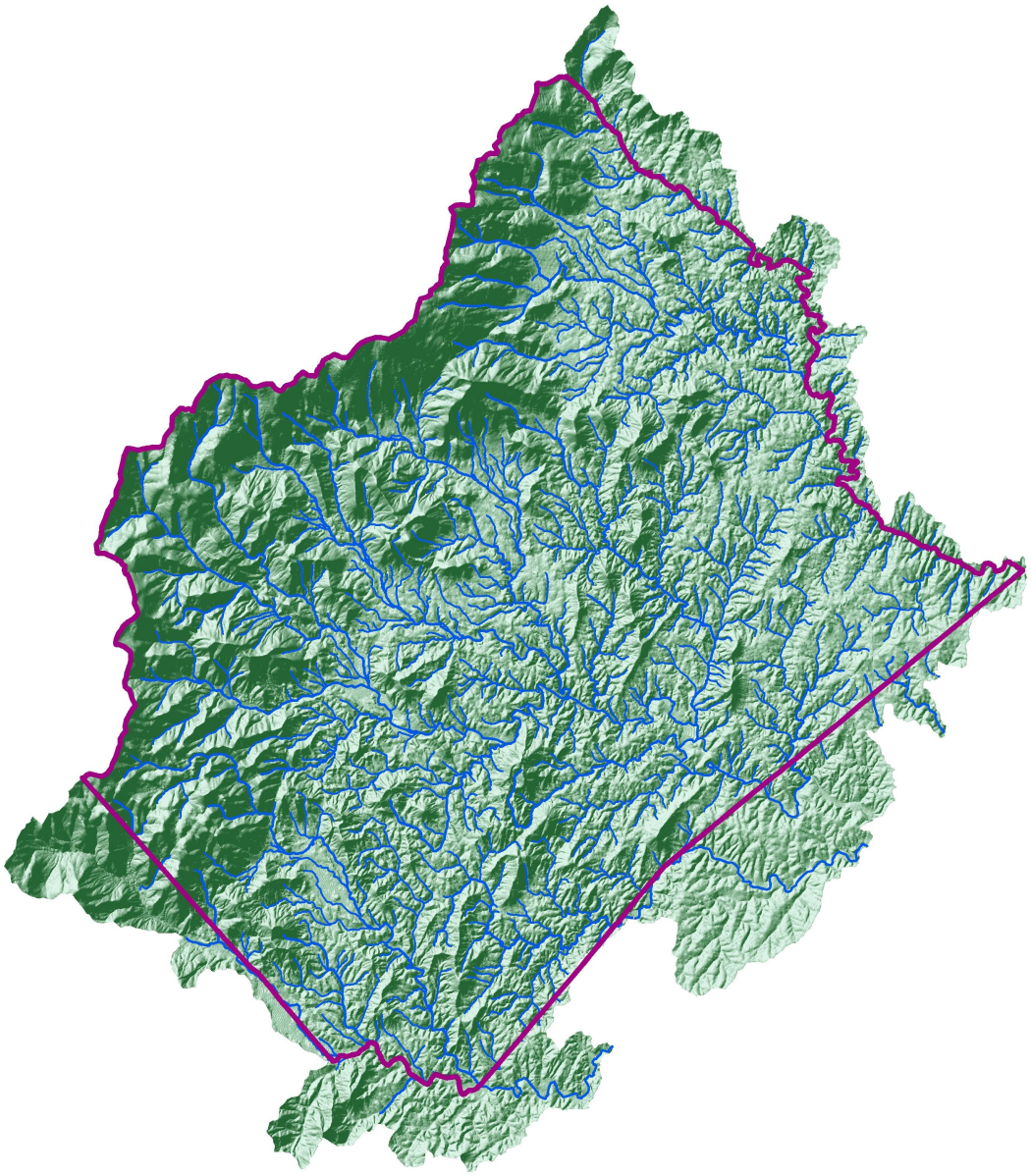
Assessing the health and protection of watersheds in
Rappahannock County, Virginia:

People, Land and Water at the Headwaters of the Upper Rappahannock River Basin

Photo by Chris Russell



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October 10, 2008

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Acknowledgements

This work was accomplished by volunteer citizen efforts, with financial help from several agencies and individual donors. Costs were covered in part by grants # 2006-0100-001 and 2005-0001-039 from the National Fish and Wildlife Foundation's Chesapeake Bay Small Watershed grant program; and a grant from the Rappahannock-Rapidan Planning District Commission and Virginia DCR (2005).

RappFLOW[1] is a not-for-profit, grassroots, citizen-based organization whose work is accomplished by volunteers trained primarily by the Culpeper Soil & Water Conservation District. Many individuals and organizations contributed in a variety of ways to the work reported in this document. Greg Wichelns, Manager of the Culpeper Soil & Water Conservation District, has provided hundreds of hours of technical assistance, guidance and training in stormwater management, landscape and stream buffer assessment, water quality, erosion & sedimentation control, and many other technical topics.

John McCarthy, County Administrator, provided guidance and data on public policy, local and state regulatory issues, zoning, ordinances, and public outreach. Members of the County Board of Supervisors and the Planning Commission provided ongoing encouragement and guidance and suggestions for the ongoing research. County leaders who have encouraged and inspired this work over the years include Bob Anderson, Chairman of the Board of Supervisors, and his predecessor Pete Estes who shared with us his reverence for our county's land, history and rivers. Charley Strittmatter, Chair of the Planning Commission, was part of the strategic planning group that challenged RappFLOW to produce a scientifically defensible description of the watersheds. Tom Tepper (Planning Commission), Bryant Lee (Board of Supervisors), Kenner Love (Agricultural Extension), Medge Carter (Dept of Health) and Reid Folsom (Agricultural consultant) have all contributed to this work in several ways over the past several years, including their participation in the County Water Quality Advisory Committee.

Ron Vickers, teacher at Rappahannock County High School (RCHS), with encouragement from the school system administration and the Virginia Department of Education, and professional assistance of Beverly Hunter, has trained dozens of students in technical skills related to the spatial analysis and mapping used in this work. Several RCHS students, notably Larry Oliver, Chris Mitchell, Donovan Zeh, Joshua Makela, Forrest Marquisee, John Mellow, Justin Fitzmorris, and Zach Herbert contributed to team projects or worked as summer GIS interns, helping to produce the maps and data provided with this report.

Several farmers in the County, especially Cliff Miller, Chris Parrish, Monira Rifaat, Elizabeth Haskell, Bryant Lee, and Robert Anderson helped in understanding factors affecting local agriculture and land management practices. Cliff Miller has generously contributed the use of his property for training of water quality monitors, public outreach activities, stream buffer restoration projects, and water quality studies.

Sarah Gannon, formerly with the Piedmont Environmental Council, and Jill Keihn a biologist from Page County, helped to devise the subwatershed delineation and assessment methods. Scientists at the Center for Watershed Protection assisted in developing our methodology. Tim Bondelid, a professional hydrographer, has provided technical assistance in data analysis and the use of the National Hydrographic Dataset, as well as research and interpretation of scientific literature. Brett Valentine, President of RappFLOW and a soils scientist with Fauquier County, interpreted soils data. Jenny Fitzhugh gathered and organized dozens of documents for

research and public education on topics of this report. Hal Hunter helped find and acquire data, handled logistical and administrative tasks, provided financial support, collaborated with partner organizations, and conducted research on easements and other conservation tools. Pam Owen of the Rappahannock League for Environmental Protection's Biodiversity Task Force organized educational opportunities that help to inform the ecological perspective.

Kenny Giles, Christina Loock, and Louise Bondelid provided training and leadership for water quality monitoring volunteers, in cooperation with the CSWCD. Several individuals in the Virginia Departments of Environmental Quality (DEQ), Conservation & Recreation (DCR), and Forestry (DOF), and the Rappahannock-Rapidan Regional Commission (RRRC) have provided technical assistance, data, information on regulatory matters, and assistance in obtaining grant support for the work. These include most notably James Beckley and Bryant Thomas (DEQ), Mike Santucci (DOF), May Sligh (DCR), and Jeff Walker (RRRC). Several agencies have provided ongoing updates to key data sources, including the Virginia Outdoors Foundation (VOF), DCR, and DEQ and Trout Unlimited.

Todd Benson, John McCarthy, Dick McNear, Monira Rifaat, Brett Valentine, and Greg Wichelns all reviewed drafts of this report, but the author takes responsibility for any inaccuracies herein.

Fish Survey on Thornton River Photo by Richard Lykes

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1 Executive Summary

This report summarizes the results of a four-year project to describe the watersheds of Rappahannock County, Virginia. It is written for landowners and residents, to assist in continuing efforts to preserve, protect, conserve, and restore water resources and watersheds of Rappahannock and neighboring counties.

Rappahannock County thus far has avoided major watershed problems that have resulted in other localities from rapid, dense development. Protecting watersheds from future degradation and vulnerability is far less costly than restoring them after damage has been done. Therefore, this study focuses primarily on factors that contribute to protecting our watersheds from future damage, as well as sources of present vulnerability.

The local government provides protection for the watersheds through its Comprehensive Land Use Plan and its enforcement of state and local ordinances including Zoning, Subdivision, Stream Buffer Protection Overlay of Zoning, Erosion & Sedimentation Control, Biosolids, Stormwater Management; and the Land Use taxation, Farmland Preservation, and Agricultural/Forestal Districts Programs.

Subwatersheds

The health and condition of a stream is a direct reflection of the health of its surrounding watershed. Nearly every subwatershed in the County drains to one of four river segments that have been designated as "impaired" by the Virginia Department of Environmental Quality. The water in those river segments has exceeded Federal standards for levels of certain bacteria. High bacteria levels are an indicator of other types of contamination. However, the subwatersheds vary in the extent to which they contribute to contamination of streams.

We divided the County into 26 subwatersheds, based on topography and other considerations. The main purposes for dividing into subwatersheds are to:

- assist landowners in understanding the watershed conditions in their own localities.
- identify areas that are the least well protected, so that high-priority efforts can be given to improvement in those areas by local landowners and conservation organizations.
- study in more detail smaller areas than an entire county.

Factors Used to Assess Watershed Health and Protection

We applied the following factors in a systematic way to assess and compare the extent to which subwatersheds within and adjacent to this County are protected: Shenandoah National Park; Conservation Easements; Forested Land Cover; Stream Buffer Vegetation; Zoning; and Soil Erodibility. Maps 2 – 12 show the distribution of these protection factors across the County.

The result of this model is depicted in Map 13: Subwatershed Protection Assessment. The least-protected (most vulnerable) subwatersheds are White Walnut Run, Upper Battle Run, Lower Rush, Hawkins Run, Indian Run Hazel, and Covington. The subwatersheds that rank highest (most well protected) include Upper North Fork, Piney, South Fork Thornton, Keyser Run, and Upper Rush.

Additional factors affecting the protection or vulnerability of watersheds in our particular area include future development, changing patterns of temperature and precipitation due to global climate change, over 400 miles of private roads and driveways; road/stream crossings; residential

landscaping and land management practices; agricultural and forestry land management practices; sewage treatment plant effluent discharge to streams; private septic systems; and future development patterns. Of these, agricultural land management is the most significant variable that can be improved or mitigated – specifically the use of best management practices to protect stream buffer vegetation on pastures. Pastures account for over ninety percent of the bacterial contamination of the designated impaired streams.

Landowner Concerns and Values

Landowners' greatest water-related concerns include quality of well water, adequate supply of good drinking water, and bacterial contamination of streams. The greatest threats perceived by landowners to their watershed include subdivision of land parcels, population growth, and sewage treatment plant discharges to streams. Over ninety percent of landowners support expenditures of public money on watershed protection and restoration. Groups of landowners in several subwatersheds have demonstrated strong commitment to protecting their streams through their participation in public forums and other community actions. Several non-profit organizations and volunteer groups have as part of their missions the conservation, preservation and protection of environmental, cultural, ecological or economic aspects of our watersheds.

Indicators of Water Quality and Quantity

To assess the quality of surface water in the 755 miles of streams and 540 acres of ponds in the County, there are only a few sources of data, and these provide information regarding water quality in a small sample of locations. The sources include the following:

- There are four stream segments designated 303d "Impaired" for Ecoli by the DEQ.
- Countywide, there are about 12 DEQ ambient monitoring stations, although not all are currently active. See Map 16.
- There are currently 8 locations where citizens monitor the macroinvertebrates.
- Some streams are classified by the Virginia Department of Game and Inland Fisheries as coldwater or trout streams, within subwatersheds designated by Trout Unlimited as Brook Trout Protection Area.
- RappFLOW volunteers have sampled chemical and biological water quality in selected locations, in spring 2005 and in summer 2006.
- There is one USGS streamflow gage, in Laurel Mills.
- There are no groundwater monitoring stations in the county.

Further Questions

Future studies might address questions in the following areas: water quality; precipitation and stream flow; effects of climate change; groundwater patterns and trends; biological indicators; environmental services; incentives for agricultural landowners; and sustainable forestry.

Suggested Goals

Individuals, groups of landowners within subwatersheds, and other organizations may wish to consider the following goals as the most likely ways to help restore and provide greater protection for the future.

Goal 1: Increase monitoring of water quality, water quantity, and other indicators of watershed health, and make this information continually accessible to the community.

Goal 2: Increase the percentage of 100-foot riparian buffer zone that is managed to provide protection for streams, from the present 62% to 80%.

Goal 3: Increase the percentage of privately held land in easement from the present 20% to 40%.

Recommendations

1) Expand existing water monitoring programs and to establish and operate new programs of data collection, analysis, and reporting beyond those currently in place through state and volunteer activities.

2) Find new and additional incentives to assist farmers in implementing Best Management Practices on hayfields and pastures, in particular to improve vegetative buffers along the streams. This is likely have the most impact on increasing the protection of watersheds.

3) Focus resources and priorities for watershed improvement on the least-protected subwatersheds.

2 Introduction

This report is written for landowners and residents, to assist in their continuing efforts to preserve, protect, conserve, and restore water resources and watersheds of Rappahannock and neighboring counties in Virginia.

2.1 Purposes of this work

The purpose of the work reported here is to describe the watersheds of Rappahannock County in a scientifically defensible way, drawing upon all available data. By having an accurate understanding of the health and vulnerabilities of the watershed, citizens can target their efforts for improvement in a more cost-effective way.

The questions we addressed are the following:

- What do Rappahannock County's residents and landowners most value about the health of their watersheds?
- In what ways do landowner decisions and public policy contribute to the health and protection of our watersheds, and the quantity and quality of water in Rappahannock County?
- What makes our watersheds vulnerable?
- What factors contribute to the health and protection of our watersheds?
- Where in our County are the most-protected and least-protected subwatersheds?
- In general, how well protected are the watersheds of the County?
- In what ways does our local government and the Commonwealth help in protecting our watersheds?
- What data and methods are available to help make these assessments?

These were the initial questions that RappFLOW volunteers and our partner organizations attempted to answer in the studies that are reported in this document.

This report is intended to accomplish the following:

- summarize what has been learned to date with regard to the above questions
- identify questions for further inquiry
- suggest goals for improved protection, especially of the least-protected subwatersheds

Why is this information useful?

This information can help landowners, the general public, nonprofit organizations, and the leaders of the County decide on ways to improve watershed protection through individual landowner practices, through efforts of community organizations or groups of landowners within a subwatershed, or through public policy. Collectively, these actions will reduce the amount of sediments, nutrients, and contaminants entering streams, ponds, and groundwater. Healthier watersheds mean healthier habitats for humans, farm animals, pets, and wildlife. Increased watershed protection will also result in less severe flooding, better ground water supply through reduced stormwater runoff, improved water quality in the Upper Rappahannock River Basin, and, indirectly, improved water quality in the Chesapeake Bay.

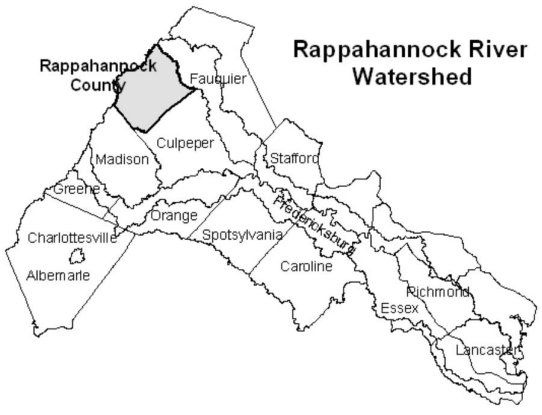
This project addresses goals of the Chesapeake 2000 Agreement, Rappahannock River Basin Tributary Strategy, and Rappahannock County Comprehensive Plan. The project addresses these commitments in the *Chesapeake 2000 Agreement*: 1) Preserve, protect, and restore those habitats

and natural areas that are vital to the survival and diversity of the living resources of the Bay and its rivers; 2) Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health; 3) Develop, promote, and achieve sound land use practices which protect and restore watershed resources and water quality, maintain reduced pollutant loadings for the Bay and its tributaries, and restore and preserve aquatic living resources; and 4) Promote individual stewardship and assist individuals, community-based organizations, businesses, local governments, and schools to undertake initiatives to achieve the goals and commitments of the agreement.

