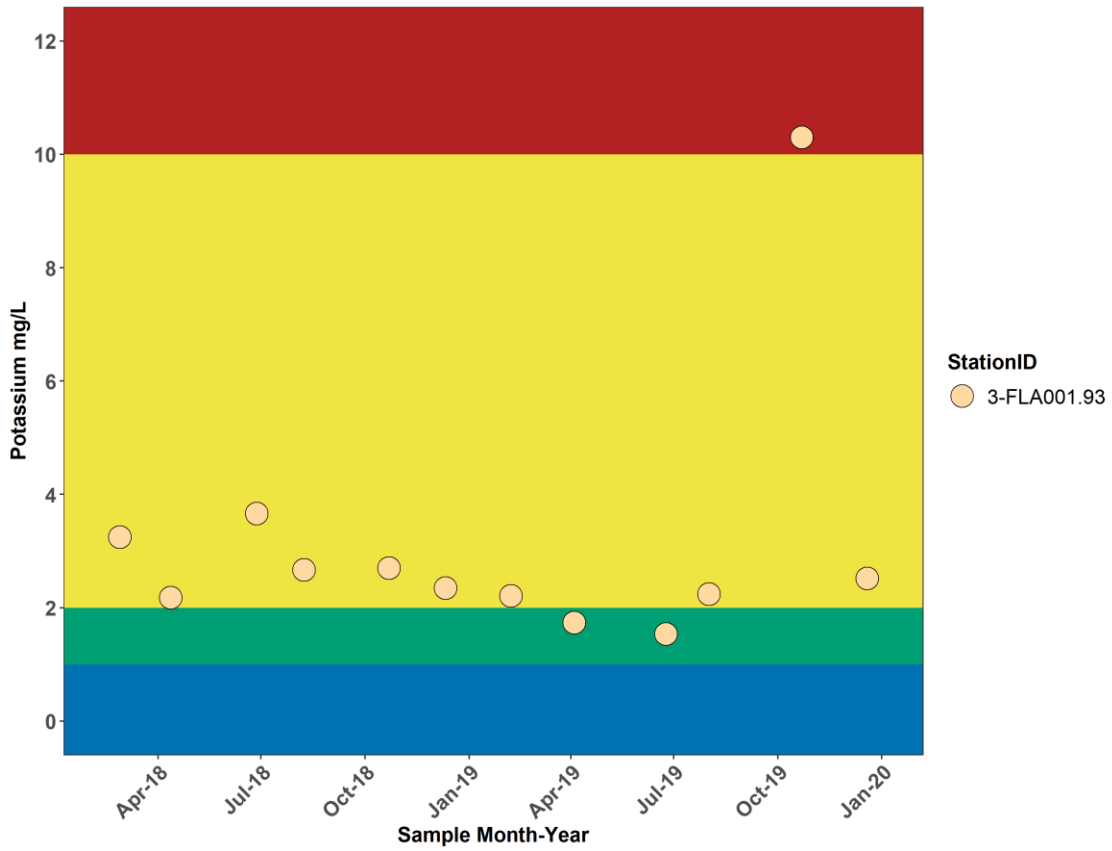

Figure 19-27. Potassium Measurements in Flat Run

The data measured ranged from low probability of stress to high probability of stress, with the average and median values indicating medium probability of stress.

19.8.4 Sodium

19.8.4.1 *Mainstem Mountain Run*

In the impaired portion of Mountain Run samples for sodium used in this analysis were collected between 2018 and 2020. Sodium measurements along Mountain Run ranged from 3.21 - 37.4 with a median value of 10.2 and an average value of 11.53 (n=72) (Figure 6-28).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median sodium values were 11.13 and 9.94 respectively (n=27).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for sodium values were 12.8 and 12.1 respectively (n=15).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median sodium values were 15.98 and 14.55 respectively (n=14).

At the upstream most monitoring station, 3-MTN021.11, the average and median sodium values were 7.12 and 6.25, respectively (n=16).

