Water Quality Improvement Plan

Crooked, Stephens, West Runs & Willow Brook

A plan to reduce bacteria in the water

August 18, 2016

Prepared by

The Virginia Department of Environmental Quality

In Cooperation with

Local Stakeholders

Department of Biological Systems Engineering,

Virginia Tech Center for Watershed Studies

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Warren County Farm Bureau
Warren Heritage Society

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A landowner's guide to Crooked Run

Crooked Run is a beautiful river, rich in history. The core of the first settlement in the northern Shenandoah Valley was in the Crooked Run watershed in between Middletown and Cedarville in the 1730's when colonists began to establish farms and homesteads in the region. The very first person to settle and build a home in what eventually became Warren County was Thomas McKay, who constructed his home at a bend in Crooked Run at the intersection of Reliance Road and Highway 340/522. Mr. McKay settled here and used what is now known as McKay springs for his drinking water and Crooked Run to water his livestock. Though much has changed in the area since then, this part of Warren and Frederick Counties has largely maintained its rural character, with the majority of the watershed in agricultural and forested land uses. Despite the fact that large portions of the land surrounding the river remain pristine, water monitoring has shown that Crooked, Stephens and West Runs and Willow Brook have high concentrations of bacteria, which means that people face an increased risk of getting sick when coming into direct contact with the water (swimming and splashing water into your eyes or mouth). As a result, these streams are included on Virginia's list of "dirty waters."

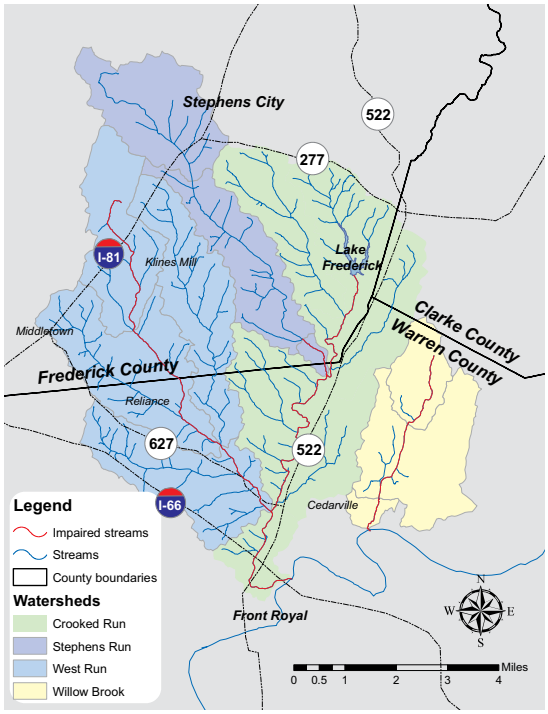
A study of the sources of bacteria in Crooked Run and Willow Brook was completed by the VA Department of Environmental Quality in 2014. Bacteria sources include failing septic systems and straight pipes (pipes discharging untreated sewage into the stream), pet waste, runoff of manure from pasture and cropland, livestock in the stream, and wildlife. This plan can act as a road map to fix these problems with the help of local landowners. The plan lists the actions needed to restore these streams so that they are considered safe for all types of recreation. Examples include: repairing failing septic systems, excluding livestock from streams, and planting trees and shrubs along the river. It is expected that it will take about ten years to remove the streams from the dirty waters list.

Many of the actions included in this plan can improve stream health *and* offer economic gains to landowners. These may include reduced veterinary bills for farmers with livestock, and higher property values for homeowners with functional septic systems. However, the upfront cost of some of these actions can be considerable. The estimated cost to make the river safe for swimming is about $8M. The good news is that there are numerous state and federal programs to help landowners with the cost of of these actions.

Outreach will be critical to make the community aware of the actions landowners can take to help, and the resources available to them. Outreach could include farm tours where BMPs have been installed and postcard mailings reminding homeowners to have their septic tank pumped every 3-5 years. Key partners in this effort include: USDA Natural Resource Conservation Service, the Lord Fairfax SWCD, the Health Department, Clarke, Frederick and Warren Counties and local landowners.

What is needed to clean up Crooked Run and Willow Brook?

The list of actions below is an estimate of what it would take to make these streams safe for all kinds of recreation. While the list is long and the extent of work needed is large, it is important to remember that if everyone makes small changes in their daily lives, it will make a BIG difference in the river.