This work supports the Rappahannock River Tributary Strategy in several ways, especially by placing a high value on vegetated stream buffers in our assessment of watershed health and protection. According to the Tributary Strategy, "The 100-foot buffer area … is deemed to achieve at least 75 percent reduction of sediments and a 40 percent reduction of nutrients."[2] Among the Rappahannock Tributary Strategy goals for improving water quality and habitat by the year 2010 are: reduction in nutrient and sediment loading, addressing chronic erosion and stream bank instability in the western Rappahannock basin, and implementing the CREP program basin-wide. The Rappahannock County allocations for the Tributary Strategy "Input Deck" in 2005 provided provisional goals for 2010 for forestry, agricultural, and urban/suburban Best Management Practices (BMP's) with respect to riparian forested buffers and hence reductions in erosion, sedimentation, nutrients, biological impairments and other contamination. The Tributary Strategy for Rappahannock County called for an increase by the year 2010 from 972 to 1,704 acres of forested buffer area in agricultural BMPs, and establishment of 908 acres of forested buffers in suburban BMPs.

This work supports the Rappahannock County Comprehensive Plan in several ways as discussed in Section 7 of this report. Information developed from this project was used to assist in the drafting of the Stormwater Management Ordinance and Stream Buffer Overlay District of the Zoning Ordinance. RappFLOW provides ongoing findings from the study to the County's Water Quality Advisory Committee, the Board of Supervisors, the Planning Commission, to nonprofit organizations, and to the general public through the website www.rappflow.org and articles in the local newspaper and public workshops.

2.2 Overview of Rappahannock County's People, Land, and Water.



Our rural County (population about 7,000) is at the headwaters of the Upper Rappahannock River Basin, and covers an area of about 267 square miles (170,880 acres). The county seat, the Town of Washington, is about 65 miles west of Washington, D.C. and 120 miles NW of Richmond. The NW boundary is in the Blue Ridge Mountains. The Rappahannock River forms the NE boundary with Fauquier County. Altitudes range from about 3,700 feet above sea level in the Blue Ridge, to the lowest point at 360 feet near the Culpeper County border. Most of the County's topography can be classified as having steep or rolling hillsides. See Map 1: Elevation Contours. The county is located in the Headwaters of the Rappahannock River Watershed, meaning that we are the beginning, the uppermost reaches of the Rappahannock

River. All streams in the County eventually drain to the Rappahannock River. All our surface water originates from rainwater – no streams come down to our county from anyplace upstream, because all streams originate here. Seven hundred and fifty-five (755) stream miles, many on steep slopes, crisscross our rural landscape. There are approximately 576 ponds totaling about 540 acres in area, and about 712 acres of wetlands.[3] Drinking water for 96 % of residents comes from private wells, springs or streams. Segments of four of our major streams are designated 303(d) impaired by the VA DEQ.[4]

2.3 Watershed Protection versus Watershed Restoration

In reviewing watershed assessments from areas where a high degree of development has taken place[5], it becomes obvious that protecting watersheds from degradation and vulnerability is far less costly than restoring them after damage has been done. Rappahannock County thus far has avoided major problems that typically result from development.[6] Therefore, this study focuses primarily on factors that contribute to protecting our watersheds from future damage, as well as identifying sources of current vulnerability.[7]

3 What factors can we use to assess the health and protection of our watersheds?

The quality of water in the streams is a reflection of the health of the surrounding watershed. Nearly every subwatershed in the County drains to one of four river segments that have been designated as "impaired" by the Virginia Department of Environmental Quality. The water in those river segments has exceeded Federal standards for levels of certain bacteria. High bacteria levels are an indicator of other types of contamination such as nutrients and sediments. However, subwatersheds vary in the extent to which they contribute to contamination of streams.

Many factors contribute to the health and protection of watersheds – from the ways in which individual landowners use and manage their lands, to naturally-occurring topography, soils, and vegetation, to public policies and other legal and regulatory tools. The following are the six factors we used to assess and compare the extent to which subwatersheds within and adjacent to this County are "protected", within the context of the larger natural and human and policy factors.

3.1 Shenandoah National Park (SNP)

The SNP provides permanent Federal government protection of 31,700 forested acres within the county's land area – about 18.5 percent. This provides the highest level of protection available to land in this county, both in terms of legal protection and forest land cover. See Map 2: Percent of Land in Shenandoah National Park.

3.2 Conservation Easements.

Easements help to protect against subdivision of land parcels and the fragmentation of forest land that typically results from subdivision. Over 19 percent of privately owned land in the County is under permanent conservation easement with the Virginia Outdoors Foundation. Subwatersheds in the County vary in terms of the percentage of land in easement. Several local organizations, including the County government, Rappahannock County Conservation Alliance (RCCA), the Krebser Fund, and Piedmont Environmental Council (PEC), have proactive programs to encourage conservation and farmland preservation through easement donation and purchase of development rights. See Map 3: Percentage of Land in VOF Easement.

3.3 Land Cover.

"Land cover" is a way of categorizing what is covering the land. Land cover dramatically affects

what happens to raindrops when they hit the earth. Major categories include: water; developed (e.g asphalt, buildings); barren (e.g bare soil, forest clearcuts); forested upland; shrubland; non-natural woody (e.g. vineyards); herbaceous upland (e.g. upland grasses); planted/cultivated (e.g. pasture, hay, lawns); wetlands.[8] Nearly 69 percent of the County's land cover is deciduous, mixed, or coniferous forest. Pasture, hay, and crops account for nearly 30 percent of land cover, and less than one percent of land cover is "developed" low density residential or commercial. We used the National Land Cover Database[9] to assess land cover, in combination with aerial photos. See Map 4: National Land Cover Data and.Map 5: Percentage of Land in Forest Cover.

3.4 Forested Stream Buffers.

Scientific research has shown that the vegetation in a 100-foot buffer area along the streams serves many important functions for protecting the quality of surface water and groundwater, recharging groundwater, and providing a corridor of habitat protection for wildlife.[10] According to the Rappahannock Tributary Strategy, "The 100-foot buffer area … is deemed to achieve at least 75 percent reduction of sediments and a 40 percent reduction of nutrients." This is especially the case in Rappahannock County, where we have many miles of small streams, which are more vulnerable than larger rivers downstream from us. According to a recent review of the scientific literature on the subject of riparian buffers, "Substantial evidence exists to emphasize the importance of maintaining riparian zones in upstream headwaters or backwaters regions, which can be areas of high nitrogen removal. For a 10th order stream[11], up to 90% of the cumulative stream length consists of ephemeral, first, and second order streams (NRC 2002). Thus, the largest proportion of annual stream nutrient load enters watersheds from the headwaters where the capacity to remove nitrogen is great, while less additional nitrogen processing occurs in the main channels of higher order streams "(Richardson et al. 2004, Bernot and Dodds 2005).[12]

County-wide, 62 percent of the 100-foot stream buffer area is forested. Among the 26 subwatersheds in the County, the percentage of 100-foot riparian buffer area that is forested ranges from 26 percent in White Walnut Run to 99 percent in the Upper North Fork. We used the NLCD to quantify stream buffer vegetation, in combination with aerial photos and field observations. See Map 6: Stream Buffer Vegetation, and Map 7: Percentage of Stream Buffer Area Forested. Also see maps 25, 31 and 39 for stream buffer vegetation in White Walnut Run, Lower Rush, and Upper Battle Run.

3.5 Zoning.

Overall for the County, more than 97 percent of the land area is zoned Agricultural or Conservation Zone. These zones protect against intensive development, allowing for a maximum of one new dwelling per 25 acres. Map 8 shows the zoning for the County and Map 9 shows the percentage of each subwatershed's area that is zoned Conservation or Agricultural.

3.6 Erodible Soils on Non-forested Land.

Using the Official Soil Survey for Rappahannock County by the Natural Resource Conservation Service (NRCS), we assessed a subwatershed's vulnerability to erosion by a combination of soil type, slope and land cover. In the Soil Survey interpretive tables the Erosion Factor called "Kw," estimates erosion based on the texture (with rock fragments) of the soil type. Then we looked at the slope classes of the soil map. Soils on steeper slopes have greater potential for erosion. A GIS layer was created combining the Kw factor, the slope classes along with the vegetative cover of the county, producing an erodibility potential map. Since forested areas represent the best management to protect the land from erosion, the maps focus on land cover other than forests. See maps 10 and 11 for the results of the erodibility analysis.

4 What and Where are the County's Subwatersheds?

Following recommendations from the Center for Watershed Protection[13] we divided the County into 26 subwatersheds.[14]All raindrops falling on land within a subwatershed drain to a common point. Often that point is where the main stream of the subwatershed joins a larger stream. The main purposes for dividing the overall county into smaller subwatersheds are to:

- assist landowners in understanding the watershed conditions in their own localities.
- identify areas that are the least well protected, so that priority efforts by the local landowners and conservation organizations can be given to improvement in those areas.
- look in more detail at factors that affect the health of the watersheds, within a smaller area than an entire county.

Each subwatershed is named after the major stream that flows through that area. Table 1 lists the 26 subwatersheds, their land areas, and stream miles.

Subwatershed Name	Acres	Square Miles	Stream Miles
Beaverdam Creek	3101.42	4.85	14.95
Big Branch	2015.77	3.15	9.11
Blackwater Creek	24036.04	37.56	64.15
Covington	5554.93	8.68	30.31
Five Forks	4688.22	7.33	22.41
Hawkins Run	8940.40	13.97	34.37
Hazel River	15111.36	23.61	67.51
Hughes River	19512.22	30.49	42.10
Indian Run Hazel	2287.81	3.57	12.35
Indian Run Jordan	9324.21	14.57	35.04
Jordan R.	12583.34	19.66	72.35
Keyser Run	3816.94	5.96	11.59
Lake Mosby	8703.29	13.60	36.54
Lower Battle Run	7761.37	12.13	37.21
Lower Rappahannock R.	5619.81	8.78	21.61
Lower Rush	2855.35	4.46	23.02
Lower Thornton	13852.96	21.65	67.93
Middle Rush	3128.81	4.89	23.00
North Fork	2873.24	4.49	24.20
Piney	4780.44	7.47	14.17
Racer Run	2468.74	3.86	8.34
South Fork Thornton	6782.88	10.60	18.80
Upper Battle Run	9769.23	15.26	40.05
Upper North Fork	5753.17	8.99	16.33
Upper Rappahannock R.	13090.44	20.45	46.66
Upper Rush	6766.90	10.57	28.07
White Walnut Run	5038.70	7.87	21.94

Table 1: Subwatershed Names, Areas and Stream Miles

As shown on Map 12: Subwatersheds, portions of some subwatersheds lie in Fauquier, Culpeper, and Madison counties.

5 How well protected are our watersheds?[15]

One challenge in assessing the health and protection level of our watersheds is to decide what the yardstick is. Protection compared to what? A state of nature without people? Other counties in northern Virginia?

5.1 Comparisons with an "ideal"

A perfectly protected watershed from an ecological standpoint would be a completely vegetated, highly diverse ecosystem with no human activities and land uses to interfere with nature's processes for stormwater management and no human-created pollution to compromise the water quality or cause erosion. From a legal standpoint, there would be no threat of developing impervious surfaces like roads and rooftops. Portions of Rappahannock County subwatersheds are nearly perfectly protected, both legally and in land use, where they are inside the Shenandoah National Park.

In the model we developed for assessing Rappahannock County's subwatersheds, a "perfectly protected" subwatershed would have 100% of its land in the Shenandoah National Park, 100% of the land cover in forest, 100% of the 100-foot stream buffers in forest cover, no land in commercial or residential zoning, and no highly erodible soils on nonforested land.

For subwatersheds that do not lie within the SNP, conservation easements can help to protect the watershed by protecting in perpetuity parcels larger than 100 acres against future subdivision and development.[16] (The easement does not necessarily require protection of stream buffer vegetation, however.)

5.2 Comparisons with poorly protected areas elsewhere

A poorly protected urban or suburban watershed would be one that has a high percentage of impervious surfaces such as parking lots, highways, residential and commercial development. In a rainstorm, polluted runoff from impervious surfaces and mowed lawns would run directly into streams, either in concrete channels or eroded streambeds. Rappahannock County has no such subwatersheds, and under current zoning and subdivision regulations and the stormwater management ordinance, it will not in future have any subwatersheds so poorly protected.[17]

A very poorly protected agricultural watershed would have dense collections of livestock, such as feedlots, very close to streams, or row crops right alongside the streams, where nutrients such as fertilizers and manure run off into the streams directly in a rainstorm. Rappahannock County does not have any agricultural subwatersheds in such a low-protection status. However, some subwatersheds have a relatively low percentage of well-vegetated stream buffer area.

5.3 How did we quantify the protection level of subwatersheds in the model?

We used the six factors listed above in conducting a systematic assessment across all subwatersheds in the county, as shown in Maps 1 through 12. We used computer-based data and spatial analysis techniques generally referred to as GIS, to compute the percentage of the land area of the subwatershed that is protected by a particular factor. We assigned points to each subwatershed for each of the six factors, based on those percentages. For example, for conservation easements we calculated the number of acres of VOF easement[18] in each subwatershed, and then divided that by the total number of acres (outside the SNP) in the subwatershed. This resulted in a "Percent VOF" figure. We converted the percentages to points for each subwatershed. We then assigned weights, or relative importance, to each of these six

factors. SNP points are multiplied by 4; VOF points by 3; Forested stream buffer points by 2.

(SNP points * 4) + (VOF points * 3) + (Forested Stream Buffer points*2) + Forest Cover Points + Zoning Protection Points + Erodible Soils points = Total Score

5.4 Comparing the subwatersheds' protection levels

Chart 2 shows the list of subwatersheds and their total protection points according to this model. The three lowest-scoring subwatersheds are White Walnut Run, Upper Battle Run, and Lower Rush. Sections 10-12 below provide more detailed descriptions and maps of these three subwatersheds.

Subwatershed	Soil Points	Zoning Points	08VOF Points	SNP Points	Forest Points	Forested Stream Buffers	Total Protection Points
Upper North Fork[19]	10	10	7	10	10	10	111
Piney	10	10	0	7	10	10	78
South Fork Thornton	10	9	0	8	9	8	76
Upper Rush	10	10	2	6	9	8	75
Keyser Run	10	10	1	6	10	9	75
Indian Run Jordan	9	10	4	3	8	7	65
Hughes River	9	10	1	4	7	5	55
Hazel River	9	10	1	3	7	6	53
Big Branch	9	9	6	0	6	5	52
Racer Run	9	10	2	0	9	8	50
Jordan R.	8	10	3	1	6	6	49
North Fork	9	10	1	2	7	6	49
Lake Mosby	9	10	2	0	7	8	48
Beaverdam Creek	8	10	1	2	6	5	45
Upper Rappahannock R.	9	9	2	0	7	7	45
Lower Thornton	8	10	2	0	6	7	44
Lower Battle Run	8	10	3	0	5	5	42
Lower Rappahannock R.	9	9	0	0	7	8	41
Middle Rush	8	9	2	1	5	4	40
Five Forks	7	10	2	0	5	6	40
Blackwater Creek	9	10	0	0	7	7	40
Covington	8	10	2	0	5	5	39
Indian Run Hazel	10	9	0	0	6	6	37
Hawkins Run	9	10	0	0	5	6	36
Lower Rush	8	9	1	0	5	5	35
Upper Battle Run	7	10	2	0	5	3	34
White Walnut Run	6	10	1	0	4	3	29

Table 2: Subwatershed Protection Points

5.5 Using the subwatershed protection map

Map 13 shows the results of the subwatershed protection analysis. The subwatersheds shown in orange are those receiving the lowest number of "protection points." The subwatersheds colored

yellow are next-to-lowest. These are the areas of the county where highest priority should be given to improvement of stream buffer vegetation and increased easement protection as discussed in the Goals section below. More details for the Lower Rush, White Walnut Run, and Upper Battle Run are provided in later sections of this report. To see more detailed maps of your own subwatershed, please go to www.rappflow.org and click on "My Subwatershed."

6 Values, concerns, and knowledge of those who own or use the land

From homes on small lots in the villages, to 25 acre residential homesteads in agricultural zones, to commercial shops and service stations along the highways, to farms and forests on hundreds-of-acres parcels, each individual homeowner, landowner, and land user makes the daily decisions that affect landscaping, stormwater management, stream buffer vegetation, animal and crop management, road maintenance, and the myriad other practices that in combination determine the quality and health of their watershed. These practices derive from individual and family history, values, aesthetics, economics, background knowledge, and know-how. Understanding these values, concerns and knowledge is essential to the development of cost-effective strategies for public education and policy.

In this study, we used several methods to identify the range of values, concerns, knowledge and practices among the full range of stakeholders. Four of these methods are discussed here: 1. a mailed questionnaire survey; 2. consultations with individual landowners; 3. observations at public hearings related to watershed protection; and 4. work with subwatershed groups.