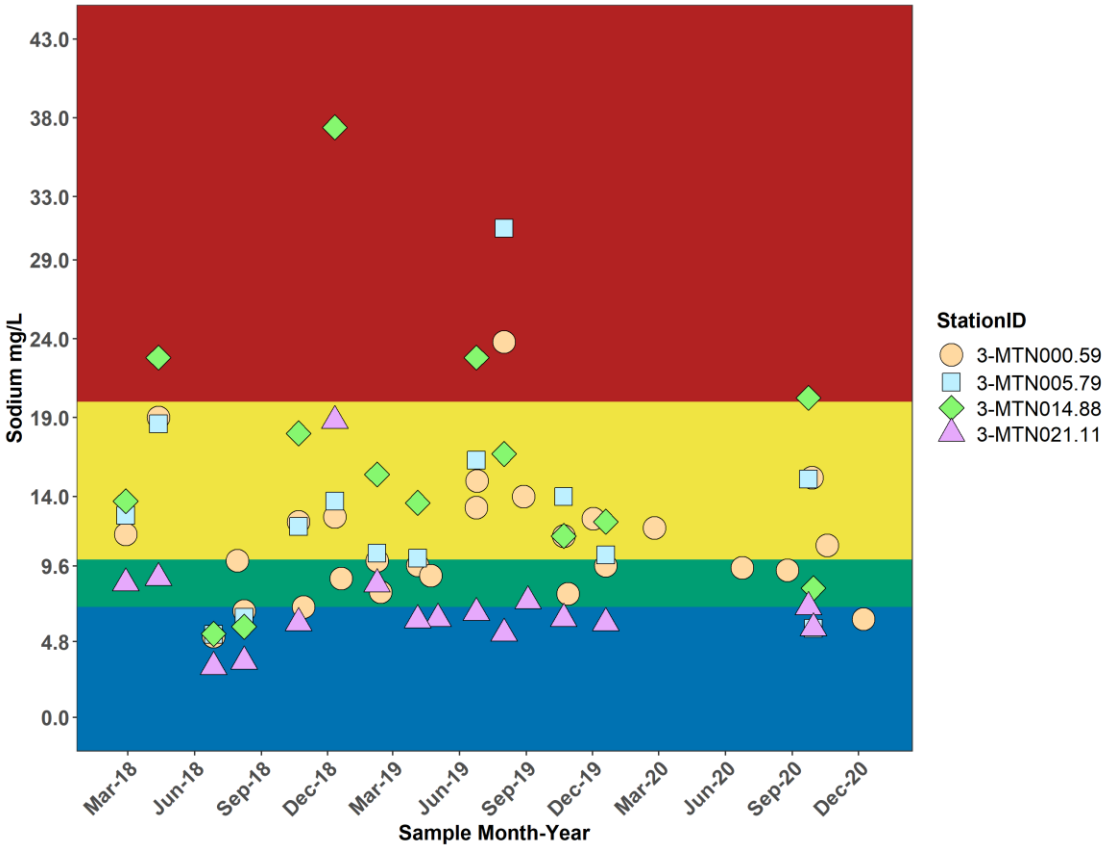

Figure 19-28. Sodium Measurements in Mountain Run

The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating medium probability of stress.

19.8.4.2 *Jonas Run and the Unnamed Tributary to Jonas Run*

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for sodium used in this analysis were collected between 2018 and 2019. Sodium measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 3.56 - 12.4 with a median value of 6.93 and an average value of 8.09 (n=13) (Figure 6-29).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median sodium values were 8.47 and 7.51 respectively (n=12).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median sodium values were 3.56 and 3.56 respectively (n=1).

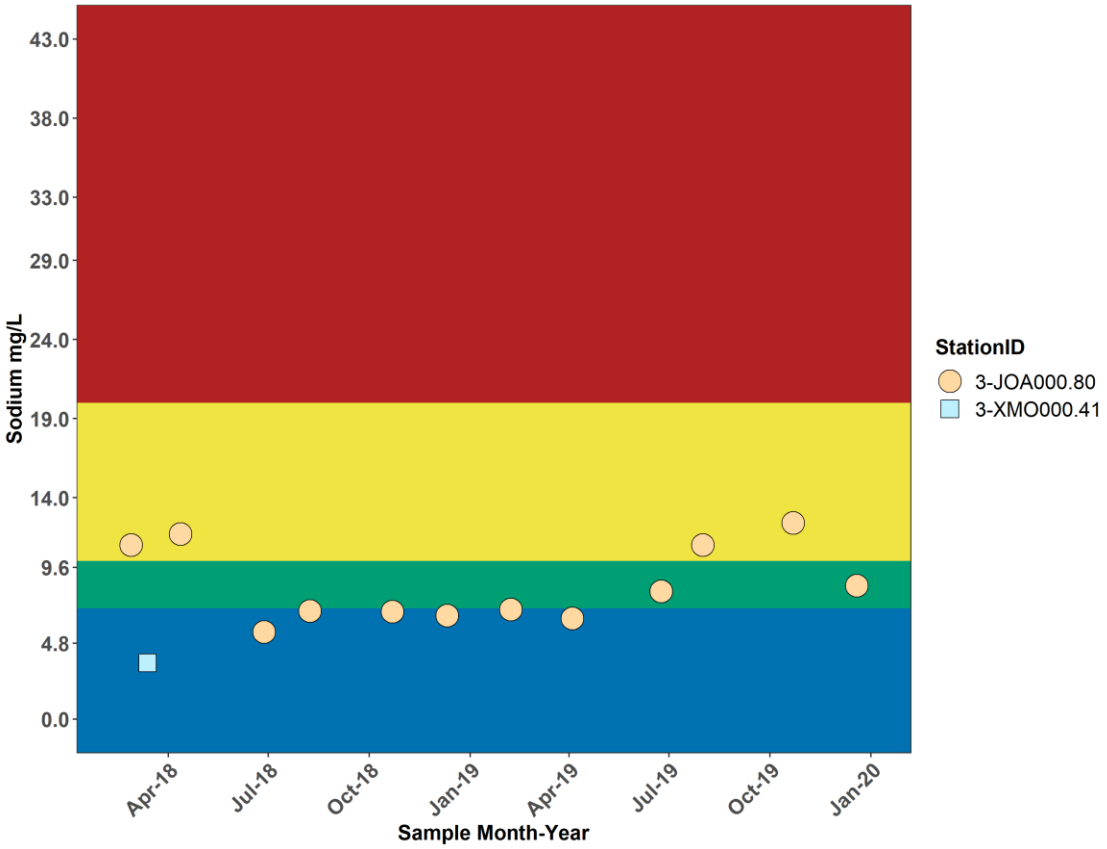

Figure 19-29. Sodium Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The data measured ranged from no probability of stress to medium probability of stress, with the average value indicating low probability of stress and median value indicating no probability of stress.

19.8.4.3 *Flat Run*

In the potentially impaired portions of Flat Run samples for sodium used in this analysis were collected between 2018 and 2019. Sodium measurements along Flat Run ranged from 4.47 - 22.9 with a median value of 8.15 and an average value of 9.72 (n=12) (Figure 6-30).