Residential actions:

- 584 Septic tank pumpouts
- 5 Connections to public sewer
- 340 Septic system repairs
- 30 Septic system replacements with conventional systems
- 112 Septic system replacements w/ alternative waste treatment sys.
- 2 acres streamside plantings
- 8 Pet waste disposal stations
- 20 Pet waste composters/digesters
- 1 Pet waste education program
- 10 acres treated by rain gardens and bioretention filters
- 70 acres treated by detention basin retrofits

Agricultural actions:

- 17.8 miles livestock stream exclusion fence (includes length of fence on both sides of the stream)
- 9,091 acres improved pasture management
- 4 acres vegetative cover on critical areas of pasture (highly eroded or denuded areas)
- 362 acres tree planting on highly erodible pasture
- 122 acres annual cover crop plantings
- 0.4 acres streamside plantings on cropland
- 23 acres continuous no till
- 43 acres permanent vegetative cover on cropland

To learn how you can help:

- Technical and financial assistance with agricultural practices

  Lord Fairfax Soil and Water Conservation District
  website: http://lfswcd.org phone: (540)465-2424 extension 5

- Information about septic system maintenance, contact your local Health Department

  Frederick County phone: (540)722-3482
  Warren County phone: (540)635-3159
  Clarke County phone: (540)955-1033
  website: www.vdh.virginia.gov/LHD/LordFairfax

- Information about water quality, citizen monitoring, and TMDL implementation

  Virginia Department of Environmental Quality
  website: www.deq.virginia.gov phone: (540)574-7850

INTRODUCTION

The Clean Water Act (CWA) of 1972 requires that all of our streams, rivers, and lakes meet the state water quality standards.

The CWA also requires that states conduct monitoring to identify polluted waters that do not meet standards. Through our monitoring program, the state of Virginia has found that many streams do not meet state water quality standards for protection of the five beneficial uses: recreation, the production of edible and marketable natural resources, aquatic life, wildlife, and drinking. When streams fail to meet standards they are placed on the state's impaired waters list, and the state must then develop a Total Maximum Daily Load (TMDL) for each pollutant. A TMDL is a "pollution budget" for a stream, meaning that it sets limits on the amount of pollution that a stream can tolerate and still maintain water quality standards. In order to develop a TMDL, background concentrations, point source loadings, and non-point source loadings are considered. Non-point source pollution occurs when pollutants from multiple sources are transported across the land to a body of water when it rains. Point source pollution occurs when pollutants are directly discharged into a stream. Through the TMDL process, states establish water-quality based controls to reduce pollution and meet water quality standards.

Water quality problems in Crooked Run and Willow Brook:

TMDLs were completed for Crooked Run and its tributaries and Willow Brook in 2014 after water quality monitoring showed that the rivers were violating the State's water quality standard for bacteria. This standard is based on the concentration of *E. coli* bacteria in the water, and is designed to minimize the risk of illness or infection after coming into contact with the water. The standard states that the *E. coli* bacteria count should not exceed a geometric mean of 126 cfu per 100 mL of water for two or more samples taken over a 30-day period. In addition, a stream will be placed on Virginia's impaired waters list if over 10.5% of samples collected during a 6-year assessment window exceed 235 cfu per 100 mL. Table 1 shows the frequency at which the rivers are violating this standard based on monitoring by the Virginia Department of Environmental Quality (VADEQ).

Table 1. Monitoring stations in the Crooked, Stephens, West and Willow Brook watersheds and violation rates of the *E.coli* water quality standard.

Station ID	Stream Name	Description	# of samples	Violation rate	Sampling period
1BCRO002.75	Crooked Run	Off Rt. 627	104	15.4%	2005-2015
1BSTV000.20	Stephens Run	Near Rt. 639 Bridge	101	12.9%	2003-2015
1BWLO000.71	Willow Brook	Near Rt. 658 Bridge	43	34.9%	2004-2014
1BWST000.20	West Run	Near Rt. 609 Bridge	75	17.3%	2005-2014

Creating a Water Quality Improvement Plan

Once a TMDL is developed for a stream, the next step is to create a plan that identifies how the pollutant reductions identified in the TMDL can be achieved. A water quality improvement plan (also known as a TMDL implementation plan) describes actions that can be taken by landowners in the watersheds that will result in improved water quality in the stream. There are nine components included in an implementation plan:

1. Causes and sources of bacteria that will need to be controlled to meet the water quality standards
2. Reductions in pollutants needed to achieve water quality standards
3. Management measures (BMPs) that will need to be implemented to achieve the pollutant reductions
4. Technical and financial assistance needed, associated costs, and the authorities that will be relied upon to implement the plan
5. An information/education component that will be used to enhance public understanding on the project and encourage participation in selecting and implementing best management practices
6. A schedule for implementation of the practices identified in the plan
7. Goals and milestones for implementing best management practices
8. A set of criteria for determining if bacteria reductions are being achieved and if progress is being made towards attaining water quality standards
9. A monitoring program to evaluate the effectiveness of the implementation effort

(VADCR & VADEQ, 2003)