6.1 Mailed questionnaire surveys

In January 2006, RappFLOW mailed 998 surveys to all known addresses of residents and landowners in the subwatersheds of the Upper Thornton River Watershed.. Respondents were offered a free aerial photo of their property as an incentive to return the survey.[20] One hundred sixty-two persons responded to this survey. Respondents represent a good spectrum of size of landholding and years lived there. In 2008, the survey was repeated in the Hughes River subwatershed and 88 persons from Rappahannock, Culpeper, and Madison counties responded.

The survey offers 17 answers for what a person values the most in their watershed. Scenery (82), Privacy (77), and Quality of life (77) are the three answers most frequently chosen by respondents. Income from farm (7) or Income from forest (1) were chosen as highest priority values by very few respondents. The survey offers 12 water issues of possible concern. Out of these, quality and/or quantity of drinking water is the most important issue to the most people. The first 157 respondents answered this question in the following way:

Three water issues that concern me the most are the following:

Answer choice	# out of 157 choosing
b. quality of well water	95
a. adequate supply of good drinking water	83
h. bacterial contamination of stream water	56
g. trash in the streams	40
l. need to help clean up the Chesapeake Bay	35
j. nutrients (nitrogen and phosphorus) in streams and ponds	31
f. stream bank erosion	30
k. loss of fish species in waterways	26
e. sediment in streams and ponds	19
d. floods	18
c. sufficient water for livestock	13
i. algae in ponds	7

Table 3: Water Issues of Most Concern

The survey offers 19 possible threats to the watershed, and asks respondents to choose the THREE that concern them the most. The three threats of most concern to the most people include: Population growth (32%); Subdivision of land parcels (32%); and Public sewage treatment plant discharge to streams (29%). More than a third of respondents said that "bacterial contamination of stream water" is a major issue, but fewer than 10% said that livestock in streams and ponds is a major concern to them, and lack of forested buffers along streams and ponds is a most important threat to only 17 respondents.
The first 157 respondents answered question 8 as follows:

Three threats to my watershed that concern me the most are:

Threat	# choosing (n = 157)
m. subdivision of land parcels	51
l. population growth	50
b. public sewage treatment plant discharge to stream	45
e. pesticides and herbicides	41
a. septic tanks & other private sewage disposal	31
k. commercial development	27
g. loss of farms	25
n. agricultural runoff (nutrients)	21
s. invasive species	20
c. erosion and sedimentation from driveways and private roads	20
i. conversion of forests to other land uses	19
p. lack of forested buffers along streams and ponds	17
f. livestock in streams and ponds	16
d. stormwater runoff	15
h. clear cutting of forests	15
j. traffic	11
q. stream bank erosion	11
o. residential runoff (nutrients)	6
r. wildlife in streams and ponds	3

Table 4: Threats to My Watershed that Concern Me the Most

The responses reveal an opportunity for education regarding relationships among forested riparian buffers and those issues that most concern people, such as clean and plentiful drinking water and bacterial contamination of stream water. The major concern about public sewage treatment plant effluent to stream, in contrast to low concern about lack of riparian buffers and livestock in streams, provides good opportunities for education regarding sewage treatment plant effluent versus impact of land use practices and other nonpoint source pollution issues.
The major concerns about population growth and land subdivision provide good opportunities for public education about conservation tools such as easements.

"I support expenditures of public money on watershed protection and restoration." This statement was answered by 144 respondents. Of these, 92 percent in the Upper Thornton survey answered "yes." In the Hughes subwatershed survey, only 4 out of 88 answered no to this question.
The survey offers 18 possible individual and community efforts on watershed protection. Respondents checked all items they encourage. Nearly all (153) respondents to the survey checked at least one of these items. The following chart shows the number of respondents who encourage certain efforts that are now or might be supported by our county government. Ordinances and zoning were chosen by even more respondents than were

education items.

Chart 1: County Efforts Encouraged by Landowners

The following chart shows the number of respondents who encourage efforts typically undertaken by landowners with assistance of governmental or volunteer organizations. Seventy-five percent (115) of respondents encourage conservation easements, which is consistent with the concerns about population growth and subdivision of land parcels in question 8.

Chart 2:Landowner and Volunteer Efforts Encouraged by Respondents

6.2 Consultations with individual landowners

In the spring of 2007, RappFLOW volunteers with technical assistance from the CSWCD conducted assessments of 11 residential and commercial properties in Sperryville along the Thornton River and discussed with the landowners their objectives for the properties.[21] This was part of a pilot test of a program for providing cost-sharing assistance to riparian landowners to improve land management practices on non-agricultural land. The purposes of the assessment were to identify possible improvements in land management, especially stream buffer vegetation, that would reduce nutrient runoff and sedimentation in the river, and to work with the landowners to identify what assistance they might require in order to implement such changes. For one of the commercial sites, both the site itself and the landowner objectives allowed for a full buffer vegetation restoration project, the Old Schoolhouse buffer restoration. This site was improved through more than 1000 volunteer hours of work, and is serving as a training ground for volunteers as well as public outreach and education site.

· For three of the commercial sites, the site itself does allow for improvement in the buffer vegetation, and one of the landowners has implemented one recommendation -- to mow higher. The other two cases required more technical assistance than can be provided on a volunteer basis. For three of the commercial sites, neither the site itself nor the landowner objectives will allow for any improvement or restoration of vegetative buffers or changes in the land use. The reason is that all of the riparian buffer zone is currently being used for commercial purposes and there is no space to add vegetation.
· One of the four residential sites is ideally buffered and the landowner is fully supportive of maintaining the land in that condition. One of the residential sites would benefit from additional vegetation in the buffer area, but the landowner's decision to sell the property defeated efforts to invest in improvements to the property. The other two residential sites would benefit from additional vegetation and the landowners do not want to change their land management practices.
RappFLOW volunteers have also conducted individual conversations with dozens of landowners in the context of public education events and workshops. In general, for the individuals who attend such events, it can be said that they are very much interested in "doing the right thing" for their land and the environment, and that their needs for technical assistance, education and advice are wide-ranging.

6.3 Participation in Public Hearings

Hundreds of citizens participated over the past few years in public hearings on issues related to watershed and water quality protection. The opinions expressed in these public forums – by both the public and county officials -- provide insights into the range of values and knowledge among landowners and citizens. Three examples included the following:

- public hearing on the subject of sludge ordinance;
- public hearings on proposed Tier III "significant waters" designation for the Hazel River;
- public discussions concerning proposed permit for discharge of sewage treatment plant effluent to the Rush River.

In the case of the sludge ordinance issue, the courthouse was packed to overflowing with citizens, nearly all of whom wanted the County government either to defend the county's existing ban on sludge in legal actions against the Commonwealth, or to devise a very tightly controlled alternative ordinance that would effectively ban sludge applications in a legally defensible manner. The public clearly wanted to protect soil and water from contaminants known to be in biosolids/sludge.
In the case of the Hazel Tier III designation, the citizens best prepared to speak on the matter at the hearing were a small number of landowners on the Hazel River who feared the potential of future limitations on their land use due to the possibility of future changing regulations by the US EPA or the VA DEQ. While the majority of landowners on the Hazel River were aware of the issue and supported the designation, they did not appear in person at the hearing. The Board of Supervisors voted to disapprove the designation for Tier III protection on the basis that they did not wish to invite any unnecessary regulation from the federal or state government.
In the case of the Town of Washington's application to the VA DEQ for permit to discharge sewage treatment plant effluent to the Rush River, a great many citizens became involved both in public hearings and in task force meetings.[22] Probably as a result of the extensive public inquiry and concern, the VA DEQ issued the town a permit containing the most stringent requirements for nutrient removal of any such permit in the DEQ history. The public concern also resulted in the collection of considerable additional baseline data on water quality in the watershed, both by the DEQ and by RappFLOW volunteers.

6.4 Subwatershed Landowner Groups

Several groups of landowners within a particular subwatershed, or whose property is adjacent to a particular major stream, have worked together on various issues of importance to them. Four such groups over the past four years have included the Friends of the Rush, Hazel River Task Force, Friends of the Hughes, and the Jordan River Landowners supporting Scenic River designation for the Jordan River. RappFLOW has provided scientific and technical assistance to these groups, in the form of maps of their watersheds, aerial photos, research on relevant regulations, water quality sampling, and coordination with relevant state agency programs. Through these efforts it becomes apparent that groups of landowners will work together most readily when there is a clear, defined, immediate threat to water quality or to their property rights. Some landowners will work together to take advantage of opportunities that could result in added protections for their streams or neighborhood.

7 Public Policy: Local Government Protections for Watersheds

Citizens of Rappahannock County have a long history of supporting public policy to protect their environment. The local government uses many of the tools available to it from the Commonwealth to support the Goals of its Comprehensive Land Use Plan. The following tools used by the County provide a high level of local and state government support for watershed protection:

- Comprehensive Land Use Plan, especially Chapter 6: Goals, Principles and Policies
- Zoning and subdivision ordinances
- Stream Buffer Protection overlay of the Zoning Ordinance
- Erosion & Sedimentation Control ordinance
- Sludge ordinance
- Stormwater Management Ordinance
- Land use taxation
- Farmland Preservation Program
- Agricultural/Forestal Districts

7.1 Comprehensive Land Use Plan, especially Chapter 6: Goals, Principles and Policies

The 2004 County Comprehensive Plan recognizes the County's waters as one of the most significant environmental resources, and this intention is woven throughout the goals, principles and policies statements. The following are some of these policies:

Principle 1 – To encourage agricultural operations and ensure the preservation of the productivity, availability, and use of agricultural lands for continued production of agricultural products.

Policy 4. Encourage traditional and innovative soil and water conservation practices among the county's farmers in order to preserve productive soils, to control erosion and siltation, and to protect water resources.

Policy 12. Upon requests for rezoning land for more intensive use, encourage the placement of open-space easements on important ... water resource ... lands as a reciprocal benefit.

Principle 2 – Preserve the natural, historic, recreational and scenic values,…so as to ensure that development…is in conformance with their natural beauty and environmental limitations.

Policy 1. Promote multiple uses of forested land and land not in productive agricultural use, including ... watershed protection.

Policy 3. Ensure that timber harvesting and road construction is conducted such that sedimentation of streams and other environment impacts are minimized.
Policy 4. Promote the placement of conservation easements on land adjoining or visible from Shenandoah National Park and Rappahannock River and other state designated scenic rivers and roads and seek to protect the scenic value of those lands when land use decisions and plans are made.

Principle 3 --Protect natural resources, including soil, water, air, view-sheds, scenery, and fragile ecosystems.

Policies
1. Require that environmental impacts of activities directly or indirectly related to new construction, including removal of vegetation, cutting of trees, altering of water sources and courses for existing users, drainageways, grading, and filling, are minimized.
2. Prohibit land uses if they have significant adverse environmental impacts that cannot be eliminated or minimized.
3. Continue to implement the County's Erosion and Sedimentation Control Ordinance including Responsible Land Disturber (RLD) certification.
requirements. The County should consider allowing Low Impact Development (LID) or other alternate E&S measures, where appropriate.
4. Promote the best management and prevention measures for potential groundwater pollution sources, including septic tanks, wells, and under- ground petroleum storage tanks.
5. Participate where appropriate and cooperate with federal and state groundwater protection programs.
6. In flood hazard areas without public sewage disposal systems, encourage low-density growth, to minimize loss of life and property damage.
7. Enforce floodplain management regulations so that property owners continue to be eligible for inexpensive flood insurance under the National
Flood Insurance Program.
8. Support the conduct of an inventory to identify environmentally significant lands, and the establishment of a countywide groundwater- monitoring network.
9. Recognize the county's rivers as one of the most significant environmental resources and provide for their protection by:
a) Encouraging greenbelts along the rivers.
b) Informing the public of the benefits and values of preserving the river corridor.
c) Controlling development in areas adjacent to the rivers that may include development restrictions such as setbacks, buffers, or other means, or limitations on water withdrawals and/or effluent discharges.
10. Consider carefully the impact of experimental agricultural practices that could negatively impact natural resources.

Principle 7 – Promote only economic growth that assists in maintaining our existing balance and is compatible with the environmental quality and rural character…

Policy 4d. Allow certain commercial development that by its nature must be located in sparsely populated areas, near agricultural operations, near existing neighborhoods or on specific sites to be so located if the development does not overburden the County's water resources, and does not require the transfer of water resources from other jurisdictions to sustain the development.

Principle 10 – Promote the philosophy that land is a finite resource and not a commodity, that all citizens are stewards of the land, and that the use and quality of the land are of prime importance to each present and future citizen as well as to the Commonwealth, the Country, and indeed the world.

Policies promote public education and information; inclusion of these subjects in school curricula; proper land use by government agencies and private organizations; and recognition of landowners' practices that protect and preserve the land.

7.2 Zoning and subdivision ordinances

Together, the zoning and subdivision ordinances (set forth as chapters within the Rappahannock County Code) guide the patterns of future development of the watersheds, in terms of where development takes place, the types and densities of uses that will be made of the land, and protections for the watershed including both soil and water. By zoning land so that commercial and residential areas are focused around existing villages, and specifying the detailed types of uses of the land that can take place in those areas, these ordinances provide stronger protections for the watersheds of Rappahannock County than one might see in ordinances in many other Virginia counties. The Board of Supervisors adopted a down-zoning of approximately 90 percent of the County's land area in 1986 (down-zoning resulted in substantially less density allowed than had theretofore been the case), thereafter allowing a maximum development density of one dwelling unit per 25 acres in Agricultural zones, and even less dense development in Conservation zones which are characterized by steep slopes. The Comprehensive Planning justification for these changes was based on natural resource conservation imperatives.

Chapter 170: Zoning establishes two types of resource preservation zoning districts — conservation districts and agricultural districts.
"The Conservation District contains those mountains which are environmentally sensitive, have physical limitations and contain much of the County's timber resources. The regulations are designed with emphasis on the conservation of those areas to minimize the potential adverse environmental impact while providing for compatible very low-density residential uses.

"The Agriculture District generally contains those areas where agriculture and forestry are the predominant uses or where significant agricultural lands or larger lot farmette-type residential developments exist. The regulations are designed to assist in the protection and preservation of the agricultural and forestry uses and to mitigate land use conflicts between agricultural uses and appropriately limited residential development."
Chapter 170 establishes the uses and the maximum densities (dwelling units/acres) that are permitted in Conservation and Agricultural districts. In general, a new dwelling in either district requires 25 acres (§170-37 and §147-37).
From the watershed perspective, one disadvantage of the provision for 25-acre parcel size subdivision provision is the extended network of private roads that results when many individual landowners construct new private roads, especially on sloping land. Potentially offsetting this pattern is the exception allowed for Clustering. "Lot size requirements may be conditionally reduced by the Zoning Administrator in cases where subdivision clustering is required to meet open space requirements and/or can be proven to significantly reduce overall imperviousness of the subdivision by reducing street, private road and/or driveway lengths." [23]

Article V: Overlay District Regulations provides for Floodplain Districts at §170-45 and Stream Protection Overlay districts at §170-45.2.
Chapter 147: Subdivision of Land establishes subdivision standards and procedures that support the intent of Chapter 170: Zoning. For example, §147-17 prohibits residential occupancy in new subdivision developments in floodplains. Chapter 147 also establishes requirements for public and private water and sewer.

7.3 Stream Buffer Protection Overlay (SPO) District of the Zoning Ordinance

Chapter 170-45.2 of the Zoning Ordinance describes the Stream Protection Overlay District. The purpose of the Stream Protection Overlay District is to apply special regulations to the riparian buffer area no less than 100 feet wide on each side of perennial streams and wetlands adjacent to those streams. The purpose of the buffer is to retard runoff, prevent erosion, filter nonpoint source pollution from runoff, moderate stream temperature, and provide for the ecological integrity of stream corridors and networks. The SPO provides protection for streams in future development in areas zoned residential or commercial.

7.4 Erosion & Sediment Control Ordinance

The Erosion & Sediment Control Ordinance requires a land-disturbing permit and associated plans and practices for the clearing, filling, excavating, grading, transporting of land or for any combination thereof for land disturbance over 10,000 square feet. The purpose of this ordinance is to prevent degradation of properties, stream channels, waters and other natural resources of Rappahannock County by establishing requirements for the control of soil erosion, sediment deposition and nonagricultural runoff and by establishing procedures whereby these requirements shall be administered and enforced. This article is authorized by the Code of Virginia, Title 10.1, Chapter 5, Article 4 (§ 10.1-560 et seq.), known as the "Virginia Erosion and Sediment Control Law."

7.5 Biosolids Ordinance

The Biosolids Ordinance was adopted by the Board of Supervisors on July 2, 2007. Biosolids ("sludge") are the solids that are extracted from wastewater treatment systems, such as municipal wastewater treatment plants. Depending upon the source of the biosolids and the level of pre-treatment of them, they can contain varying levels of undesirable materials, such as heavy metals. Because these biosolids contain high levels of nutrients such as nitrogen and phosphorous, they are used as fertilizer.