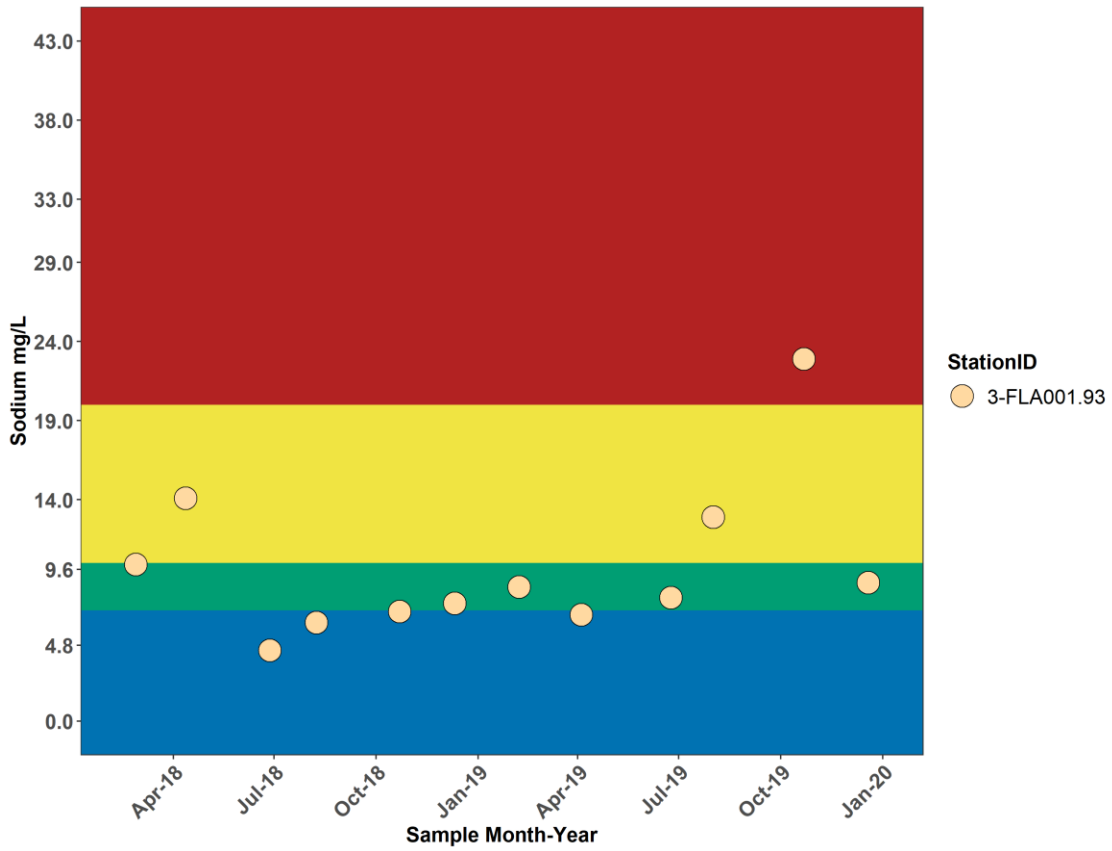

Figure 19-30. Sodium Measurements in Flat Run

The data measured ranged from no probability of stress to high probability of stress, with the average and median values indicating low probability of stress.

19.9 Dissolved Metals

19.9.1 Metal Cumulative Criteria Unit

The Metal Cumulative Criterion Unit (Metals CCU) is a measurement that accounts for the additive effect of dissolved metals in the water column by standardizing each dissolved metal's concentration with chronic criterion values established by DEQ. Arsenic, chromium III, copper, lead, nickel, and zinc are included in the calculation, as they are generally considered the most prevalent in the environment. These metal criteria are dependent on the water hardness; therefore, hardness was also included in the calculation.

19.9.1.1 *Mainstem Mountain Run*

In the impaired portion of Mountain Run samples for Metal Cumulative Criterion Unit (Metals CCU) used in this analysis were collected between 2019 and 2020 at three of the four monitoring stations. Metals CCU measurements along Mountain Run ranged from 0.41 - 0.96 with a median value of 0.77 and an average value of 0.7 (n=7) (Figure 6-31).

Samples taken 5.2 river miles above the downstream most station, at station 3-MTN005.79, were collected on 9/23/20 and 9/30/20 and the average Metals CCU was 0.7 (n=2). The result of the 9/23/20 sample was 0.43 and the result of the 9/30/20 was 0.96.

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, samples were also collected on 9/23/20 and 9/30/20 with the average Metals CCU was 0.66 (n=2). The result of the 9/23/20 sample was 0.41 and the result of the 9/30/20 was 0.91.

At the upstream most monitoring station, 3-MTN021.11, the average and median Metals CCU were 0.73 and 0.77, respectively (n=3). Samples were collected on 9/3/2019, 9/23/20 and 9/30/20 and the results were 0.77, 0.53 and 0.88 respectively.