REVIEW OF TMDL STUDY

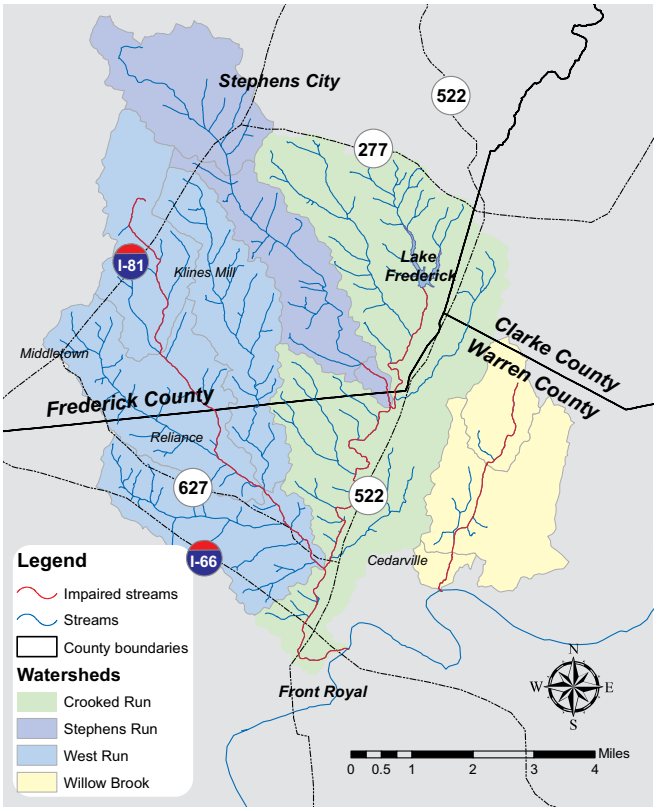


Figure 1. Location of the watersheds

Watershed Characteristics

Crooked Run and its tributaries (Stephens and West Runs) are located primarily in Frederick and Warren Counties, and a small portion of the Crooked Run watershed reaches into Clarke County. The Willow Brook watershed is located in Warren County. Crooked Run empties into the Shenandoah River's mainstem in Front Royal, while Willow Brook discharges to the Shenandoah River approximately 4 miles downstream. As shown in Figure 1, the impaired segment of Crooked Run extends 8.87 miles from the Lake Frederick dam down to its confluence with the Shenandoah River (VADEQ, 2002). The impairment on Stephens Run is less than a mile long, extending from its confluence with an unnamed tributary down to its confluence with Crooked Run. West Run is impaired from its headwaters to its confluence with Crooked Run (6.12 miles) and Willow Brook is impaired from its headwaters 3.95 miles downstream to its confluence with the Shenandoah River (VADEQ, 2010, 2006).

Land uses in the watersheds are shown by county in Table 2. According to the 2012 Census of Agriculture, the average farm in Frederick County is 148 acres, and 139 acres in Warren County. Over 60% of primary farm operators in both counties identified their primary occupation as something other than farming. The average net cash income for a farm in Frederick County was estimated at $5,167, and -$5,083 in Warren County (USDA, 2012).

Table 2. Land use acreages in the watersheds by county.

Land use	Clarke	Frederick	Warren	TOTAL
Cropland	115	1,063	252	1,430
Forest	45	6,800	5,844	12,689
Hayland	69	1,648	1,317	3,034
High intensity development	0	77	117	195
Low intensity development	75	2,059	1,866	4,000
Pasture	517	6,650	5,732	12,898
Transportation	13	77	102	192
Water	4	172	61	238
TOTAL	**837**	**18,548**	**15,290**	**34,675**