The Commonwealth does not allow localities to ban the application of biosolids. The Ordinance recognizes the importance of our waters being part of the Chesapeake Bay watershed, and uses the State authority provided in the Chesapeake Bay Act and the Virginia Water Quality Improvement Act as partial legal justification for protective measures. Some of the major protective measures incorporated into the Ordinance include:

- A 100 foot vegetative buffer must be established and maintained along any stream on land where biosolids are applied. A Nutrient Management Plan (NMP) must be developed to ensure that the biosolids application does not exceed the ability of the land and crops to properly utilize the nutrients from the biosolids. No biosolids can be applied on land that drains to a DEQ 303(d) designated impaired water. No land application can be applied upstream of a Fish Consumption Advisory that is in the County or in a County that is immediately downstream.
- No application can occur immediately before or during extreme weather events such as storms, snowfalls, or high winds, nor can they be applied on saturated or snow covered ground. No application is allowed within 400 yards of a water supply source, such as a potable water supply well.
- All biosolids applications must be registered with the County Administrator, where they will become part of the permanent record in the County Land Records. This can protect future purchasers of the land.
- There are provisions for testing the content of the biosolids before application by a qualified Sludge Monitor to ensure that the content does not include excessive amounts

of bacteria and that all stipulations of the Ordinance are being met.
Enforcement of the Ordinance requires the services of a qualified Sludge Monitor; this position has not as yet been filled, nor has there as yet been an application to land-apply sludge.

7.6 Stormwater Management Ordinance

The Stormwater Management Ordinance (SWM) was adopted by the Board of Supervisors on January 7, 2008. This chapter is adopted pursuant to the authority conferred by the Virginia Erosion and Sediment Control Law (Virginia Code, 10.1-560 et seq.) and the Virginia Stormwater Management Act (Virginia Code, 10.1-603.3 et seq.)

The purpose of the SWM Ordinance is to protect local streams, rivers, groundwater and properties from increases in the volume and rate of stormwater runoff and increases in pollutants when land is converted to more intensive uses such as commercial or residential subdivisions. This protects the safety and welfare of citizens, property owners, and businesses by minimizing negative impacts of increased stormwater discharges from new land development. By minimizing runoff, groundwater supplies are also protected. The ordinance also integrates stormwater management with other County ordinances, programs, policies, and comprehensive plan.
The SWM Ordinance applies to all land development projects that disturb over 2,500 square feet of land, except agricultural, horticultural, or forest crop activities. Where the land development activity results from construction or alteration of a single-family residence, an "agreement in lieu of a plan" may be substituted for a formal stormwater management concept and design plan.
The ordinance applies at the time requests are made for driveway entrance permits, land disturbance permits, preliminary plans of subdivision, and major site development plans, and extends through construction and maintenance of stormwater management practices and facilities.

The Ordinance specifies standards for protection of both quality and quantity of water, in terms of the outcomes to be achieved. Basically, the development must be designed and constructed in such a manner that the amount of stormwater runoff after the development is completed will be the same or less than it was before the development took place.
The SWM Ordinance encourages the use of Low Impact Development (LID) approach. LID is modeled after nature: manage rainfall at the source, using decentralized small-scale controls.
Private roads and driveways are one of the County's greatest sources of stormwater runoff, erosion, sedimentation, and pollution. If a private road or driveway will be more than 1,000 feet in length and have 10% grade at any point, then an engineer's plan proving adequate erosion and stabilization measures is required.
Protection of the stream buffer area is addressed in the Zoning Ordinance in a Riparian Buffer Overlay District. The Culpeper Soil and Water Conservation District staff and County staff review and approve stormwater management plans.

7.7 Land use taxation

Virginia Code (Title 58.1: Taxation; Article 4: Special Assessment for Land Preservation) establishes four special classifications of real estate — agricultural use, horticultural use, forest use, and open-space use — and authorizes local governments to adopt ordinances that provide for use value assessment and taxation in accordance with Title 58.1.
"Use value taxation" means the land is taxed based on the way it is used, not on its market value. For example, land that is farmed is typically taxed at about one third of its fair market value. Landowners must demonstrate that they meet the requirements of land use taxation each year.

About 80 percent of privately held land in Rappahannock County is in land use taxation, although the County utilizes only the first three classifications of land discussed above in its program. The benefit to watersheds is to protect the land and water from subdivision of farmland and the resulting development, population increase, forest fragmentation, added roads and other impervious surfaces, and other potential threats .
Landowners who opt out of land use taxation pay five years in "roll-back" taxes — the difference between land use value and market value for the previous five years. Roll-back taxes are applied to the Farmland Preservation Program, discussed at 6.8 below.

7.8 Agricultural and Forestal Districts

Over 21,310 acres of land in the County are in Agricultural/Forestal Districts. An Agricultural and Forestal District is a State-approved method by which Rappahannock landowners can set aside land for ten-year periods in return for tax benefits and protections against government interventions. The county currently includes ten Districts, which protect about 21,000 acres. The program was initiated in 1980 and has remained relatively stable in acres protected since 1990. Land owners who participate in the program cite as its strongest features 1) greatly reduced local tax rates, 2) a guarantee against changes in the land-use taxation program, and 3) the opportunity to contribute to the scenic and rural character of the county. The weakest feature from the landowner standpoint is the requirement to tie up land for ten-year periods (i.e. no construction, subdivision, sale of the property).
The public purposes of an Agricultural and Forestal District are to:
• "conserve and protect, and to encourage the development of, the Commonwealth's agricultural and forestal lands for the production of food and other agricultural and forestal products..." and
• "to conserve and protect agricultural and forestal lands as valued natural and ecological resources which provide essential open space for clean air sheds, watershed protection, wildlife habitat, as well as for aesthetic purposes" (Section 15.2-4301 Code of Virginia)

7.9 Farmland Preservation Program

The Farmland Preservation Program is a County purchase-of-development-rights (PDR) program that pays working farmers not to develop or subdivide their land. The County places the development rights under a conservation easement. The farmer retains all other rights, including the right to continue farming and sell the land, but not to develop the land through subdivision. The program provides the same protections for watersheds as conservation easements, but provides added incentives to the farm landowner to put the land in easement.
Funding for the program is provided by "rollback" taxes and private contributions, almost entirely from the Rappahannock County Conservation Alliance, which holds an annual fundraiser for that purpose. County funds are matched by the state to a maximum that varies from year to year. A proposal in 2005 to add two pennies per hundred dollars in real estate taxes to enable a predictable income stream for the Farmland Preservation Program was defeated. To date, two farmers have participated in the program.

7.10 Septic System Cost Sharing Program

Through a grant from the VA Water Quality Improvement Fund, the County and the CSWCD provide cost sharing for septic system improvements within 300 feet of any stream in the county. This includes inspection, cleanout, repair, replacement of and component of the system.

8 Taking a Closer Look at Watershed Health and Protection

In addition to the six factors used to compare the subwatersheds' protection levels, this study explored other factors affecting the health of our watersheds. These include future development, climate change, private roads and driveways; road/stream crossings; stability of streambeds; residential and commercial landscaping and land management practices; agricultural land management practices; forestry and logging practices; sewage treatment plants; septic systems and other household sewage.

8.1 Future development

There are already on record in the County about twice as many parcels of land as there are parcels with dwellings on them. There are also parcels that under the current zoning regulations could be subdivided by right if the owner so chooses. In 2000, an analysis was made in order to estimate the impact on the County if all the existing and sub-dividable parcels were developed into residences. This build-out analysis used conservative assumptions, such as the assumption that half of all potential lots under 2 acres are not suitable for subdivision or construction, and that land under easement is not buildable. At 2.5 average persons per household, the build-out would show a population of 18,000 for the county, roughly two and a half times greater than the current population. The development patterns would add more than 500 miles of private roads and driveways to the landscape for a total of 900 miles as discussed below.

8.2 Climate change

The impact of climate change has already been observed in many ways in our locality. The loss of hemlock forests to the expansion of the hemlock woolly adelgid is but one example.[24] Nearly all hemlock forests in SNP have died, and forestry experts predict eventual loss of all hemlock forests in our area. The spread of the woolly adelgid (an invasive sap-sucking insect from Japan) has been abetted by the recent warmer winters. The hemlock's shallow root system excels along riparian corridors, where the soil remains moist throughout the year. These shade-tolerant trees form dense canopies that provide cool refuge for fish and wildlife. Rich in biodiversity, eastern hemlock forests are (were) habitat for more than 120 different vertebrate species, including black bear, marten, fisher, bobcat, white-tailed deer, snowshoe hare, red squirrel, porcupine, ruffed grouse, pileated wood pecker and many other birds. Streams sheltered by hemlocks are more likely to contain brook trout.

Future strategies for protecting our watersheds and water quality and quantity will need to take into account the predicted climate changes for this area of Virginia. Current predictions suggest greater swings of temperature (higher highs and lower lows) as well as precipitation (droughts and wet periods).

8.3 Private roads and driveways.

In the county, there are more than 400 miles of privately maintained (mostly gravel or dirt surfaced) roads and driveways, sometimes on steep slopes. This is nearly 60 percent of all road miles in the county. These private roads are a major source of stormwater runoff, erosion, sedimentation, and other types of pollution in streams. In addition, roads going into forested areas fragment the forest. Map 14 shows private roads and driveways in a sample area of the County, based on the County's E911 roads file.

8.4 Road/stream crossings.

When a road crosses a stream or is in the stream buffer area, it may compromise the stream in several ways. Pollutants from vehicles and road maintenance easily wash into the stream. The impervious surface of the road causes stormwater to run quickly into the stream, increasing the

erosion and sedimentation. Culverts channelize the water in the stream, making it flow faster during storms and thus causing damage to the stream banks. Culverts interfere with migration of small fish. Roads break up the forest cover, reducing the passageway for wildlife.
For the 14 subwatersheds in the Upper Thornton River Watershed, we identified areas where roads intersect with streams. The stream buffer area is 100 feet on both sides of the streams. The road buffer area is 40 feet for secondary roads and 100 feet for major highways. This is illustrated by example in Map 15. We then computed for each subwatershed the total acreage of road/stream intersections.

Subwatershed	Subwatershed acres	Subwatershed Square Miles	Stream Miles	Acres of Road/Stream Intersection
Upper North Fork	5753.17	8.99	16.33	2.67
Piney	4780.44	7.47	14.17	8.22
Big Branch	2015.77	3.15	9.11	9.77
Five Forks	4688.22	7.33	22.41	10.63
Lower Rush	2855.35	4.46	23.02	12.26
Racer Run	2468.74	3.86	8.34	12.80
Beaverdam Creek	3101.42	4.85	14.95	19.07
Keyser Run	3816.94	5.96	11.59	20.06
White Walnut Run	5038.70	7.87	21.94	25.32
Middle Rush	3128.81	4.89	23.00	28.32
Covington	5554.93	8.68	30.31	32.19
Upper Rush	6766.90	10.57	28.07	46.59
North Fork Thornton	2873.24	4.49	24.20	53.67
South Fork Thornton	6782.88	10.60	18.80	54.55

Table 5: Acres of Road/Stream Intersection in the Upper Thornton River Subwatersheds.

8.5 Stability of Streambeds

Unstable, eroding streambeds are commonly seen across the County, in both residential and agricultural areas. Streambeds in this condition promote soil erosion and siltation of the water, which damages the habitat for fish and other aquatic life. There are many causes of streambank erosion, but the most commonly observed is the lack of forested buffer area adjacent to the stream. Preventing streambed erosion is far less expensive than is restoration of a damaged streambed.

8.6 Residential and commercial landscaping and land management practices.

RappFLOW volunteers with technical assistance from the Culpeper Soil & Water Conservation District conducted site visits to evaluate land management practices on residential and commercial properties. Volunteers also developed, tested, and trained others in the use of a Riparian Buffer Evaluation Handbook.[25] A list of recommended native trees, shrubs and grasses for riparian buffers, and a list of nurseries for native plants, are some of the other resources developed to assist landowners in protecting and restoring stream buffer areas. The volunteers also restored a riparian buffer area on a large commercial property in Sperryville, thus gaining first-hand experience. This area serves as an educational place for citizens to learn about stream buffers, and public workshops are held there. Another outcome of this work was a set of guidelines for landowners.[26] The following are some of the key concepts and practices that could be easily adopted by any residential landowner:

Advice to Residential Landowners

You can do something on your property that can help the watershed and also meet your desires. Watershed protection goals are to prevent pollution from entering our streams, recharge groundwater, and reduce flooding.

Small streams are as important as larger streams.

The primary pollutants of concern are Nitrogen, Phosphorous, sediment, and bacteria.

Trees, shrubs, and tall grasses in the area beside the stream are "the last line of defense" in keeping pollution out of the stream. They stabilize the stream bank. The trees help keep the water cooler and provide beneficial "leaf litter" for the stream. These actions of the buffer greatly improve the water quality, making better "homes" for fish and other critters in the stream. Proper buffers can transform a stream from having no fish, into a stream that "cold water" fish like Trout can thrive in.

Buffers can be improved in many ways. It can be as simple as not mowing 35 to 50 feet along the stream and letting the trees that want to be there develop. Even 15 feet can be better than no buffer at all!

You can develop an attractive landscaping plan and then plant native trees, shrubs, and other native plants.

If it's important to you to keep a nice waterfront view, do it with "clever" landscaping -- use more low-growing plants, pathways and seating areas.

Make sure that there is not a "back door" for water to enter the stream, such as a drainage ditch or a pipe that circumvents the buffer. Many of the benefits of the buffer are then lost!

Take a holistic view when looking at the property. Observe what happens with runoff in a heavy rain. Look at overall drainage, lawns, swales, and ponding areas. There are many things that can be done on the property BEFORE runoff reaches the stream or drainage ditch. The "mantra" is to SLOW the water down, let it seep into the ground. For instance, you could select an area to stop mowing and let it grow up into a forested area. This will be a haven for many interesting forms of wildlife, birds, and butterflies.

Proper lawn care practices can make an incredible difference, don't cost anything and can actually save money! Five important things to consider are:

1. Mow higher, say 4 inches instead of 2 inches. It's is better for the grass and will help rainwater infiltrate into the soil – it SLOWS the water down. The higher you mow, the deeper the roots of the grass grow. This can help the grass in dry weather conditions because the roots are reaching farther down to get moisture. The grass uses the nutrients in the runoff and removes pollution from the shallow groundwater, and this also helps keep pollution from going into the deeper groundwater that our wells use for our water supply.
2. Fertilize only as needed. Healthy grasses and soils need less fertilizer.
3. Don't rake up the clippings – these are actually a form of "free" fertilizer and they return nutrients to the soil.
4. Be very selective about using herbicides, and be sure they biodegrade quickly.
5. Clean up after pets – this is a source of pollution just like cow or horse manure.

8.7 Agricultural land management practices.

Agricultural land management practices, especially those affecting livestock on pastures, are by far the largest factor in protecting the water quality in streams in Rappahannock County. According to the study Bacteria Total Maximum Daily Load Development for the Rappahannock

River Basin [27], pastures constitute over 95% of the source of E. coli bacterial contamination of streams in the watersheds to the impaired stream segments. If animals are actually in the stream, they also destabilize streambanks, create erosion and sedimentation, and add high levels of nutrients to the water.
Since 2004, the county's farmers have protected 1,271.4 acres of pasture and stream buffer through Virginia cost-sharing programs for Best Management Practices, as follows:

YEAR	# PROJECTS	ACRES PROTECTED
2004-05	11	190.1
2005-06	6	98.1
2006-07	10	395.5
2007-08	13	584.7

In addition, 33 landowners have taken advantage of the USDA's CREP cost-sharing program to restore and protect about 825 stream buffer acres since the program's inception in 2000.

8.8 Forest Management.

Conservation of forested lands and the economic and ecological sustainability of those forested lands are central to the future health of the watersheds. There has been a small amount of logging operations in the County in recent years. In the year July 2006 – June 2007, the DOF reported a total of 1,082 acres of logging in the County. In the year July 2007 – July 2008, 635 acres were reported.
Conservation and sustainability depend upon landowner education and forest management planning. Invasive species are the most significant threat to forest health.[28] Drought and record-high temperatures have exacerbated the impacts on previously stressed tress, leading to secondary insect and disease problems and tree mortality.
A Sustainable Forestry Task Force was created by a group of volunteer citizens in 2008[29]. This task force and the VA Department of Forestry are conducting programs of education for owners of forested land in Rappahannock County.