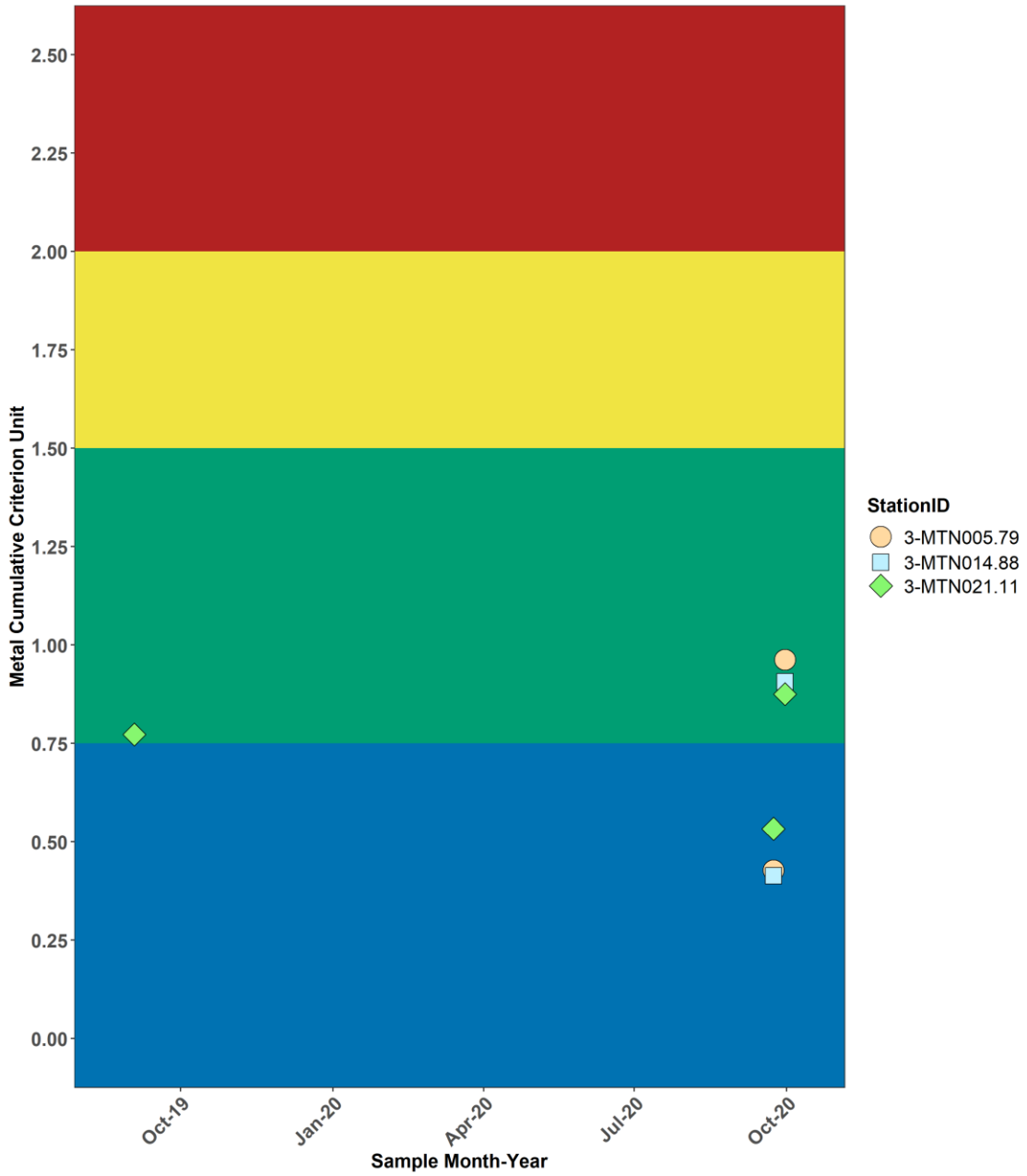

Figure 19-31. Metals CCU Measurements in Mountain Run

The data measured ranged from no probability of stress to low probability of stress, with the average value indicating no probability of stress and median value indicating low probability of stress.

19.9.1.2 *Jonas Run and the Unnamed Tributary to Jonas Run*

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run a single sample for the parameters that make up the Metal Cumulative Criterion Unit (Metals CCU) used in this analysis was collected at station 3-XMO000.41 on 3/13/2018. The results of that sample was 0.92 (n=1) (Figure 6-32).

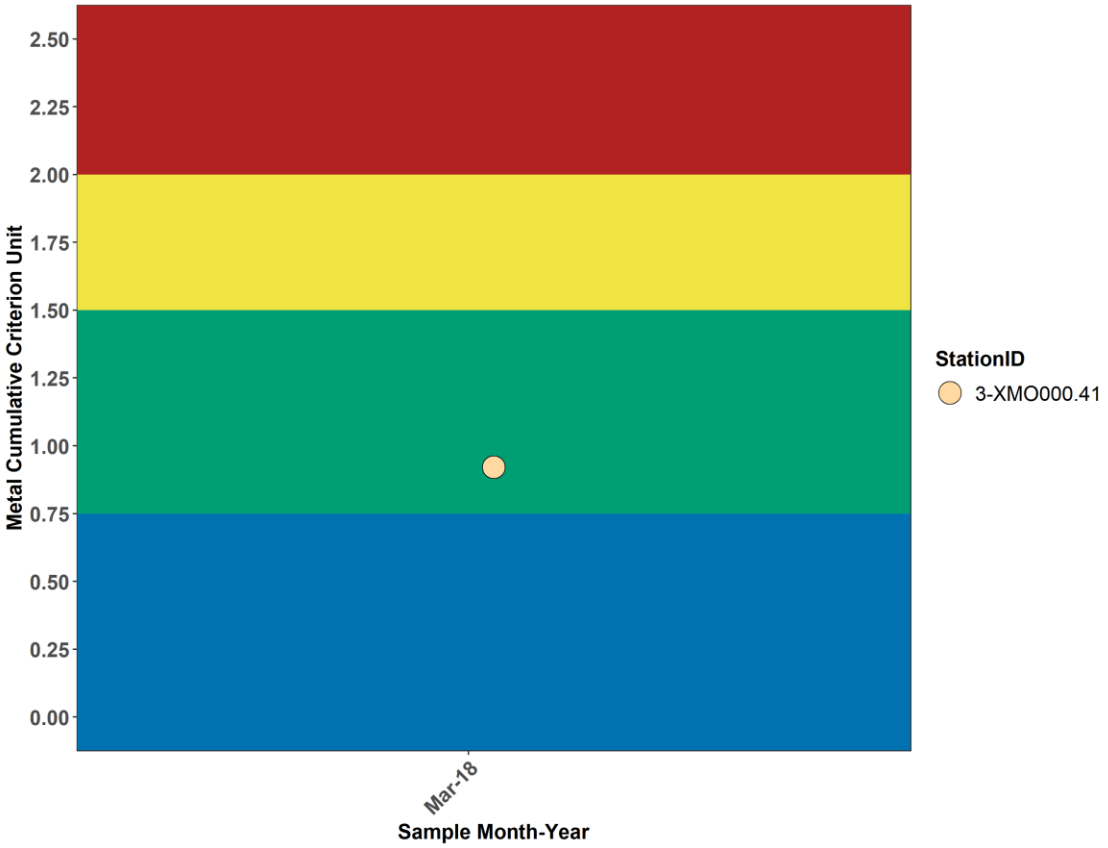

Figure 19-32. Metals CCU Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

This single sample indicates a low probability of stress.