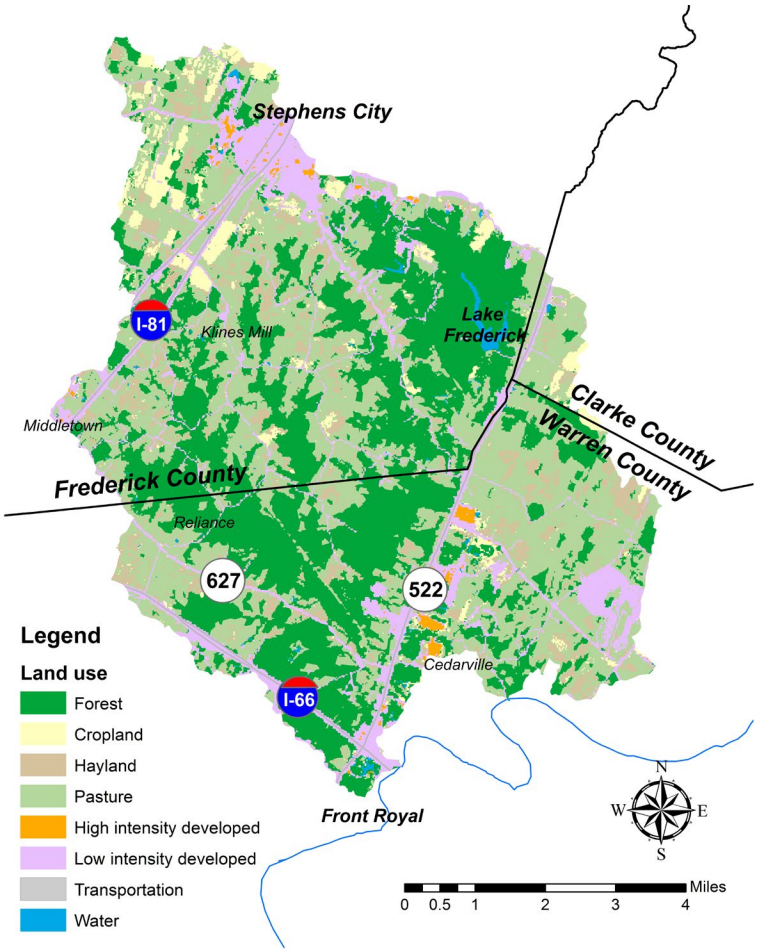


Figure 2. Watershed land use

Sources of Bacteria

Agricultural runoff, direct deposition of manure in streams by livestock, and wildlife have been identified as the primary sources of bacteria in the rivers. Non-point sources of bacteria in the watersheds include failing septic systems, livestock, wildlife, and domestic pets. Point sources including individual residences can contribute bacteria to streams through their permitted discharges. There are currently 89 point sources permitted to discharge bacteria in the watersheds, 79 of which are single family home permits. There are seven permitted facilities in the Crooked Run watershed and one in the West Run watershed. All of these facilities and homes are permitted to discharge at a concentration of 126 cfu *E. coli*/100mL, bringing the total point source *E. coli* load to $1.68x10^{12}$ cfu/year.

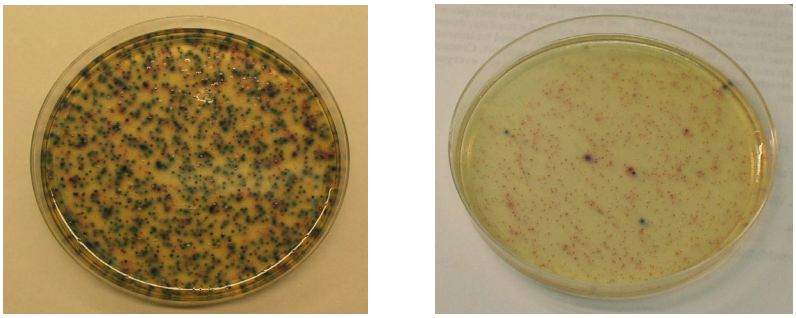


Photo shows coliscan plates, which reveal the presence and abundance of *E.coli* colonies (blue dots) and coliform bacteria colonies (red dots) in a stream where livestock have access (left) and where they have been excluded (right). Photo: Bobby Whitescarver, NRCS

Goals for Reducing Bacteria

The TMDL study completed for the rivers identified goals for reducing bacteria from the different sources in the watersheds. The goals shown in Table 3 below are based on what it would take to remove the creeks from the impaired waters list. This can occur when the single sample water quality criterion for *E. coli* (235 cfu/100mL) is violated no more than 10.5% of the time. The TMDL also identifies greater reductions in non point source pollution that are needed in order to achieve a 0% violation rate of the geometric mean standard of 126 cfu/100mL. This standard is based on a rolling average *E. coli* concentration and requires a larger . However, the focus of this plan is on achieving de-listing of the streams since even healthy streams may occasionally violate our water quality standards. De-listing will occur based on compliance with the single sample criterion as described above.

Table 3. Bacteria reduction goals for removal of streams from the impaired waters list (VADEQ, 2014)

Watershed	**Fecal Coliform Reduction from Source Category (%)**					**% Violation of *E.coli* standard** (Single sample criterion)
	Straight Pipes & Failing Septic	Livestock stream access	Pasture runoff	Cropland runoff	Urban/Res. runoff	
Crooked Run	100%	45%	40%	10%	5%	10%
Stephens Run	100%	20%	34%	10%	5%	10%
West Run	100%	78%	43%	10%	0%	10%
Willow Brook	100%	80%	35%	10%	0%	10%

COMMUNITY PARTICIPATION

Collecting input from the local community on conservation and outreach strategies to include in the water quality improvement plan was a critical step in this planning process.

A public meeting was held on the evening of January 28, 2016 at Lord Fairfax Community College in order to kick off development of the plan. This meeting served as an opportunity for local residents to learn more about the problems facing the creeks and work together to come up with new ideas to protect and restore water quality in their community. The meeting was publicized through notices to local media outlets, email announcements, invitations mailed to riparian landowners, and fliers distributed in the watersheds. The meeting included a presentation by VADEQ staff on current water quality issues in the watersheds and development of the plan. This presentation was followed by break out sessions to collect local input on characteristics of the watersheds and ideas regarding what to include in the plan. Approximately 25 people attended the meeting. A final public meeting was held on June 29, 2016 at the North Warren Volunteer Fire Department to present the completed draft plan to the public and collect local input.