8.9 Sewage treatment plants.

As discussed in section 6.1, about a third of respondents to our watershed survey said that public sewage treatment plant discharge to stream was one of the threats to their watershed that most concerned them. There are four sewage treatment permits in the county plus an inactive one in Shenandoah National Park. Two are for the high school and the elementary school. The permit for the town of Washington is not yet operational. One operational permit is the Sperryville Sewage Treatment Plant (STP). In 2005, some landowners questioned the possible sources of fecal coliform exceedance measured by the VA DEQ in the Thornton River below Sperryville. On three dates in spring of 2005, RappFLOW volunteers collected water samples in the Thornton River above and below the Sperryville Sewage Treatment Plant.[30] On our first sampling, FC levels just downstream of the Sperryville STP were slightly elevated and exceeded standards compared to FC levels collected upstream of the STP but this result was not repeated in the second testing. We collected a sample where the wastewater effluent pipe outlet enters the Thornton River. This level of 300 colonies was higher than the 140 colonies collected just upstream of the effluent discharge location. However, DEQ often allows wastewater treatment plants to maintain a mixing zone downstream of their effluent location so the river can dilute the waste and to reach acceptable levels.
They did not find any significant difference in the levels of fecal coliform in samples above and

below the plant at the confluence of the North and South Fork of the Thornton River.
The Sperryville Sewage Treatment Plant (STP) is required by its DEQ permit to monitor certain water quality parameters from its effluent on a monthly basis and send this information to DEQ. We obtained historical data from VA DEQ for the Sperryville Sewage Treatment Plant covering a six-year period from February 1999 to April 2005. We compared the monthly parameter values to allowable limits set forth in the STP DEQ National Pollutant Discharge Elimination System Permit # VA0062880. Secondary wastewater treatments such as STP with design flows of 55,000 gallons per day are small package plants. They do not have a bacteria standard in their permit limits and they do not test for bacteria in their effluent or in the stream. Instead, they treat with chlorine levels suitable to kill bacteria. When chlorine levels measured as Total Contact Chlorine are equal to or greater than 1.0 mg/l, the levels are considered sufficient to kill FC to acceptable concentrations (<200 colonies per 100 mls water). In the 6-year effluent data the average Total Contact Chlorine level was 0.79mg/l. Prior to January 2002, the monthly average Total Contact Chlorine was 0.57 mg/l. No level of 1.0 mg/l Total Contact Chlorine was reached between February 1999 and January 2002. Whether the current Total Contact Chlorine level is sufficient to remove the bacteria warrants further study. Additional investigation is also needed to determine the duration of time the waste is exposed to the chlorine to ensure proper contact for efficient bacterial removal. [31]
Water quality parameters we evaluated for the Sperryville STP included ammonia, biological oxygen demand, dissolved oxygen, sediment loadings, and pH. There were four exceedances of allowable STP permit levels over the 6-year time period. These exceedances were for ammonia levels above the permitted 5.1 mg/l in the wastewater effluent. These occurred in 2000 and 2001 (ammonia levels of 6.2 mg/l, 9.8, 5.5, and 25.8). There was no correlation between the elevated ammonia concentrations and water flow levels. The average dissolved oxygen in the STP effluent was 7.6 mg/l, thereby meeting their permit requirements for being above a minimum of 6.0.
The Biological Oxygen Demand (BOD_5) in the STP effluent was a monthly average of 8.0, well within the allowable 30 mg/l permit requirement, although several peaks were near 30 mg/l. Typical streams in our area have a BOD_5 of 2-4 mg/l.
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8.10 Septic Systems

Nearly all residents of the County depend on private septic systems (except Sperryville and in future, the town of Washington). Septic systems are designed to filter septic tank effluent through the soil allowing removal of bacteria and nutrients from the wastewater. Septic system failure is manifested by the rise of effluent to the soil surface. Surface runoff can transport the effluent containing fecal coliform to receiving waters.
The following information is from the TMDL Study referenced earlier. It addresses the Rush River in particular, but similar methods and conclusions also apply to other impaired stream watersheds.

> In accordance with estimates from Dr. Raymond B. Reneau, Jr. from Virginia Tech, a 40% failure rate for systems designed and installed prior to 1984, a 20% failure rate for systems designed and installed between 1985 and 1994, and a 3% failure rate on all systems designed and installed after 1994 was used in the development of the Rush River (VAN-E05R-01) TMDL. An average number of people per household and number of houses and people in each subwatershed in 2006 were established using 1990 and 2000 U.S. Census Bureau demographics data (UCSB, 1990 and 2000). The applicable failure rate was multiplied by each total and summed to get the total failed septic systems per subwatershed.

Daily total fecal coliform load to the land from a failing septic system in a particular sub-watershed was determined by multiplying the average household occupancy rate for that subwatershed by the per capita fecal coliform production rate of $1.95 \times 10_9$ cfu/day (Geldreich et al., 1978). Hence, the total fecal coliform loading to the land from a single failing septic system in a subwatershed with an occupancy rate of 2.09 persons/household was $4.08 \times 10_9$ cfu/day. Transport of some portion of the fecal coliform to a stream by runoff may occur during storm events. The number of failing septic systems in the watershed is given in Table 3.25.

Straight Pipes. Houses that deliver a waste load directly to the stream, or straight pipes, were estimated by identifying those houses located within 150 feet of streams in the pre-1967 and 1967-1987 age categories. Any houses within 150 ft of streams are considered potential straight pipe dischargers. Using the age categories (pre-1967, 1967 – 1987, post 1987), 10% of old houses (pre-1967) within 150 ft of streams and 2% of mid-age houses (1967 – 1987) within 150 ft of streams are assumed to be straight pipe dischargers (CTWS, 2004). This method yielded 15 houses that potentially could be classified as straight pipes in the Rush River (VAN-E05R-01) watershed (Table 3.25).

Estimated human population, number of sewered houses, number of unsewered houses by age category, number of failing septic systems, number of straight pipes, and pet population in the Rush River watershed. (Table 3.25 from the TMDL Study).

9 Indicators of water quality and quantity

To assess the quality of surface water in the 755 miles of streams and 540 acres of ponds in the County, there are only a few sources of data, and these provide information regarding water quality in a small sample of locations. The sources include the following:

- There are four stream segments that have been designated 303d "Impaired" for Ecoli by the DEQ. See Map 16.
- Countywide, there are about 12 DEQ ambient monitoring stations, although not all are currently active. See Map 16.
- There are currently 8 locations where citizens monitor the macroinvertebrates.
- There are some streams classified by the Virginia Department of Game and Inland Fisheries as coldwater or trout streams, and these are within subwatersheds designated by Trout Unlimited as Brook Trout Protection Area.
- RappFLOW volunteers have sampled chemical and biological water quality in selected locations as part of special studies at requests of landowners.
- To measure quantity of surface water, there is one USGS streamflow gage, located in Laurel Mills.
- There are no groundwater monitoring stations in the county. The nearest one is near Berryville.

9.1 Impaired stream segments: what they mean and do not mean.

Segments of the Rush, Thornton, Hughes, Hazel and Rappahannock Rivers in Rappahannock County have been designated "303d Impaired" for fecal coliform or ecoli bacteria by the Virginia Department of Environmental Quality. [32] The goal of the Clean Water Act is that all streams should be suitable for recreational uses, including swimming and fishing. Fecal coliform and *E. coli* bacteria are used to indicate the presence of pathogens in streams supporting the recreational use goal. Bacteria in certain segments of the Hughes River (VAN-E03R-01), Hazel River (VAN-E04R-01), Rush River (VAN-E05R-01), Hazel River (60076), Rappahannock River and Thornton River exceed the fecal coliform criterion. [33]

> Pollution from both point and nonpoint sources can lead to fecal coliform bacteria contamination of water bodies. Fecal coliform bacteria are found in the intestinal tract of warm-blooded animals; consequently, fecal waste of warm-blooded animals contains fecal coliform. Even though most fecal coliform are not pathogenic, some forms can be harmful to human health and their presence in water indicates recent contamination by fecal material. Because fecal material may contain pathogenic organisms, water bodies with fecal coliform counts may also contain pathogenic organisms. For recreational activities involving contact with water, such as boating and swimming, health risks increase with increasing fecal coliform counts. If the fecal coliform concentration in a water body exceeds state water quality standards, the water body is listed for an exceedance of the state fecal coliform standard for contact recreational uses. Virginia has adopted an Escherichia coli (*E. coli*) standard for water quality. The concentration of *E. coli* (a subset of the fecal coliform group) in water is considered to be a better indicator of pathogenic exposure than the concentration of the entire fecal coliform group in the water body.

It is important to understand what these "impaired" designations tell us, and what they do not tell us, about water quality in Rappahannock County's streams. First, one might easily infer that streams other than the designated "impaired" streams are NOT impaired, but that is not correct. RappFLOW volunteers sampled stream waters within the subwatersheds of two "impaired" stream segments and in subwatersheds that are upstream of the impaired stream subwatersheds. They found very high levels of fecal coliform or ecoli bacteria in some of the streams.[34] Those streams are NOT designated as "impaired" by the state. Therefore the citizen should not infer that because their stream has not been designated as "impaired" that it is therefore safe to swim or wade or go tubing in the stream.

Secondly, one might infer that since the impaired designation is based only on bacteria levels, that there are not other excessive pollutants in those impaired streams, such as excessive nutrients or suspended solids from erosion and sedimentation. This is also incorrect. There do not exist state standards by which to evaluate nutrients or turbidity in the streams, so therefore we do not have "impaired" designations for those. Similarly, a stream might lack the level of dissolved oxygen needed to support certain fish species, but not be designated as "impaired" under this system.

9.2 DEQ Ambient Monitoring Stations Data[35]

DEQ staff in each of the regional offices collects water samples on a routine schedule at more than 1,000 locations across the Commonwealth. These water samples are shipped to a state laboratory for chemical and bacterial tests. The samples are tested for levels of nutrients, solids, bacteria associated with human and animal wastes, toxic metals, some pesticides and harmful organic compounds.

DEQ's scientists also perform on-the-spot field tests for dissolved oxygen, pH, temperature,

salinity, and additional indications of water quality. Samples from the mud at the bottom of lakes and rivers also are tested for the presence of pesticides and other harmful compounds.

The DEQ ambient monitoring stations in the County are shown on Map 16.

9.3 Citizen Macroinvertebrate Monitoring Stations[36]

Volunteers trained and certified in the Virginia Save Our Streams (VA SOS) method, monitor macroinvertebrates (tiny critters) in streams. Volunteers in Rappahannock County participate in the Upper Rappahannock Watershed Stream Monitoring Program, led by the Culpeper Soil and Water Conservation District and the John Marshall SWCD (Fauquier County). The result is summarized by an index, in which a score of 0 – 6 is considered "unacceptable" and a score of 7 – 12 is "acceptable" water condition. The higher the score, the healthier the stream.

The locations currently monitored by citizen monitoring are shown on Map 16.

Stream-bottom macroinvertebrates differ in their sensitivity to water pollution. Some stream-bottom macroinvertebrates cannot survive in polluted water. Others can survive or even thrive in polluted water. In a healthy stream, the stream-bottom community will include a variety of pollution-sensitive macroinvertebrates. In an unhealthy stream, there may be only a few types of nonsensitve macroinvertebrates present.

Stream-bottom macroinvertebrates provide information about the quality of a stream over long periods of time. It may be difficult to identify stream pollution with water analysis, which can only provide information for the time of sampling. Even the presence of fish may not provide information about a pollution problem because fish can move away to avoid polluted water and then return when conditions improve. However, most stream-bottom macroinvertebrates cannot move to avoid pollution. A macroinvertebrate sample may thus provide information about pollution that is not present at the time of sample collection.

9.4 Coldwater Streams and Brook Trout Protection Area

Certain subwatersheds in Rappahannock County are included in the Trout Unlimited Brook Trout Protection area. See Map 16A. Brook trout require high water quality in cold water streams surrounded by forest land cover, and to survive a population requires high ability to travel from one small stream to another, unimpeded by obstacles such as culverts. According to Trout Unlimited,

> A recent assessment by the Eastern Brook Trout Joint Venture examined conditions from Ohio to Maine to Georgia and determined that brook trout populations in streams and rivers remain undisturbed in less than 5% of their historic subwatersheds. Brook trout are extirpated from 21% of subwatersheds. ...Like other salmonids in the char genus, brook trout are intolerant of water pollution and non-native fish, and are classic indicators of water quality and ecosystem integrity....Virginia contains a concentration of protection priorities at existing population strongholds, particularly in portions of the headwaters of the Potomac, Rappahannock and James Rivers.[37]

9.5 Special water quality studies

Volunteers have been trained to conduct water quality samples using state-approved procedures and equipment, and RappFLOW has received small grants from state and private agencies for equipment to test chemical and biological indicators of water quality. Special studies were

undertaken in the spring of 2005 in the Beaverdam Creek subwatershed and in the summer of 2006 in the Rush River subwatersheds.

9.6 Precipitation and Surface Water Flow Measurements

There is one USGS stream flow gage in the County, on Battle Run near Laurel Mills.[38] One can obtain historical data for this site for analysis of trends over time. Below is the information on data available.

USGS 01662800 BATTLE RUN NEAR LAUREL MILLS, VA
Stream/River Site

DESCRIPTION:

Latitude 38°39'20", Longitude 78°04'27" NAD27
Rappahannock County, Virginia, Hydrologic Unit 02080103
Drainage area: 25.8 square miles
Datum of gage: 374.62 feet above sea level NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Real-time	-- Previous 60 days --		
Daily Data			
Discharge, cubic feet per second	1958-05-01	2008-10-06	17609
Daily Statistics			
Discharge, cubic feet per second	1958-05-01	2007-09-30	17237
Monthly Statistics			
Discharge, cubic feet per second	1958-05	2007-09	
Annual Statistics			
Discharge, cubic feet per second	1958	2007	
Peak streamflow	1959-09-30	2007-03-02	47
Field measurements	1958-09-02	2008-08-25	495
Field/Lab water-quality samples	1968-03-28	1968-03-28	1
Additional Data Sources	**Begin Date**	**End Date**	**Count**
Instantaneous Data Archive **offsite**	1990-10-01	2006-09-30	259046
Annual Water Data Report (pdf) **offsite**	2006	2007	2

Table 6: Stream Gage Data Available from USGS

Chart 2 below shows an example of the recent flow data from the Laurel Mills gage. The triangles show the 47-year median daily statistic. Notice that after major rain event spikes, the base discharge of the stream is falling below the historic median. One speculation is that the lower base flow is due to reduced groundwater levels, but further research would be needed on groundwater in order to evaluate that idea.

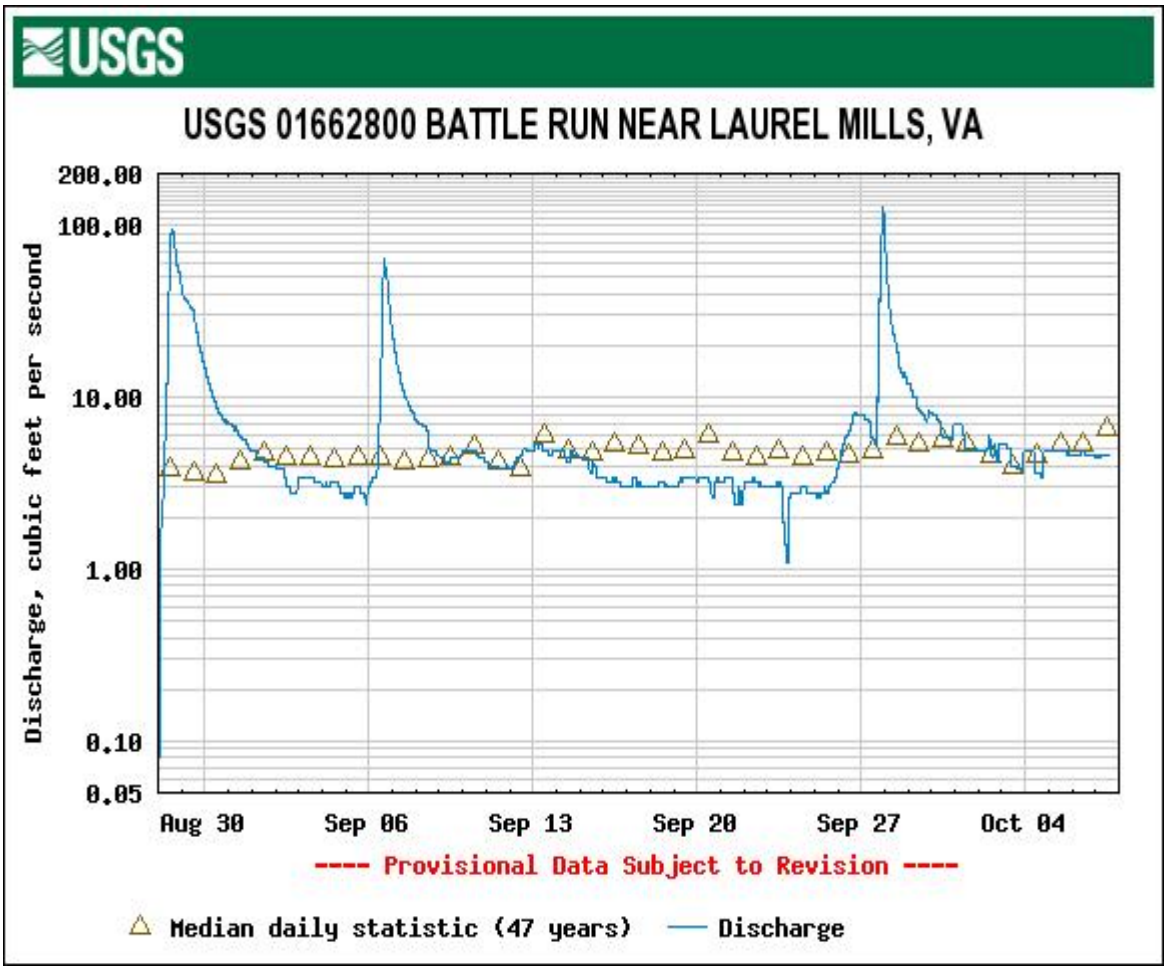


Chart 2: September 2008 Stream Flow Data at Laurel Mills Gage

9.7 Ground Water Measurements

There are currently no studies or instrumentation for measuring ground water levels and trends. This has been a subject of recent discussion with the Water Supply Planning office of the Virginia Department of Environmental Quality.