19.9.1.3 *Flat Run*

No data was available in Flat Run for dissolved metals

19.9.2 Individual Water Quality Criteria

A suite of dissolved metals were sampled at four stations in the watershed from 2018-2020. The measurements were compared to each of their applicable freshwater aquatic life water quality criteria (Table 6-5 - Table 6-12). With the exception of arsenic, chromium VI and selenium water quality criteria for dissolved metals are hardness dependent with the criteria formulas allowing a minimum and maximum hardness of 25 mg/L as CaCO3 and 400 mg/L as CaCO3, respectfully. Therefore, using hardness data from each sampling event, criteria were calculated for each metal sampling event.

Values shown for chromium are in the total dissolved form because DEQ monitoring does not differentiate the results into valence states. Chromium primarily occurs in the environment in two valence states, chromium III and chromium VI (USEPA, 2000b). Because Virginia's WQS for chromium are based on the different valence states, the monitoring results for total dissolved chromium were compared to criteria for the two valence states. However, because it is highly unlikely for one valence state to dominate the total dissolved sample, the comparison should be considered with caution.

Comparison of the measured values against the applicable freshwater quality criteria showed no exceedances at any of the stations where data was collected.

19.9.2.1 *Mainstem Mountain Run*

Table 19-5. Dissolved Metals Measurements Collected from 3-MTN005.79 on September 23, 2020[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.4	340	150
Cadmium	0.1	1.5	0.6
Chromium[c]	0.3	489.1 (III) / 16 (VI)	63.6 (III) / 11 (VI)
Copper	1.36	11.3	7.6
Lead	0.02	76.7	8.7
Nickel	0.4	155.8	17.3
Selenium	0.11	20	5
Silver	0.004	2.5	-
Zinc	0.71	100.1	100.9

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 83 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A ”-“ indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

Table 19-6. Dissolved Metals Measurements Collected from 3-MTN005.79 on September 30, 2020[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.7	340	150
Cadmium	0.1	0.9	0.4
Chromium[c]	0.3	323 (III) / 16 (VI)	42 (III) / 11 (VI)
Copper	2.86	7.0	5.0
Lead	0.05	43.9	5.0
Nickel	0.67	101.5	11.3
Selenium	0.14	20	5
Silver	0.004	1.0	-
Zinc	0.95	65.1	65.7

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 50 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A ”-“ indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

Table 19-7. Dissolved Metals Measurements Collected from 3-MTN014.88 on September 23, 2020[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.4	340	150
Cadmium	0.1	1.6	0.6
Chromium[c]	0.3	508.3 (III) / 16 (VI)	66.1 (III) / 11 (VI)
Copper	1.36	11.8	8.0
Lead	0.02	80.8	9.2
Nickel	0.4	162.1	18.0
Selenium	0.11	20	5
Silver	0.004	2.7	-
Zinc	0.71	104.1	105.0

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 87 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A ”-“ indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

Table 19-8. Dissolved Metals Measurements Collected from 3-MTN014.88 on September 30, 2020[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.7	340	150
Cadmium	0.1	1.0	0.5
Chromium[c]	0.3	344 (III) / 16 (VI)	44.7 (III) / 11 (VI)
Copper	2.86	7.5	5.3
Lead	0.05	47.8	5.4
Nickel	0.67	108.3	12.0
Selenium	0.14	20	5
Silver	0.004	1.2	-
Zinc	0.95	69.5	70.1

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 54 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A ”-“ indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

Table 19-9. Dissolved Metals Measurements Collected from 3-MTN021.11 on September 3, 2019[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.5	340	150
Cadmium	0.1	0.9	0.4
Chromium[c]	0.59	312.3 (III) / 16 (VI)	40.6 (III) / 11 (VI)
Copper	1.6	6.7	4.8
Lead	0.1	41.9	4.8
Nickel	0.33	98.0	10.9
Selenium	0.3	20	5
Silver	0.02	1.0	-
Zinc	0.85	62.9	63.4

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 48 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A ”-“ indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

Table 19-10. Dissolved Metals Measurements Collected from 3-MTN021.11 on September 23, 2020[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.33	340	150
Cadmium	0.1	0.9	0.4
Chromium[c]	0.3	312.3 (III) / 16 (VI)	40.6 (III) / 11 (VI)
Copper	0.94	6.7	4.8
Lead	0.02	41.9	4.8
Nickel	0.25	98.0	10.9
Selenium	0.14	20	5
Silver	0.004	1.0	-
Zinc	0.16	62.9	63.4

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 48 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A ”-“ indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

Table 19-11. Dissolved Metals Measurements Collected from 3-MTN021.11 on September 30, 2020[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.58	340	150
Cadmium	0.1	0.7	0.3
Chromium[c]	0.3	235.5 (III) / 16 (VI)	30.6 (III) / 11 (VI)
Copper	1.56	4.9	3.6
Lead	0.03	28.6	3.2
Nickel	0.34	73.2	8.1
Selenium	0.11	20	5
Silver	0.004	0.5	-
Zinc	0.46	47.0	47.4

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 34 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A ”-“ indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

19.9.2.2 *Jonas Run and the unnamed tributary to Jonas Run*

Table 19-12. Dissolved Metals Measurements Collected from 3-XMO000.41 on March 13, 2018[a,b]

Parameter (Dissolved)	Value (µg/L)	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Arsenic	0.2	340	150
Cadmium	0.2	0.7	0.3
Chromium[c]	0.3	258 (III) / 16 (VI)	33.6 (III) / 11 (VI)
Copper	0.56	5.4	3.9
Lead	0.2	32.3	3.7
Nickel	0.2	80.4	8.9
Selenium	0.4	20	5
Silver	0.02	0.7	-
Zinc	0.4	51.6	52.0

[a] Corresponding calculated acute and criteria freshwater criteria shown. The measured hardness value was 34 mg/L, $CaCO_3$ calculated as dissolved, which was used in the criteria calculations.