Two working groups (agricultural and residential) were formed in order to discuss implementation and outreach strategies suitable for different land uses in the watersheds. Each working group was made up of stakeholders who were familiar with land use management issues specific to their particular working group focus area. Both working groups met twice during the development of this plan.

The role of the Agricultural Working Group was to review conservation practices and outreach strategies from an agricultural perspective. During the first agricultural working group meetings, which was held as a break out session during the first public meeting in January, the group discussed the status of

farming in the region and characteristics of typical farms in the watershed. Concerns were expressed about the impact of development on local farms in northern Virginia, though it was noted that the Willow Brook watershed has been subject to far less development pressure than the other watersheds and that it was more likely to stay in agricultural land use. It was also noted that the Friends of the Shenandoah River received a grant to implement BMPs and do water quality monitoring in the Willow Brook watershed. More small organic farms are coming into the region, but that start up costs for larger operations are cost prohibitive. Many farms in the area are leased (at least 50%). Many of the landowners in the region are older and no longer farm their own land. It was noted that it's hard to even find land to lease in the region, and that it's very competitive when property comes up to lease. The group agreed that long term leases are much better for farmers than short term (1 year agreements), 5-10 years was noted as ideal. If a longer lease agreement can be reached, the farmer may be more interested in implementing BMPs such as livestock exclusion systems. It was also noted that there has been an increase in the use of poultry litter in the watershed on both crop and hay land.
DEQ staff asked participants about potential partners for outreach activities. Participants suggested VA Cooperative Extension along with the local Farm Bureaus. In order to gage local interest in different BMP options and identify the most suitable livestock exclusion fencing systems for inclusion in the plan, a survey was distributed to meeting participants. Everyone was asked to rank a series of BMPs along with a series of obstacles to livestock exclusion. Livestock exclusion and riparian buffers were ranked as the two most important BMPs to include in the plan, and cost and fence maintenance were identified as the two largest obstacles to installing livestock exclusion fencing.

A second agricultural working group meeting was held on March 8, 2016 at the Front Royal Volunteer Fire Department. The group reviewed the different types of livestock exclusion systems that are available for cost share through state and federal programs. Even with 75% of the costs paid for through these programs, fencing remains cost prohibitive for some farmers. Maintenance issues were discussed included repairing washed out fencing and controlling invasive species. One participant suggested working with the Department of Corrections to both maintain fences and put them up. This could decrease the cost of installing the initial fencing and also save farmers time and money when it comes to maintenance. It was noted that there are only three farms located along Willow Brook where the creek is actually flowing. Two of these farms have already excluded their cattle from the stream, leaving only one farm in the watershed to install fencing before the whole stream is excluded from livestock. A participant at the meeting explained that the water quality issue in Willow Brook is really driven by livestock in the stream rather than runoff based on the soils found in the watershed and the hydrology. The group also discussed the use of rotational grazing in the watershed. Participants agreed that it was an environmentally and economically beneficial practice, but that it takes a lot of time and effort. VA Cooperative Extension has been holding a series of workshops on how to increase the number of days you can graze each year along with a "fencing school" for farmers. The group agreed that it would be a good idea to approach Cooperative Extension about a partnership to bring these programs to the area in a more targeted manner. Cropland BMPs were also discussed, and the group agreed that practices such as cover crops and continuous no till are likely to be underreported to the Soil and Water Con-

servation District, which has cut back their cover crop program to a tax credit only program for the past two years. However, the group agreed that there is still more room for cover crops and no till on the remaining cropland in the watershed. The group voted on a timeline for implementation efforts needed in order to remove the creeks from the impaired waters list, and 10 years was agreed upon.