The USGS has 467 active water level monitoring wells in Virginia, but none in Rappahannock County. The nearest is near Front Royal. There are 46 monitoring wells in Clarke County and 50 in Frederick County.

9.8 Quantity and Quality of Well Water

Given the central importance of well water to 96% of residents in the county, there is a surprising lack of systematic and dependable data on the subject of the quantity and quality of well water countywide. The number of new wells drilled varies from year to year, but would probably average around 50. Sometimes a new well is drilled because a spring has gone dry, and a family

had depended on the spring for household water.

The records on quantity of well water across the county are spotty. For about 25 years, the Department of Health has received information from well drillers when they drill a well. They provide logs showing basic construction details, including depth and yield. Given the lack of standard procedures for computing these data, however, it would not likely be useful to try to use these records to identify trends over time or location. Hence there is not currently a basis for determining trends regarding well yields. Anecdotally, there appear to be some places around the county where there have been some difficulties in drilling productive water wells.

With regard to water quality in wells, the majority of homeowners who have a problem typically take a sample of their water to one of several private testing labs.

In 1992, a study was made to evaluate the quality of household well water in Rappahannock County.[39] Tap water samples were taken from the homes of 236 volunteer homeowners in the County. These were analyzed for general water chemistry. Of those participants, 195 also submitted samples for bacteriological testing. A smaller subset of samples (40) were also tested for pesticides and other compounds.

In the "nuisance" category of chemicals, iron and manganese were the chemicals that were found most frequently to exceed EPA standards, but even for those the percent of cases were only six and seventeen percent respectively. Excessive manganese can cause dark stains on laundry and cooking utensils, and give the water a bitter taste. There is a "saturation index" is a measure of corrosion potential, or corrosivity, of the water. A saturation index less than zero indicates that the water may cause corrosion in pipes, leading to dissolved lead and copper concentrations due to corrosion of pipe walls and plumbing fixtures made of these materials. Values indicating corrosivity were determined for 86% of the raw water samples and 89% of the tap water samples. The natural lack of calcium in the water and the acidic nature of Rappahannock County water supplies both contributed to the excessive corrosion potential.[40]

The major health-related concerns were corrosivity (because of its effect on plumbing systems and the potential to raise dissolved copper and lead levels in water), and bacteria. Forty percent of the samples in the bacteriological analysis tested positive for total coliform and 16% for fecal coliform bacteria.

The limited pesticide analysis revealed few problems with such contamination. Only two of the 40 samples tested had concentrations of one or more of the 32 pesticides and other compounds analyzed present in quantities exceeding EPA Maximum Contaminant Levels or Health Advisory Levels. The chemicals found in excessive concentrations were alachlor, chlordane, heptachlor, and heptachlor epoxide.[41]

10 Least-protected subwatersheds: The Lower Rush

The Lower Rush subwatershed is an area of 2,855 acres or 4.46 square miles, just south of the town of Washington. Map 18: Lower Rush Subwatershed Surface Water shows the Lower Rush with its surrounding subwatersheds, roads, and streams.
When we assessed all 26 subwatersheds in the County, the Lower Rush was determined to be one of the least well protected. Special aspects of interest in the Lower Rush include the following:

- The segment of the Rush River that flows into the Lower Rush subwatershed has been identified by the Virginia Department of Environmental Quality (DEQ) as "303d Impaired" for ecoli bacteria.
- The Rush River sometimes is at a very low flow or no flow.
- The Town of Washington has obtained a permit from VA DEQ to discharge the effluent from a public sewage treatment plant into the Rush River immediately upstream of the Lower Rush subwatershed.
- Landowners and residents in the Lower Rush subwatershed have indicated strong interest in the quality of the water in the Rush River and in the health of their watershed, as evidenced through their participation in public meetings on the subject, their participation in RappFLOW's Upper Thornton Watershed survey of landowner concerns and values, and their volunteer work to assist in this study.
- The Lower Rush subwatershed includes a mix of agricultural, residential, and commercial land uses that are representative of the land uses in Rappahannock County. By analyzing the Lower Rush subwatershed, we may identify factors and watershed management tools that will be useful to apply more broadly throughout the county and in similar rural Virginia watersheds.

10.1 Rush River and Tributary Streams

The Rush River has its headwaters in the Shenandoah National Park and flows about 12.5 miles through the Upper, Middle, and Lower Rush subwatersheds before its confluence with the Thornton River near Rock Mills. Big Branch tributary joins the Rush at the northern edge of the Lower Rush subwatershed. See Map 17.

10.2 Lower Rush Easements

Map 21 shows easements (VOF) in the Lower Rush Subwatershed. It shows all easements as of the May 2008 database, and in separate symbology those easements that were in place as of 2005. This shows the growth in easement lands over the past three years.

10.3 Lower Rush Topography and Soils

Map 19 shows the topography of the subwatershed. Most of the area is fairly flat, between 500 and 600 feet in elevation. On the northwestern edge is (name) mountain, at elevation 1200 feet, and on the eastern edge is Long Mountain at 900 feet.
Map 20 shows the erodible soils on nonforested areas in the Lower Rush subwatershed

10.4 Streams, ponds, wetlands and floodplains in the Lower Rush subwatershed.

There are a little over 15 miles of streams and about nine acres of ponds in the Lower Rush subwatershed, as calculated from the National Hydrology Database. One small, unnamed tributary to the Rush River flows from the eastern side of the town of Washington. Another small, unnamed stream flows from the western side of the town into Big Branch, which in turn is a tributary to the Rush. On the basis of the National Wetlands Inventory we calculated there are

only about 22 acres of wetlands in this subwatershed. One-hundred-year floodplains as defined by FEMA are also shown in map 18.
The amount of water flowing in the Rush River varies greatly. From 1954 to 1977, the US Geological Survey had a water flow monitoring station on the Rush River just outside the town of Washington. The meter recorded the cubic feet of water flow per second (cfps), and the average flow was recorded on a daily basis. For that thirteen-year period, the average daily flow varied from a low of zero (0) cfps on many occasions, to a high of 1140 mean daily cfps on August 18, 1955. The highest flow rate recorded was 2880 cfps on October 9, 1976. The lowest annual mean was 7.70 cfps in 1966 and the highest annual mean was 30 in 1972.

All residents in the Lower Rush subwatershed obtain their drinking water from wells. Our survey of landowner values and concerns (see section 4 below) offers 12 water issues and respondents were asked to choose THREE of the most concern to them. Out of these, 88% of respondents in the Lower Rush subwatershed chose "quality of well water" and 44% cited "adequate supply of good drinking water" as one of their biggest concerns.

10.5 Water Quality – Rush River

Water quality data for the Rush River and its tributary streams are available from four main sources:

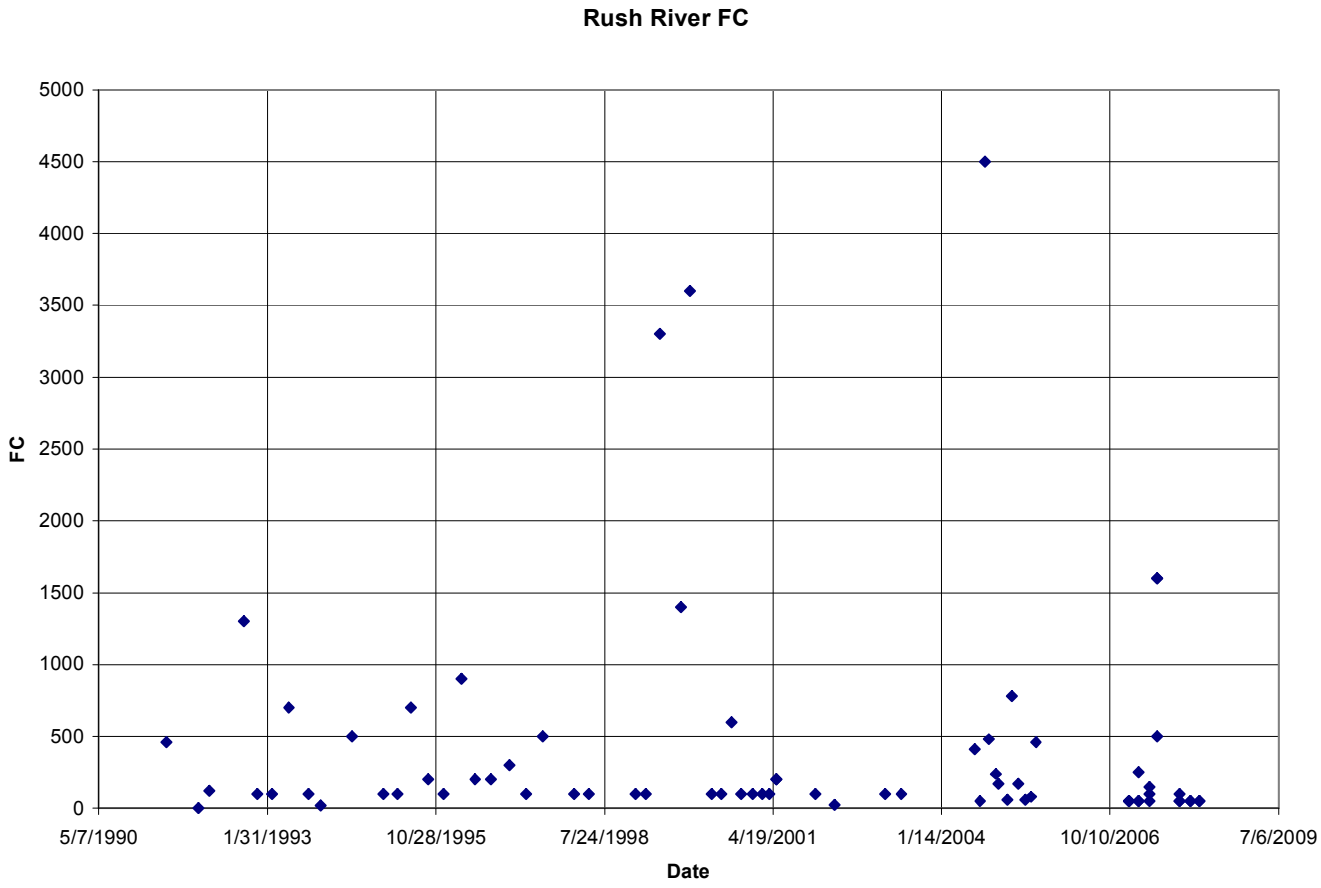
1 historical water quality data from the VA DEQ ambient monitoring station near the town of Washington;
2 information about the sources of e coli bacteria, collected by VA DEQ in conjunction with the Washington application for sewage effluent discharge;
3 Virginia Save Our Streams (SOS) invertebrate monitoring station at that same location;
4 data collected by RappFLOW volunteers in the spring of 2006 at 13 locations along the Rush River and tributaries.

RappFLOW volunteers collecting water samples in Rush River in July 2006. Photo by Ellie Clark.

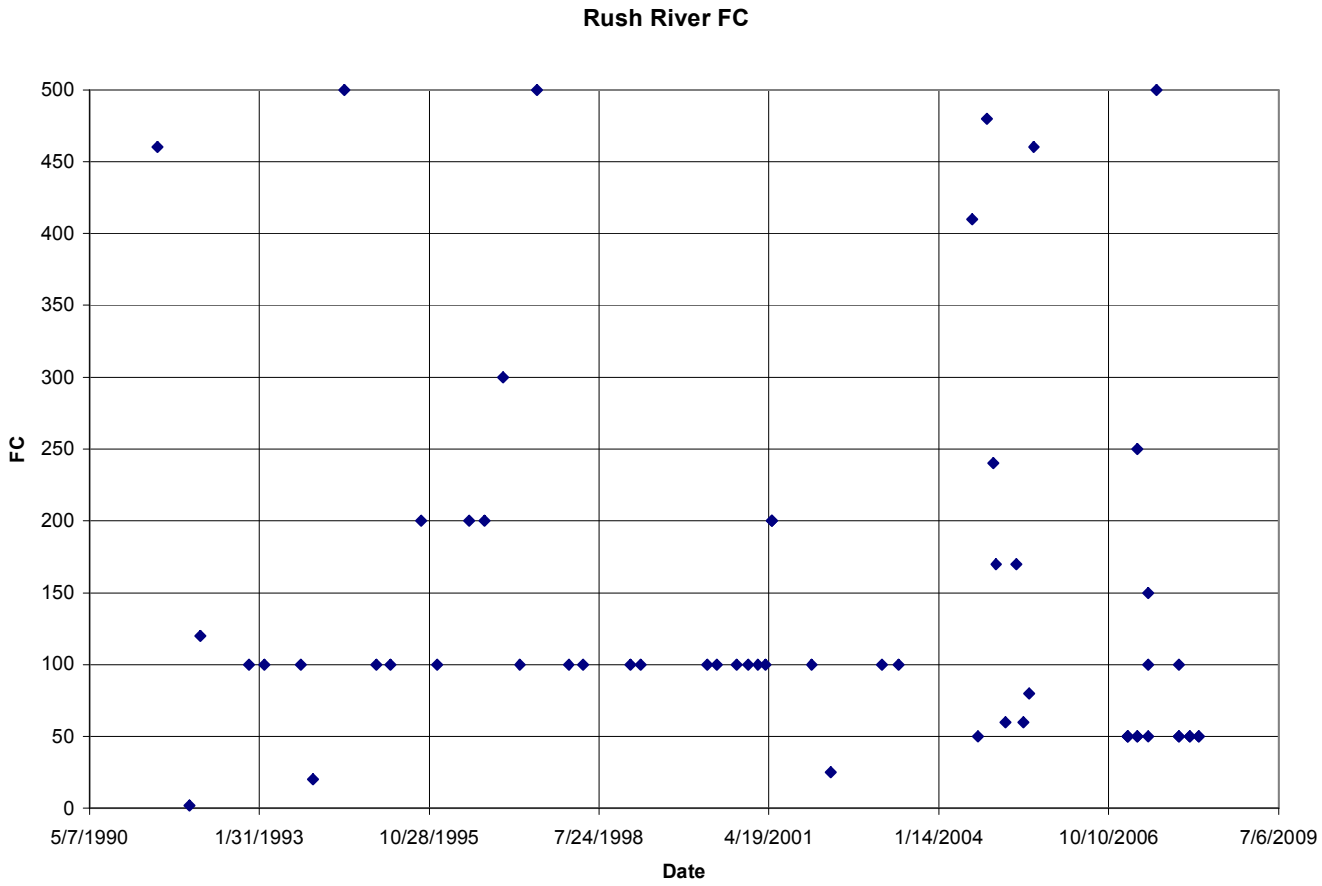
10.5.1 DEQ Monitoring Data for Rush River.

In 2004, the VA DEQ designated a segment of the Rush River as "303d impaired" for fecal coliform bacteria. Sufficient exceedances of the instantaneous fecal coliform bacteria criterion (4 of 17 samples - 23.5%) were recorded at DEQ's ambient water quality monitoring station 3-RUS005.66 at Route 211/522 to assess this stream segment as not supporting of the Recreation Use goal for the 2004 water quality assessment.

Graph 1 shows the historical data from the DEQ monitoring stations on the Rush River from 1990 to 2008 for fecal coliform, with the extremely high values shown. Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 mL of water for two or more samples over a calendar month Graph 2 shows more detail for the values below 500 colonies/100 ml.



Graph 1: Fecal coliform values from DEQ stations on Rush River.



Graph 2: Fecal coliform data from DEQ monitoring stations on Rush River, showing values up to 500 colonies per milliliter.

10.5.2 Sources of E. coli.

"Bacterial source tracking" is a method used to identify the percentage of wildlife, human, livestock, and pet sources of E. coli within a water sample. MapTech, a contractor to the VA DEQ, studied monthly water samples from the DEQ monitoring station on the Rush River outside the town of Washington between July 2004 and July 2005. In general, on those occasions when the E. coli levels exceeded the state water quality standards (September 2004 and March 2005), the predominant source was livestock. When E.coli levels did not exceed the standard, the predominant sources were wildlife, livestock, and pets. In none of the cases was the majority source attributed to humans. [42]

Table 5.68 Bacterial Source Tracking for Rush River at Station 3RUS005.66.