[b] A "-" indicates there is no criteria for that parameter.

[c] Chromium was measured as total dissolved with no distinction among the valent forms, Cr III and Cr VI.

19.9.2.3 *Flat Run*

No data was available in Flat Run for dissolved metals

19.10 Temperature

Benthic macroinvertebrates require a suitable instream temperature range to persist in the environment. According to the Virginia WQS, Class III Nontidal Waters (Coastal and Piedmont Zones) streams cannot have temperatures exceeding 32°C (9VAC25-260-50).

19.10.1 Mainstem Mountain Run

In the impaired portion of Mountain Run samples for Temperature used in this analysis were collected between 2015 and 2020. Temperature measurements along Mountain Run ranged from 0.73 - 27.94 with a median value of 13.84 and an average value of 14.62 (n=124) (Figure 6-33).

At the downstream most monitoring station near the confluence with the Rappahannock River, 3-MTN000.59, the average and median Temperature were 14.61 and 14.29 respectively (n=56).

Located 5.2 river miles above the downstream most station, at station 3-MTN005.79, the average and median values for Temperature were 12.71 and 10.79 respectively (n=22).

Approximately 9.1 river miles upstream of the station above and 6.2 river miles below the upstream most station, at monitoring station 3-MTN014.88, the average and median Temperature were 15.76 and 14.89 respectively (n=24).

At the upstream most monitoring station, 3-MTN021.11, the average and median Temperature were 15.31 and 15.56, respectively (n=22).

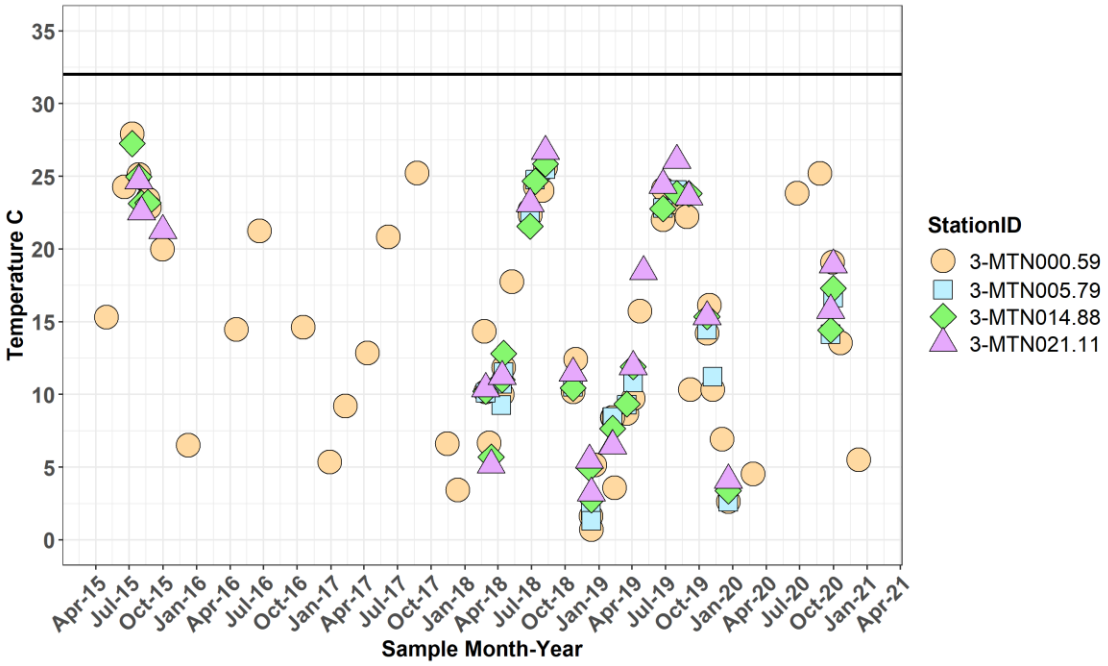

Figure 19-33. Temperature Measurements in Mountain Run

The black line at 32° C shown in Figure 6-33 represents the water quality criterion for Temperature. All data measured were below the water quality criteria.

19.10.2 Jonas Run and the unnamed tributary to Jonas Run

In the impaired portion of Jonas Run and the unnamed tributary to Jonas Run samples for Temperature used in this analysis were collected between 2018 and 2020. Temperature measurements along Jonas Run and the unnamed tributary to Jonas Run ranged from 1.76 - 25.39 with a median value of 10.76 and an average value of 13.54 (n=21) (Figure 6-34).

At the Jonas Run monitoring station near the confluence with Mountain Run, 3-JOA000.80, the average and median Temperature were 14.24 and 12.38 respectively (n=19).

Further upstream on the unnamed tributary to Jonas Run just below Rt. 685 at station 3-XMO000.41, the average and median Temperature were 6.96 and 6.96 respectively (n=2).