The primary role of the Residential Working Group was to discuss methods needed to reduce human sources of bacteria entering the creeks, recommend methods to identify and correct or replace failing septic systems and straight pipes, and provide input on the BMPs to include in the plan. At their first meeting on January 28th, the residential working group discussed the need for increased education and outreach regarding septic system maintenance. Participants thought that education on septic systems and alternative waste treatment systems could be targeted towards realtors and homebuilders in addition to homeowners in the watershed. Any outreach efforts that are made should emphasize the voluntary nature of assistance programs since fear of any regulatory responses from the Health Department will be an obstacle in terms of getting homeowners with septic system problems and straight pipes to come forward. It was suggested that the VA Department of Health work with local realtors to require the inclusion of the capacity of septic systems in real estate transactions. The Friends of the Shenandoah River has worked with homeowners on septic tank pumpout programs in the past, which provided assistance with the cost of pumpouts. It was noted that there are many challenges associated with working in karst/shale topography with respect to septic systems and alternative waste treatment systems. The percentage of alternative systems is higher than average in the watersheds because this topography makes it difficult to install a conventional drainfield. The group discussed potential partner organizations for rain garden installations in the watersheds including Front Royal Tree Stewards and the Garden Club of Warren County. During a discussion about pet waste management strategies, it was noted that peer pressure is a key component in getting pet owners to pick up after their pets. It was noted that there is a need for sanitary facilities at Lake Frederick for fishermen after peak fishing season. Currently facilities are not available year round. Participants discussed other outreach opportunities regarding septic systems and pet waste. A local newspaper education campaign was suggested. The campaign could make the connection between groundwater science, septic system maintenance and financial cost share. Coliscan monitoring was suggested as a good tool for making upstream downstream comparisons to convince landowners to exclude their livestock. Friends of the Shenandoah River is already doing some bacteria testing in West Virginia. They already have an excellent monitoring network that they are willing and able to expand. McKay Springs was identified as a particular location the needs some additional monitoring. Another participant suggested launching a drinking water campaign. "Taste of the Shenandoah" could work with participating businesses and local Chambers of Commerce to stress local resources, health and taking care of our children by caring for our water. Local schools could also be involved in monitoring and outreach. They could play an important role in recruiting local service organizations such as Boy Scouts and Girl Scouts. Envirothon could be another tool to reach out to the local community. The group reviewed overall residential priorities and ranked them in order of importance: 1) Straight Pipes and Failing Septics 2) Homeowner Education 3) Connections to public sewer.

A second Residential Working Group meeting was held at the Lord Fairfax Community College on April 7, 2016. The group discussed targeting strategies for septic system program outreach and suggested focusing on homes closest to streams and springs when doing initial outreach mailings. Potential neighborhoods for pet waste stations were discussed as DEQ staff explained that these stations would be most effective in densely developed areas with very small lots. The group thought that it would be a good idea to identify neighborhoods with Homeowners Associations (HOAs) since these areas may have the resources needed to ensure that the stations are stocked with bags and that trash is collected regularly. The only development in the Warren County portion of the watershed with an HOA is the Blue Ridge Shadows Golf Course. Several neighborhoods at the northern end of the Stephens Run watershed were identified for pet waste stations along with the Forest Lakes Estates development in Crooked Run. All of these developments are located in Frederick County. In addition, the group agreed that there might be an opportunity to install a 1.3 acre riparian buffer behind one of the developments in Stephens Run. The group discussed opportunities for residential riparian buffer plantings in the watersheds. The Department of Forestry would probably be able to provide seedlings and VA Master Naturalists could help with a tree planting as well. The group suggested working with the Garden Club or the Native Plant Society to select attractive riparian plants for residential buffers.

The group discussed potential locations for stormwater management BMPs in the Crooked and Stephens Run watersheds. It was noted that Riverton Commons already has a pretty sophisticated stormwater management treatment system and probably wouldn't be a good candidate for additional BMPs. The group discussed the idea of working with Sherando Park and Sherando High School on stormwater practices. The high school has a great agricultural department along with horticultural groups, who would likely be interested in helping to maintain a stormwater BMP such as a rain garden or bioretention filter. The following commercial/industrial properties in Warren County were identified as potential BMP retrofit sites: Holiday Inn, Front Royal, Sysco Systems, Ferguson, VA Inland Port, and the Economic Development Authority (estimated 70-80 acre drainage area, adjacent to Sysco).

The group discussed opportunities to partner with local organizations on education and outreach. VA Master Naturalists might be interested; however, it will be important to adopt a watershed wide approach rather than just focusing on outreach to a few specific property owners as this is their priority. The Native Plant Society would be a good partner for riparian buffer plant selection. Local realtors could be good sources of information about neighborhoods in the watershed. Civic clubs such as Rotary and Ruritans could be another great partner in outreach. While Lord Fairfax SWCD could be a great partner in outreach for both agricultural and residential practices, additional staffing at the SWCD office would be needed in order to support this sort of targeted outreach by the SWCD.

The group discussed an appropriate timeline for completion of residential/urban BMPs. The cost of the alternative waste treatment systems needed in the watersheds was noted as an obstacle to completing the work on a tight timeline. The group agreed that the timeline could note that the bulk of the alternative waste treatment systems would be installed later on in the project timeline rather

than spreading implementation out evenly across each year. This would allow partners to continue to identify other funding sources for support and build local momentum. The group agreed upon a 10 year implementation timeline

The Steering Committee met on May 24, 2016 at the Lord Fairfax Community College to discuss plans for the final public meeting and to review a draft of the implementation plan. The group provided feedback on potential speakers for the final public meeting in addition to potential locations and timing.