VADEQ ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	*E. coli* (cfu/100 ml)	Wildlife	Human	Livestock	Pet
3RUS005.66	7/28/2004	D3578	E05	24	400	8%	4%	**21%**	**67%**
3RUS005.66	8/30/2004	D3675	E05	9	70	0%	0%	**33%**	**67%**
3RUS005.66	9/28/2004	D3789	E05	24	6,000	**17%**	**12%**	**63%**	8%
3RUS005.66	10/21/2004	D3832	E05	24	142	0%	**17%**	**71%**	**12%**
3RUS005.66	11/30/2004	D3956	E05	24	164	**50%**	**29%**	**21%**	0%
3RUS005.66	12/16/2004	D4012	E05	24	90	8%	**46%**	8%	**38%**
3RUS005.66	2/8/2005	D4136	E05	18	32	**33%**	**33%**	**17%**	**17%**
3RUS005.66	3/8/2005	D4200	E05	24	790	**17%**	4%	**62%**	**17%**
3RUS005.66	4/13/2005	D4289	E05	24	171	**54%**	**17%**	4%	**25%**
3RUS005.66	5/25/2005	D4427	E05	24	90	**46%**	8%	**21%**	**25%**
3RUS005.66	6/28/2005	D4495	E05	24	122	**75%**	0%	**21%**	4%
3RUS005.66	7/26/2005	D4599	E05	24	150	**29%**	4%	**21%**	**46%**

BOLD type indicates a statistically significant value.
*NVI - No Viable isolates

This chart shows that on those occasions when the E. coli levels exceeded the state water quality standards (September 2004 and March 2005), the predominant source was livestock.

The following is from the TMDL study.[43] This study attributes over 95% of the source of fecal coliform loadings in the Rush watershed to pastures.

A synopsis of the fecal coliform loads characterized and accounted for in the Rush River (VAN-E05R-01) watershed along with average fecal coliform production rates are shown in Table 3.33. The total fecal coliform production by all sources in the Rush River (VAN-E05R-01) watershed is 6.00x1015 cfu/yr.

Table 3.33. Potential fecal coliform sources and daily fecal coliform production by source in Rush River (VAN-E05R-01) watershed.

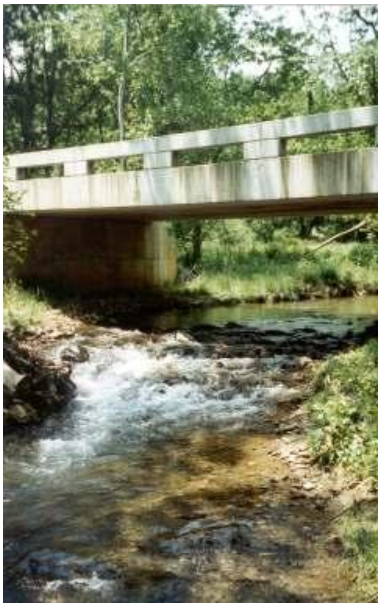
Based on the inventory of fecal coliform sources, a summary of the contributions made by the nonpoint sources to annual fecal coliform loading directly to the stream and to various land use categories is given in Table 3.34. Distribution of annual fecal coliform loading from nonpoint sources among the different land use categories is also given in Table 3.34.
From Table 3.34, it is clear in the Rush River (VAN-E05R-01) watershed that nonpoint source loadings to the land surface are more than 153 times as large as direct loadings to the streams, with pastures receiving about 96% of the total fecal coliform load. It could be prematurely assumed that most of the fecal coliform loading in streams originates from upland
Bacteria TMDLs for Rappahannock River Basin 3-33
sources, primarily from pastures. However, other factors such as precipitation (amount and pattern), manure application activities (time and method), type of waste (solid versus liquid manure), proximity to streams and environmental factors also impact the amount of fecal coliform from upland areas that reaches the stream. The HSPF model considers these factors when estimating fecal coliform loads to the receiving waters, as described in Chapter 4.

Table 3.34. Annual fecal coliform loadings to the stream and the various land use categories in the Rush River (VAN-E05R-01) watershed.

10.5.3 Macroinvertebrate data.

The macroinvertebrate monitoring station on the Rush River is near the Old Mill off Library Road. The table below shows the index for that site since 2001.

Rush River at Routes 211/522 (Station R-3)



Quarter	Index
Winter 01	9
Spring 01	12
Summer 01	12
Fall 01	10
Winter 02	10
Spring 02	9
Summer 02	9
Fall 02	no data
Spring 03	9

Quarter	Index
Summer 03	7
Winter 06	10
Spring 06	7
Summer 06	8
Fall 06	6
Winter 07	6
Summer 07	7
Winter 08	9

10.5.4 RappFLOW water quality monitoring.

In the winter of 2006, many residents and landowners in the Rush River watershed were concerned about water quality in the Rush River. This concern was expressed in several meetings related to the town of Washington's plan to discharge sewage effluent into the Rush River. In response to these concerns, RappFLOW set up a program to monitor water quality at several locations along the main stem of the Rush River and its tributaries. James Beckley of the VA DEQ assisted by training RappFLOW leaders in the use of equipment and materials for monitoring Dissolved Oxygen, pH, temperature, and E. Coli bacteria, and in establishing Quality Assurance Procedures so that the data will be useful to the DEQ. Selection of locations for monitoring was based on several considerations, including the desire to identify potential sources of the bacterial impairment of the streams, to provide a baseline reading on Dissolved Oxygen at various locations before the sewage treatment plant is constructed, and accessibility of the sites by volunteer monitors.

Trained volunteers collected and summarized data in April, May, July, and August 2006, at sixteen locations along the Rush River and its tributaries. Readings for E. coli in July are shown on Map22: RappFLOW Monitoring E. coli. Note that E. coli exceeded standards at several locations. Readings for Dissolved Oxygen in August are shown in Map 23: RappFLOW Monitoring Dissolved Oxygen.

10.6 How is the land used in the Lower Rush Subwatershed?

The ways in which the land is used, especially the extent to which forest protects the streams, is the main determinant of the health of the watershed.

10.6.1 Residential uses.

There are an estimated 120 dwellings in the subwatershed. At an average of 2.5 persons per dwelling (Census 2000), there are an estimated 300 residents. This is a population density of approximately 67 persons per square mile. By comparison, the overall county population density in 2000 was 26.2 persons per square mile.[44]

10.6.2 Land Cover.

Land cover in the subwatershed area can most easily be visualized through aerial photos. Map 24 shows the aerial photo taken in 2002.

By analyzing the National Land Cover Database, (USGS 2002), we calculated that the Lower

Rush subwatershed is approximately 46 percent forest cover, about 48 percent hay/pasture, about 3 percent low intensity residential, and contains small percentages of transitional land cover, industrial, row crops, open water, or wetlands.

10.6.3 Vegetation along Streams.

There are about 360 acres of area within 100 feet of the streams in the Lower Rush subwatershed. We used two methods to assess the vegetative cover of this buffer area.

Method 1: Aerial Photo. Using an aerial photo, we classified this stream buffer area as to whether it is fully vegetated (forest), partially vegetated, few or no trees, or a road crossing. This result is shown in Map 9: Stream Buffers. Using this method, the approximate percentages of stream buffer areas in the lower Rush are shown in Table 7:

Buffer Vegetation	**Buffer Area in Acres**	**Percent of total buffer area**
Fully vegetated	165.7	46
Partially vegetated	96	26
Few or no trees	54	15
Road crossing	44	12

Table 7: Stream Buffer Vegetation in Lower Rush Subwatershed

Method 2: NLCD. We extracted a 100-foot buffer area along the streams from the National Land Cover Database and calculated the percentage of that buffer area that was classified as forest by the NLCD. The result, 47.4 percent forested, correlates well with the results using the aerial photo method. The aerial photo method is more accurate and more current than the NLCD with respect to specific locations along the stream, but the overall percentage of forest cover is nearly the same using both methods.

Map 25 shows the stream buffer vegetation in the Lower Rush Subwatershed.

10.6.4 Roads, Private Roads and Driveways in the Lower Rush.

In addition to public roads, there are about 34 miles of private roads, lanes, driveways and farm roads in the Lower Rush subwatershed.

10.6.5 Road/Stream Intersections.

Using the method described in section x above, the Lower Rush contains 12.26 acres of road/stream intersection area. The road/stream intersection area shown in Table 7 above is considerably greater (44 acres), because that analysis is based on the aerial photo which reveals farm roads and other private roads that are not included in the county roads map.

10.6.6 Stream Buffers and Land Use.

In the Lower Rush subwatershed, most of the stream buffer areas that are unprotected by forest cover are found in areas of agricultural land use. In most cases where streams are flowing through non-agricultural residential land use, they are in forest. This is the case even on small residential parcels. On the small residential parcels where a stream is flowing through the property, compromises to the stream buffer area are typically resulting from roads and driveway crossings.

There are approximately 210 parcels in the Lower Rush subwatershed. Twenty-one parcels are 50 acres or greater. The parcels that are 50 acres or more represent approximately 43% of the total Lower Rush subwatershed area.

10.6.7 Agricultural/Forestal Districts.
As shown in Map 26, a large section of land in the Lower Rush subwatershed is in Ag/Forestal District.
10.6.8 Lower Rush Zoning
As shown in Map 27, the land area of the Lower Rush subwatershed is predominantly zoned Agricultural. In Agricultural zone, one dwelling is permitted per 25 acres. However, many smaller parcels predated the zoning ordinance and thus have higher density of dwellings. About eight percent of the Lower Rush is zoned residential or commercial. This is one of the three subwatersheds having the highest percentages of commercial and residential zoning in the County.
The County's main General Commercial zone of 60 acres on Rte. 211 is in the northwestern part of the Lower Rush subwatershed. There is also an area of a little less than 200 acres on the northeast part of the subwatershed that is zoned Rural Residential (5 acre parcels).

10.6.9 Future Development in Lower Rush Subwatershed
In the Lower Rush subwatershed, under current zoning and subdivision restrictions, approximately 110 new developable parcels could be subdivided from existing parcels in agricultural and residential zones. In addition, there are about 90 existing parcels that do not have dwellings on them. In combination, the construction of dwellings on existing parcels plus newly subdivided parcels could yield about 200 new dwellings. At an average of 2.5 persons per dwelling, this would yield an additional 500 population beyond the current estimate of 300 residents, and a population density of about 180 persons per square mile.
At present, there are on average about .16 miles of private road or driveway per developed parcel in the Lower Rush. Development of 200 parcels would add about 32 miles of private road to the present 34 miles. This would further fragment forests and compromise stream buffer areas, and contribute to sedimentation and erosion of streams.

11 Least-protected subwatersheds: White Walnut Run

White Walnut Run is an area a little less than eight square miles, north of Woodville. It is bisected by Sperryville Pike on the north-south axis, and Yancey Road bisects the watershed going east-west. . Portions of the FT Valley Road run through the western side of the watershed, and portions of Rudasill Mill Road are on the eastern side. See Map 28: White Walnut Run Aerial photo.
Map 29 shows the topography. The lowest elevation, about 500 feet, is where the White Walnut Run joins the Thornton River on the northwest edge of Red Oak Mountain. The highest point is the top of Red Oak Mountain at 1400 feet. Portions of Fielding, Red Oak, Mason, Slaughter, and Jobbers mountains are in the White Walnut Run subwatershed.

In White Walnut Run, about 42 percent of the land is forested. This is the lowest percentage of forested land cover of any of the subwatersheds. Fifty-seven percent of the land cover is hay/pasture. Twenty-six percent of the 100-foot stream buffer area is forested. This is the lowest stream buffer percentage of all the subwatersheds in the county. (See Maps 30: White Walnut Run Forest Cover and 31 Stream Buffer Vegetation.)

There are about 21 miles of streams in this subwatershed, all of which are tributaries to the White Walnut Run. White Walnut Run joins the Thornton River at the subwatershed boundary near Red Oak Mountain. At that point, the Thornton River is designated "303d Impaired" for e coli by the Department of Environmental Quality. There are no DEQ monitoring stations either

before or after the confluence of White Walnut Run and the Thornton River, so the water quality in White Walnut Run is not known at this time. See Map 31: White Walnut Run Surface Water.

About 452 acres, or 8.9 percent of land in White Walnut Run were in VOF easement as of early 2008. By comparison, for the county overall the percentage is nearly 20. Map 32 shows the land in easement.
Red Oak Valley is a large Agricultural/Forestal District on the eastern side of the subwatershed. Map 33 shows the Ag/Forestal Districts.
About 39 percent of land in White Walnut Run is in highly erodible soils on nonforested land. This is the highest percentage of all the subwatersheds. Map 34 shows these areas.
Nearly 99 percent of land in White Walnut Run is in Agricultural or Conservation Zoning. A small area of Woodville is zoned residential. Map 35 shows the zoning.

12 Least-protected subwatersheds: Upper Battle Run

Upper Battle Run is an area of 15.26 square miles, bisected by US Route 211 to the east of the Town of Washington. The intersection of US routes 211 and 522 is about in the center of this subwatershed. See Map 36: Upper Battle Run Aerial photo.
Upper Battle Run is characterized by many sloping hillsides, reflected in Maps 36 and 37. These hillsides with their varied land cover create scenic viewsheds. Portions of well-known mountains are included, such as Hickerson , Big Mulky, Fodderstack, Googe, and Round Mountain. The elevations range from about 400 feet at the lowest point where Upper Battle Run joins Lower Battle Run, to about 2400 feet in the western side in Shenandoah National Park. There are about 40 miles of streams in this subwatershed. All streams in the Upper Battle Run subwatershed drain to the Battle Run stream and thence to the Lower Battle Run subwatershed..

About 51 percent of the land is forested and about 43 percent is hay/pasture. See Maps 36 and 38. About **36** percent of the 100-foot stream buffer area is forested. See Map 39: Stream Buffer Vegetation. This is the second-lowest score for forest buffer area of all of the subwatersheds.
About 2337 acres of land, or 24 percent, in Upper Battle Run are in VOF easement as of early 2008. Map 40 shows the land in easement, which is also in the Mulkey Mountain Agricultural District. Map 41 shows the Ag/Forestal Districts. These include the Hampton Stock Farm and portions of the Mulkey Mountain Farm District.
About 32 percent of land in Upper Battle Run is in highly erodible soils on nonforested land. This is the second-highest percentage of highly erodible soils of all the subwatersheds.
Map 42 shows these areas.
Over **99** percent of land in Upper Battle Run is in Agricultural or Conservation Zoning. Map 43 shows the zoning.

13 Questions for Further Inquiry

Throughout this project, citizens and leaders have raised questions that are worthy of further study. Future studies might address these questions.

13.1 Water Quality Questions

What improvements in water quality result from implementation of Best Management Practices? What data are available to address this, and what new data need to be collected?

13.2 Precipitation and Stream Flow Questions

For water supply planning, it will be necessary to gather precipitation and stream flow data in a systematic manner.

What are the predicted effects of global climate change on our local climate in terms of precipitation patterns?

13.3 Groundwater Questions

Are groundwater levels changing?
Are wells and springs being affected by changes in groundwater levels?
How can we monitor groundwater?
Does groundwater constrain water supply for future development?

13.4 Biological Indicator Questions

What biological indicators can be used to evaluate the health of our watersheds?
How can we obtain information on fish species in particular streams?
Are there available sources of data for biological indicators?
In what ways might data from the Shenandoah National Park be of assistance in answering these questions?

13.5 Environmental Services Questions

In future, might landowners in Rappahannock County be compensated by downstream users for the protection they provide to water quality sent downstream? What market or regulatory mechanisms might make that possible?
If necessary changes were made to the nutrient trading system, might Rappahannock County landowners obtain compensation for protecting against nutrients entering the streams? What changes would be required?
Might forest landowners receive compensation for keeping forested lands performing environmental services through sustainable forestry?

13.6 Incentives for Agricultural Landowners to Protect the Streams

In addition to existing cost-sharing programs from state and federal governments, are there other programs that could make it possible for agricultural landowners to employ best management practices on their land? What further incentives could the County offer? What kinds of assistance might be provided through privately funded programs?

13.7 Sustainable Forestry Questions

In face of increasing subdivision and fragmentation of forest landholdings, what incentives are possible for forest landowners to apply practices to sustain healthy forests?
What are the threats from invasive species in our forestlands, and what can landowners do to combat these threats?

14 Goals and Tools for Protecting Vulnerable Watersheds

Taking into consideration the current status and potential future development of the vulnerable subwatersheds, and the concerns of landowners, the following are suggested goals that might be adopted and pursued by the landowners, conservation groups, county, and state government agencies.

1) Increase monitoring of water quality and water quantity, and make this information accessible to the community.
2) Particularly in the least-protected subwatersheds, increase the percentage of riparian buffer zone that is managed to provide protection for streams, water quality, water supply, and wildlife habitat.
3) Increase the percentage, countywide, of privately held land in easement.from the present 20% to 40%.

14.1 Goal 1: Increase monitoring of water quality and water quantity, and make this information accessible to the community.

Currently there are only about a dozen water quality monitoring stations active in Rappahannock County. The number of water quality monitoring locations should be continually increased, especially in the most vulnerable subwatersheds.