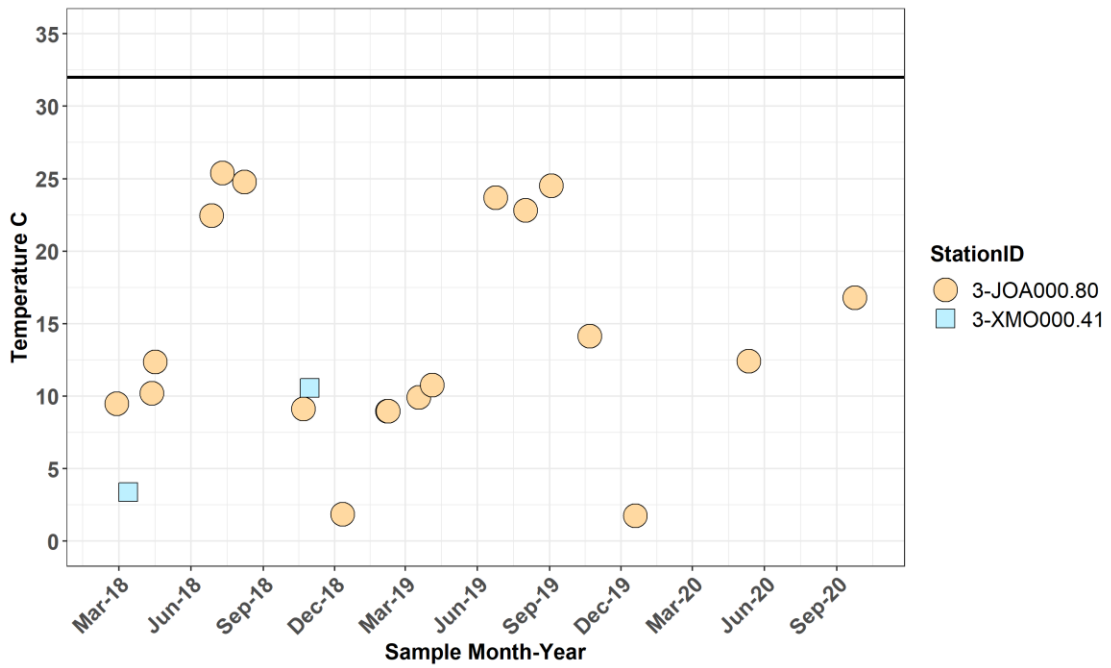

Figure 19-34. Temperature Measurements in Jonas Run and the Unnamed Tributary to Jonas Run

The black line at 32° C shown in Figure 6-34 represents the water quality criterion for Temperature. All data measured were below the water quality criteria.

19.10.3 Flat Run

In the potentially impaired portions of Flat Run samples for Temperature used in this analysis were collected between 2018 and 2020. Temperature measurements along Flat Run ranged from 1.47 - 25.02 with a median value of 11.97 and an average value of 13.61 (n=17) (Figure 6-35).

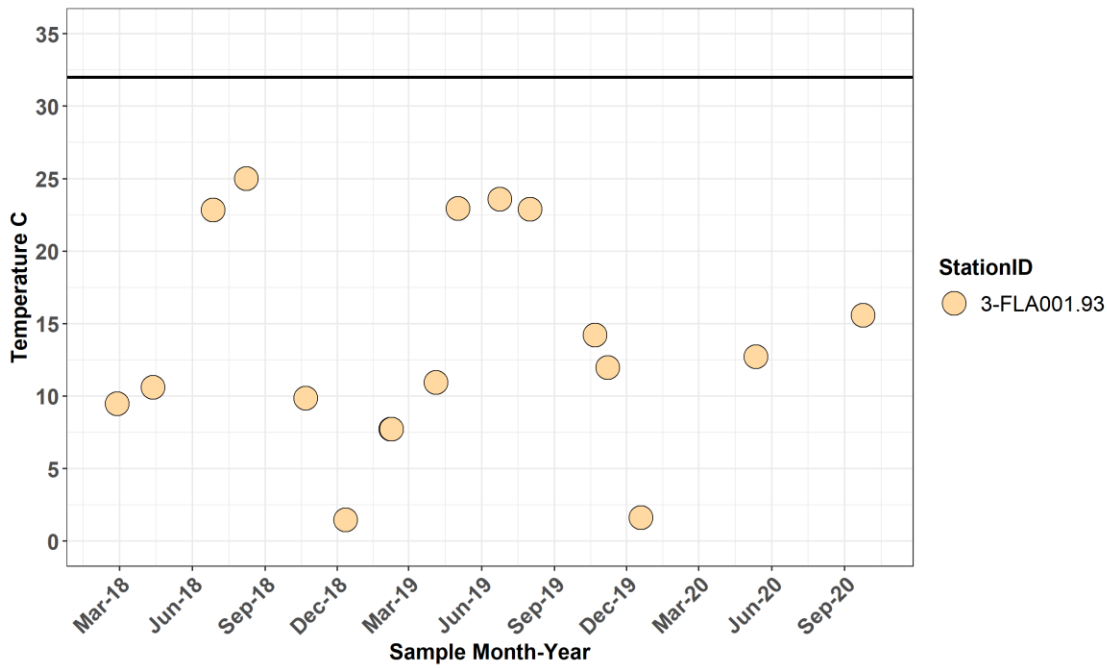

Figure 19-35. Temperature Measurements in Flat Run

The black line at 32° C shown in Figure 6-35 represents the water quality criterion for Temperature. All data measured were below the water quality criteria.

19.11 Summary of Stressor Threshold Comparisons

A summary of the comparison of data to stressor threshold values, where developed, is provided in Table 6-13 - Table 6-15 below. Based on the median values, the tables identifies whether the comparison to applicable stressor threshold values indicated there was either no probability (blue background), low probability (green background), medium probability (yellow background) or high probability (red background) that a particular candidate has potential to cause stress to the benthic macroinvertebrate community.

19.11.1 Mainstem Mountain Run

Table 19-13. Summary of Stressor Analysis Results for Mountain Run

Station ID	pH	DO	Total Nitrogen	Total Phosphorus	Total Habitat	LRBS	Metals CCU	Specific Conductance	TDS	Sulfate	Chloride	Potassium	Sodium
3-MTN000.59	7.28	9.165	1.245	0.06	118			200.5	122	18.7	16.9	3.43	9.94
3-MTN005.79	7.4	10.64	1.28	0.05	125.5		0.6951	206	134	20.8	19.6	3.39	12.1
3-MTN014.88	7.41	9.01	1.195	0.04	121.5		0.6602	246	124	19.7	25.95	3.835	14.55
3-MTN021.11	7.29	9.22	1.02	0.04	124	-0.254509973	0.7725	122	75	4.86	13.3	2.827	6.255

For the mainstem Mountain Run probable stressors include total nitrogen, total habitat and potassium. Possible stressors include total phosphorus, chloride and sodium.