The final public meeting was held on June 29, 2016 at the North Warren Volunteer Fire Hall. This meeting kicked off a 30-day public comment period during which the public could submit written comments on the draft plan. During the meeting, DEQ staff provided an overview of the process used to develop the plan and a summary of its contents. Guest speakers provided additional background information on the Crooked Run watershed, and community members were invited to offer feedback and ask questions. Several partner organizations set up displays around the room and provided attendees with informational materials about their existing programs.

IMPLEMENTATION ACTIONS


Photo: Brian Walton, Thomas Jefferson SWCD

An important part of the implementation plan is the identification of specific actions that will improve water quality in the watersheds.

This section provides a summary of what is needed to achieve the bacteria reductions specified in the TMDL study. Since this plan is designed to be implemented by landowners on a voluntary basis, it is necessary to identify actions including management strategies that are both financially and technically realistic and suitable for this particular community. As part of this process, the costs and benefits of these actions must be examined and weighed. Once the best actions were identified for implementation, estimates of the number of each action that would be needed in order to meet water quality goals were developed.

Management Actions Selected through Stakeholder Review

While management actions such as livestock exclusion and correction of failing septic systems were directly prescribed by the TMDL, a number of additional measures were needed to control bacteria coming from land-based sources. Based on the TMDL study, significant load reductions from pasture runoff are needed in order to de-list Crooked, Stephens and West Runs and Willow Brook. Various scenarios were developed and presented to the working groups, who reviewed both economic costs and the water quality benefits. The majority of agricultural best management practices (BMPs) in this plan are included in state and federal agricultural cost share programs that promote conservation. The final set of practices identified and the efficiencies used in this study are listed in Table 4. It should be noted that an adaptive management strategy will be utilized in the implementation of this plan. BMPs that are easiest to implement, provide the greatest water quality benefits, and offer the greatest economic return to landowners will be implemented first. The effectiveness of these practices will be continually evaluated, and adjustments to actions will be made as appropriate. As new technologies and innovative BMPs to address bacteria become available, these practices should also be evaluated for implementation in the watersheds.

Table 4. Bacteria reduction efficiencies for best management practices. Table shows the percent of bacteria received each BMP is capable of preventing from entering the stream.

BMP Type	Description	Bacteria Reduction	Reference
Livestock stream exclusion	Livestock exclusion from waterway	100%	1
Pasture	Streamside buffer (35-100 feet)	52.69%	2, 5
	Improved pasture management	50%	3
	Permanent vegetative cover on critical areas	LU Change	4
	Reforestation of highly erodible pasture/cropland	LU Change	4
Cropland	Cover crops	20%	5
	Continuous no till	64%	2, 5
	Riparian buffers	52.69%	2, 5
Straight pipes and septic systems	Septic tank pumpout	5%	7
	Connection to public sewer	100%	1
	Septic system repair	100%	1
	Septic system replacement	100%	1
	Alternative waste treatment system	100%	1
Residential/ Developed	Pet waste disposal station	75%	6
	Pet waste composter/digester	100%	1
	Pet waste education program	50%	6
	Riparian buffer	50%	2,5
	Rain garden	55%	2,5
	Bioretention filter	55%	2,5
	Detention basin retrofit with constructed wetland	50%	2,5,8

References

1. Removal efficiency is defined by the practice
2. Bacteria efficiency assumed to be equal to sediment efficiency.
3. VADCR and VADEQ. 2003. Guidance manual for Total Maximum Daily Load Implementation Plans. Available at: www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDLImplementationPlanGuidanceManual.aspx
4. Based on differential loading rates to different land uses.
5. Chesapeake Assessment Scenario Tool - BMP effectiveness values by land use and HGMR and pollutant
6. Adapted from Swann, C. 1999. A survey of residential nutrient behaviors in the Chesapeake Bay. Widener Burrows, Inc. Chesapeake Bay Research Consortium. Center for Watershed Protection. Ellicott City, MD. 112 pp
7. Bacteria efficiency assumed equal to nitrogen removal efficiency - Chesapeake Assessment Scenario Tool - BMP effectiveness values by land use and HGMR and pollutant
8. Retrofit efficiency calculated by subtracting the existing BMP efficiency of 10% for dry detention basins from the increased efficiency of wet ponds and wetlands of 60% to simulate the impact of the BMP restoration project. Should treatment areas for individual basins in Crooked and Stephens Runs be identified, the Retrofit Removal Rate Adjustor Curves developed by the Chesapeake Bay Expert Panel to Define Revoal Rates for Urban Stormwater Retrofit Projects should be used to predict subsequent reductions.

LIVESTOCK IN THE STREAMS

An estimated total of 18 miles of stream exclusion fencing for livestock will be needed to de-list Crooked Run and its tributaries and Willow Brook.

To estimate fencing needs, stream segments that flowed through or were adjacent to pasture were identified using GIS mapping. Not every pasture has livestock on it at any given point in time; however, it is assumed that all pasture areas have the potential for livestock access, meaning that livestock exclusion fencing should be installed. Data on stream fencing already in place was collected from the VADCR Ag BMP Tracking database and subtracted from the estimate of total fencing needed. A total of 7 miles of fencing was installed in the watersheds between 1999 and 2013.