The historical and current data from the DEQ monitoring stations are available on the Internet, but require more technical and scientific skill to access and interpret than is typical in the general public. Methods need to be devised that will make these data more readily accessible to the general public, and to bring the data to the attention of those concerned with water quality and quantity.

There is increasing need to establish baseline information regarding precipitation, water supply and water quantity, both surface water and ground water, and then to monitor changes over time.

14.2 Goal 2: Increase the percentage of 100-foot riparian buffer zone that is managed to provide protection for streams, from the present 62 % to 80%.

The single most effective way to improve the health of our watersheds and water quality and quantity, is to increase the amount of well-vegetated buffer area along the streams.

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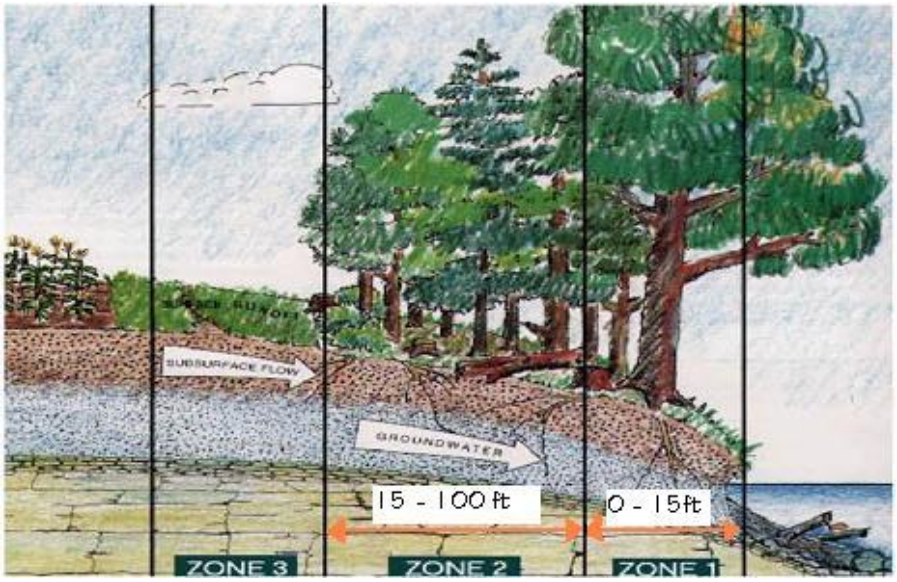

Figure 1: Riparian Buffer Zones[1]

Zone 1 occupies the first 15 feet from the stream bank and ideally should be made up of undisturbed mature forest. The primary purpose of this region of the buffer is to stabilize the stream bank and provide shade to the stream.
Zone 2 is the land from 15 to 100 feet from the bank, and is ideally a managed forest; meaning that the forest is being maintained to ensure that it is able to effectively filter the water. The primary purpose of this zone is to remove, transform, or store nutrients, sediments and other pollutants flowing over the surface and through the groundwater before they can reach the stream or aquifers.
Zone 3 is an optional zone used primarily for run off control in areas where a higher flow is expected. It typically consists of a grass filter strip that slows the run off and allows more the water to enter the ground.
Forested riparian buffers perform the following functions:

- They help prevent upland sources of pollution from reaching the stream by trapping, filtering, and converting sediments, nutrients, and chemicals.
- They supply food, cover, and thermal protection to fish and wildlife.
- They preserve the integrity of the stream in terms of aquatic organisms, depth, flow, and width by slowing the water and stabilizing the bank.
- They refresh ground water by slowing the water down and allowing it to penetrate the soil, watering plants and refilling aquifers which wells draw water from.

Tools: Conservation Incentive and Cost-Sharing Programs
The Culpeper Soil and Water Conservation District (CSWCD) and the US Department of Agriculture Natural Resources Conservation Service (NRCS) administer several programs funded by the federal and state government to provide technical and financial assistance to land owners for soil and water conservation purposes.
Here is one example of how big a difference these programs can make to a watershed. As of early 2006, there were only 86 acres of stream buffers in the Lower Rush subwatershed protected through agricultural Best Management Practices (BMPs) implemented with support of the CREP program. In that subwatershed, there were no acres of BMP's implemented through Virginia cost-sharing programs, except in conjunction with the CREP implementation. In the summer of

2006, Robert Haskell, owner of Pleasant View Farm, protected the health of the streams and the cattle with cost-sharing through a combination of CREP and Virginia incentive programs. The farm built 16,700 feet of fencing along the Rush River and its tributaries, planted trees in 42 acres of riparian buffer area, and created alternative water sources for livestock. This single project increased the percentage of forested stream buffer by about 12 percent in this subwatershed.
The 2008 Farm Bill legislation authorizes significant increases in funding for conservation practices.

Tools: Landowner education, assessments, and restoration of riparian buffers
Considerable work has been done by the County, the CSWCD, RappFLOW, and others, to reach out to the public with information and technical assistance to improve their protection of stream buffer areas. Still, mowing down to the stream or pond is a common sight everywhere in the County.
In the summer of 2006, RappFLOW began building a program to engage landowners in learning about riparian buffers and in evaluating the quality and effectiveness of buffers. This foundation includes research on the subject of riparian buffers, consultation with experts from the Department of Forestry and the CSWCD, draft handbook and buffer assessment forms, a step-by-step strategy for homeowners, and workshops conducted with landowners and other interested persons. There are numerous brochures, reference materials available. Further development and implementation of this program will be essential in meeting the goal of increasing the riparian buffer quality.

14.3 Goal 3: Increase the percentage of privately held land in easement from the present 20% to 40%.

Conservation easements vary in the extent of protections they provide for streams and groundwater. The Virginia Outdoors Foundation is increasingly requiring stronger protections for example for stream buffer vegetation. In any case, the easements do protect against future subdivision and development, and provide some help against takings by utility companies and government agencies. More than half of survey respondents cited the threat of future land subdivision and population growth as threats of highest concern. Sixty-five percent of respondents said they encourage conservation easements.
The Virginia Outdoors Foundation (VOF) currently considers for easement only parcels 100 acres or larger. About 40,000 acres in the County are still in parcels of 100 acres or more, and are not presently in easement. This provides 28% of land area candidate for additional VOF easement. In addition are a large number of forested parcels fifty acres or greater that may qualify for Department Of Forestry easement. Additional easements may be made through DHR and private land trusts.
Organizations that assist landowners in donating easements, including Piedmont Environmental Council, Rappahannock County Conservation Alliance, Krebser Fund, and the Farmland Preservation Program, might consider placing a high priority on those subwatershed areas shown by this study to be the least well protected.

Tools: VA Outdoors Foundation Conservation Easements
Conservation easements through the Virginia Outdoors Foundation (VOF) represent a significant opportunity for landowners to protect a substantial part of the land from further subdivision and development. Between 2005 and 2007, the percentage of land area protected by conservation easement (VOF) in the Lower Rush increased from less than four percent to over 9 percent. In

Rapppahannock County overall, easements represent nearly 20 percent of privately owned land area.

Tools: VA Department Of Forestry Easements

The Virginia Department of Forestry recently announced they will hold easements. The VDOF easements require a minimum of 50 acres parcel, 75% forested, and a forestry management plan. Several thousand acres in Rappahannock County qualify for this program. In addition, landowners who are currently in land use taxation under the forest use provisions of land use may choose the permanent protections of a DOF easement.

Tools: Historic Districts and Rural Historic Districts

The Comprehensive Plan encourages both historic districts and rural historic districts. The only difference is size. Washington, Sperryville, and Laurel Mills are registered historic districts. F.T. Valley (Rt. 231) is slated to become our first registered rural historic district.

If a landowner owns a property the Virginia Department of Historic Resources (DHR) considers historic, the owner can donate an easement to DHR and receive all the financial benefits of a VOF-type donation. Properties in a registered historic district are automatically eligible to apply for historic easements.

Historic easements are important to watershed protection because DHR accepts the easement on both the structure and the surrounding land. For example, a landowner with an historic property on 70 acres will likely be turned down by VOF, but accepted by DHR.

Tools: Scenic River and Scenic Byway Designations

The Virginia Outdoors Foundation looks more favorably on easement donations that front on state designated Scenic Rivers. At present, the only such river in the County is the Rappahannock.

The Department of Conservation and Recreation (DCR), which awards the designation, has recommended that several other rivers in the County be evaluated for their scenic properties. The Hughes River is in process and may be our second. Landowner groups on other major streams including the Jordan River have made some initial steps towards obtaining the designation.

VOF is also more disposed to accept an easement on properties that front on state-designated Virginia Byways. The County has four — Crest Hill Road, Fodderstack Road, F.T. Valley, and Rt. 522 from Chester Gap to the Culpeper line. The Virginia Department of Transportation shows Ben Venue Road as a Virginia Byway on its maps, although DCR has not officially recognized it.

Tools: Purchase of Development Rights (PDR)

In a PDR program, a certain value is placed upon a landowner's right to subdivide his property under existing zoning and subdivision ordinances. Those rights can be purchased by a government agency (or by some other organization such as a land trust.) This enables the landowner, such as a farmer with limited income, to obtain needed income (from the purchase of the rights), without having to subdivide and sell his property. The advantage of a PDR program to the citizens of the community is that they protect their locality from excessive population growth and hence from higher taxes in future. The program also benefits all residents of the community by keeping the land scenic and rural, as well as maintaining healthier ecosystems by avoiding development, thus contributing to the quality of life. Rappahannock County now has a limited PDR program in its Farmland Preservation Program, but that has very limited funding at present. One option for the taxpayers of the county is to encourage the county government to expand the PDR program through a small tax on property, earmarked for this purpose.

Endnotes

[1] Please see www.rappflow.org for information about RappFLOW and reports from studies.
[2] See http://www.naturalresources.virginia.gov/Initiatives/WaterQuality/FinalizedTribStrats/rappahanock.pdf for the Chesapeake Bay Nutrient and Sediment Reduction Tributary Strategy for Rappahannock River Basin (March 2005).
[3] Stream miles and pond areas were calculated based on the National Hydrographic Dataset. The wetlands data are from the National Wetlands Inventory, and these areas overlap with the ponds data.
[4] See Section 9.1 for explanation of Impaired Streams.
[5] Winer, R., T. Brown and P. Sturm. Bush River Watershed Management Plan. Center for Watershed Protection, 8391 Main St. Ellicott City, MD 21043
6 The Zoning Ordinance defines development as follows: "DEVELOPMENT — Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, the placement of mobile homes, streets and other paving, utilities, filling, grading, excavation, mining, dredging or drilling operations."

[7] The watershed assessment methodology developed by the Center for Watershed Protection focuses on impermeable surfaces which make a watershed vulnerable. We modified that methodology to focus on factors more applicable in this area.
[8] National Land Cover Classification System.
[9] National Land Cover Database, 2001.
[10] "Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations" By Paul M. Mayer , Steven K. Reynolds, Jr. and Timothy J. Canfield. U.S. Environmental Protection Agency Office of Research and Development, National Risk Management Research Laboratory Ada, Oklahoma 74820

[11] Actually, the Mississippi River is the only tenth order stream in the U.S. What the authors intend here is to emphasize that a very large river is made up of many smaller tributary streams. The smallest streams (first and second and third order) are the type of streams in Rappahannock County.
[12] See note 10.

[13] "Watershed Vulnerability Analysis" by Jennifer Zielinski, Center for Watershed Protection. January 2002. Available as pdf download at http://www.cwp.org/Resource_Library/Center_Docs/USRM/Vulnerability_Analysis.pdf.

[14] The subwatersheds delineation was based on several factors, including topography, size of areas, and USGS Hydrologic Units (HUC).
[15] In the subwatershed assessment model developed by the Center for Watershed Protection, called "Watershed Vulnerability Analysis", the vulnerability of a subwatershed is based on the percentage of impervious land cover in the subwatershed. Their method is typically used in situations where the watersheds are already compromised due to development, and the goal is to identify areas that can be restored to some extent. Instead of this model, we devised an alternative approach, more suitable for rural headwaters watersheds, that looks at the factors that protect the subwatershed, and we call this the "Subwatershed Protection Analysis."
[16] Currently the VOF is accepting easements on properties of 100 acres or larger. Other agencies

that accept smaller parcels in easement include the Virginia Department of Forestry (currently 50 acre minimum) and the Virginia Department of Historic Resources (no minimum acreage, within an officially designated Historic District.)

[17] Residential zoning of one house per acre would result in an average impervious cover of about 14%, according to Cappiella & Brown (2001). Less than 1% of the land area of the county is so zoned.

[18] VOF records as of May 8, 2008.

[19] The Upper North Fork has more points than the theoretical maximum, due to rounding in converting from percentages to protection points. It lies about 96% in the SNP, and nearly 70% of its area outside the SNP is in conservation easement.

[20] The survey instrument and report on the results is available on the RappFLOW web site http://www.rappflow.org/PDF/highlights_upperthornton_survey_july2006.pdf

[21] Please see report available at: http://www.rappflow.org/stream-buffers-2007/PDF/lRappFLOW_lessons_learned_v3.pdf

[22] See http://www.rappflow.org/rush-river/index.html for documents and news articles related to the Friends of the Rush.

[23] Added 1-7-2008

[24] Paradis, A., J. Elkinton,K. Hayhoe, and J. Buonaccorse. 2007. Role of winter temperature and climate change on the survival and future range expansion of the hemlock woolly adelgid (Adelges tsugae) in eastern North America. Mitigation and Adaptation Strategies for Global Change. Published online Oct. 11, 2007. www.springerlink.com/content/1381-2386.

[25] Available online at http://www.rappflow.org/stream-buffers-2007/

[26] "Guidelines for helping nonagricultural landowners" by Tim Bondelid. 2007. Available at http://www.rappflow.org/PDF/Guidelines%20for%20NonAg%20Evaluation.pdf

[27] Report is available at http://www.rrregion.org/pdf/publications/environment/tmdl/development/TMDL%20Development%20-%20Rappahannock%20River%20Basin%202008.pdf

[28] Page 17 in "2007 State of the Forest" Virginia Department of Forestry.

[29] For more information contact Hal Hunter. hal@rappahannock.com

[30] See http://www.rappflow.org/upper-thornton-watershed/index.html for the Pilot Study of Beaverdam Creek subwatershed.

[31] Page 22 in the report available at http://www.rappflow.org/PDF/pilot_study_sharable_V9.pdf

[32] See http://www.rrregion.org/pdf/publications/environment/tmdl/development/TMDL%20Development%20-%20Rappahannock%20River%20Basin%202008.pdf

[33] For a non-shellfish water body to be in compliance with Virginia's revised bacteria standards (as published in the Virginia Register Volume 18, Issue 20) the following criteria shall apply to protect primary contact recreational uses (VADEQ, 2000): • **Interim Fecal Coliform Standard:** Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 mL of water for two or more samples over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 mL of water. • **Escherichia coli Standard:** *E. coli* bacteria concentrations for freshwater shall not exceed a geometric mean of 126 counts per 100 mL for two or more samples taken during any calendar month and shall not exceed an instantaneous single sample maximum of 235 cfu/100mL. During an assessment period, conventional parameters such as bacteria require at least two exceedences of the standard, and an exceedance of greater than 10.5% of the total samples before a water is listed as impaired (VADEQ Assessment Guidance, 2006). If these

conditions are met, the stream segment associated with that station is classified as impaired and a TMDL must be developed and implemented to bring the segment into compliance with the water quality standard. The original impairment designation to Hughes River (VAN-E03R-01), Hazel River (VAN-E04R-01), Rush River (VAN-E05R-01), Hazel River (60076), Rappahannock River (VAN-E01R-03), Rappahannock River (VAN-E08R-04), Rappahannock River (60081), Craig Run (VAN-E08R-03), Browns Run (VAN-E08R-03), and Marsh Run (VAN-E08R-01) was based on exceedances of an earlier fecal coliform standard that included a numeric single sample maximum.

[34] See http://www.rappflow.org/upper-thornton-watershed/index.html for the Pilot Study of Beaverdam Creek subwatershed. See http://www.rappflow.org/PDF/LowerRush_subwatershed_analysis_sept06.pdf for the Lower Rush study.
[35] Historical data from these stations can be accessed at http://www.deq.virginia.gov/watermonitoring/
[36] See http://rappmonitor.va.nacdnet.org/
[37] See http://www.tu.org/site/c.kkLRJ7MSKtH/b.4348001/k.A11B/Brook_Trout.htm for discussion of the study, evaluation criteria for assessing brook trout habitat, and other scientific studies of trout.
[38] Data available at http://waterdata.usgs.gov/nwis/uv?01662800
[39] B.B. Ross, J.E. Woodard, T.A. Dillaha, T.V. Williams, H.W. Smith, and D.L. Southall. "Evaluation of Household Water Quality in Rappahannock County, Virginia." June 1992. Household Water Quality Series 3. Department of Agricultural Engineering, Virginia Polytechnic Institute and State University.
[40] Ibid. p. 10
[41] Ibid. p. 15
[42] Source: MapTech. "Bacterial source tracking analyses to support Virginia's TMDL's". 2005.
[43] See note 16
[44] Source: Rappahannock Comprehensive Plan 2004