19.11.2 Jonas Run and the Unnamed Tributary to Jonas Run

Table 19-14. Summary of Stressor Analysis Results for Jonas Run and the Unnamed Tributary to Jonas Run

Station ID	pH	DO	Total Nitrogen	Total Phosphorus	Total Habitat	LRBS	Metals CCU	Specific Conductance	TDS	Sulfate	Chloride	Potassium	Sodium
3-JOA000.80	7.685	11.8	1.935	0.03	116			190	123.5	16.95	13.25	2.175	7.51
3-XMO000.41	6.66	11.54	1.915	0.065	101	0.418616	0.9218	133.5	67	7.22	11.4	1.7	3.56

In Jonas Run and the unnamed tributary to Jonas Run total nitrogen and total habitat are probable stressors while total phosphorus and potassium are possible stressors.

19.11.3 Flat Run

Table 19-15. Summary of Stressor Analysis Results for Flat Run

Station ID	pH	DO	Total Nitrogen	Total Phosphorus	Total Habitat	LRBS	Metals CCU	Specific Conductance	TDS	Sulfate	Chloride	Potassium	Sodium
3-FLA001.93	7.22	8.62	1.445	0.09	73			212	134	26.3	11.65	2.435	8.15

In Flat Run total nitrogen, total phosphorus, total habitat, sulfate and potassium are probable stressors.

20.0 BENTHIC STRESSOR ANALYSIS CONCLUSIONS

From the results of the stressor analysis, the potential of each candidate stressor to cause stress and lead to an impaired benthic community was identified. Each candidate stressor was categorized as either a non-stressor, possible stressor, or probable stressor to the benthic macroinvertebrate community (Table 7-1). For this project, categorization of each stressor was considered at the watershed level versus at the level of the three sub-watersheds as a straight to implementation approach is being sought and not TMDL development for one or more of the identified probable stressors. Stressors where the median value from at least one station in all three sub-watersheds evaluated fell into medium or high probability of stress category are listed as probable stressors. Stressors where the median value from at least one station in at least one of the three sub-watersheds evaluated fell into medium or high probability of stress category are listed as possible stressors. All other stressors are listed as non-stressors.

Table 20-1. Non-Stressors, Possible Stressors and Probable Stressors in the Mountain Run Watershed

Non-Stressors	Possible Stressors	Probable Stressors
▪ Ammonia ▪ Dissolved Oxygen ▪ Dissolved Metals ▪ pH ▪ Specific Conductance ▪ Temperature ▪ Total Dissolved Solids	▪ Chloride ▪ Sodium ▪ Sulfate	▪ Potassium ▪ Total Habitat ▪ Total Nitrogen ▪ Total Phosphorus

20.1 Probable Stressors

20.1.1 Potassium

Median potassium values fell into the medium probability of stress to aquatic life at all stations in the watershed except at station 3-XMO000.41 where only a single value was recorded. In mainstem Mountain Run the measurements trended higher at the further downstream stations. While potassium is not a specific stressor considered in the BCG, macroinvertebrates with high tolerance to specific conductance (a measure of how well water can conduct an electrical current based on the amount of ions in water) are present indicating stress due to ions such as potassium.

20.1.2 Total Habitat

Habitat conditions were found to be marginal based on the median total habitat values at all of the stations in the watershed except at station 3-FLA001.93 on Flat Run where conditions were found to be poor for all four total measurements taken. While the total habitat metric is used in the analysis to evaluate stress to the benthic community, the individual components that make up the habitat metric provide more detail on the specific stressors. The bank stability, bank vegetation, embeddedness, riparian vegetation and sediment components were often in the marginal range (5-10) when the visual habitat assessment was performed at stations in the watershed. These scores generally indicate that the riparian corridor is highly impacted, provides conditions that favor erosion of the banks, instability of the stream channel, and the presence of deposited sediment.

20.1.3 Total Nitrogen

Median total nitrogen values fell into the medium probability of stress to aquatic life at all stations in the watershed. The median values for all stations are also above the USEPA published recommended total nitrogen criteria based on ecoregion (USEPA, 2000a) of 0.69 mg/L.

20.1.4 Total Phosphorus

Median total phosphorus values fell into the medium probability of stress to aquatic life at three stations, one each in the three sub-watersheds. The median values for these three stations are also above the USEPA published recommended total nitrogen criteria based on ecoregion (USEPA, 2000a) of 0.04 mg/L.

20.2 Recommendation for Addressing Probable Stressors

As discussed in the introduction to this report, this BSA was developed in conjunction with the Mountain Run, Muddy Run and Lower Hazel River Implementation Plan (IP) to support an approach aimed to achieve co-benefits through implementing BMPs that address more than one pollutant. Accordingly, DEQ recommends that a “straight to implementation” approach be pursued to address the probable stressors to the benthic community in the Mountain Run watershed. Additionally, DEQ recommends that the streams impaired due to an unhealthy benthic community identified in this BSA be re-categorized in the next 305(b)/303(d) Water Quality Assessment Integrated Report from 5A to 5R, as the implementation of the IP is expected to result in attainment.

DEQ will prioritize follow-up monitoring, of both the water quality and benthic macroinvertebrates, to identify if the selected approach to address this impairment is leading towards a healthier benthic community. This monitoring will occur following DEQ’s monitoring protocols for implementation plans that address benthic impairments. The general framework is that once monitoring shows water quality improvements, monitoring of the benthic macroinvertebrates will follow to identify if the benthic community is responding in a positive manner. Should follow-up monitoring identify that the health of the benthic community is not improving, despite reductions of the probable stressors identified as causing stress, further investigation of causes of stress to the impaired benthic community may be warranted.

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