It is expected that the majority of fencing will be accomplished through the VA Agricultural BMP Cost Share Program and federal NRCS cost share programs. These programs typically require that landowners enter into a 10-year contract during which they must maintain the fencing system. In order to determine the appropriate mix of fencing practices, tax parcel data was utilized in conjunction with local data from the VADCR Agricultural BMP Database to determine typical characteristics of livestock exclusion systems in the region (e.g., streamside fencing length per practice). In addition, input was collected from the Agricultural Working Group regarding typical components of each system, associated costs, and preferred fencing setbacks. An estimated 17.8 miles of fencing (includes fencing on both sides of the stream where applicable) will be needed to remove the streams from the impaired waters list: 9.3 miles in Frederick County, 7.5 miles in Warren County, and 1 mile in Clarke County.

Table 5. Fencing needs assessment

Description	Crooked Run	Stephens Run	West Run	Willow Brook	TOTAL
% livestock stream exclusion needed for de-listing	45%	20%	78%	80%	40%
Stream fencing needed (ft)	30,816	7,170	54,073	1,770	93,828

A summary of cost share programs available to farmers interested in installing fencing is provided in the funding section on pages 44-47. The codes shown in blue in the paragraph below were taken from these programs. Incentive payments vary based on the width of the streamside buffer that is installed between the fence and the stream. The portion of fencing that will be accomplished using different fencing practices was based on historical data and input from farmers and agricultural conservation professionals.

If a landowner can afford to give up 35 feet for a buffer along the stream, then they are eligible to receive cost share at a rate of 80%-85% for stream fencing, cross fencing and providing alternative water. It is estimated that **55%** of the total fencing will be installed using this practice (codes LE-1T and SL-6T). For those who are willing to install a 35 foot buffer or larger and plant trees in the buffer, USDA-NRCS's Conservation Reserve Enhancement Program (CREP) is an excellent option. This practice provides cost share and incentive payments ranging from 50% to 115% for fencing and planting materials. It is estimated that 2**0%** of fencing in the watersheds will be installed through CREP. Farmers who cannot give up 35 feet or more for a streamside buffer can receive 50% cost share for the installation of fencing with a 10-foot setback, cross fencing, and an alternative water source for their livestock. Since the agricultural working group felt that fencing costs were the primary obstacle to livestock exclusion, the extent of this practice was kept low due to the lower cost share rate provided. It is estimated that **15%** of fencing in the watersheds will be installed using this practice (code LE-2T). The stream protection practice (WP-2T)available through the state cost share program is a good fit for farmers who do not need to develop alternative water systems or establish rotational grazing. This practices provides the farmer with 75% cost share to install stream exclusion fencing and crossings on small streams. A 35 foot buffer is required, and an up front incentive payment of $0.50/linear foot of fence is provided to assist with expected fence maintenance costs. It was estimated that a small portion of fencing (**10%**) would be installed using this practice. The agricultural working group suggested working with the Dept. of Corrections to develop a fencing and buffer maintenance program to help farmers maintain fencing and buffers.

Table 6. Livestock exclusion BMPs (feet and number of exclusion systems)

Watershed	Fencing by Exclusion System Type (linear feet and # of practices)							
	LE-1T/SL-6T		CREP		LE-2T		WP-2T	
	Feet	#	Feet	#	Feet	#	Feet	#
Crooked Run	16,949	4	6,163	2	4,622	1	3,082	1
Stephens Run	4,625	2	1,434	1	1,075	1	0	0
West Run	29,740	12	10,815	4	8,111	3	5,407	3
Willow Brook	1,770	1	0	0	0	0	0	0
TOTAL	**53,083**	**19**	**18,412**	**7**	**13,809**	**5**	**8,524**	**4**

IMPLEMENTATION ACTIONS FOR PASTURE

Runoff from pastures can carry with it bacteria from manure deposited on the land on its way to the stream.

Improved pasture management can prevent overgrazing by livestock, thereby reducing runoff, increasing filtration and vegetative uptake of pollutants, and allowing farmers to better utilize their pastures. This practice includes: maintaining minimum forage height during the growing season, application of lime and fertilizer when needed, following a nutrient management plan, controlling woody vegetation, distributing manure through managed rotational grazing, a sacrifice area for feeding during winter and summer droughts, and reseeding if necessary. Grazing land management is a similar practice, but differs in that cost share is available for establishment of cross fencing and other grazing infrastructure through the Ag BMP Cost Share Program. A flat rate incentive payment is offered through the program for the improved pasture management practice. Farmers can also utilize cost share programs to convert highly erodible pasture such as areas with steep slopes and poor vegetative cover to forest. These types of pasture typically produce lower forage yields for livestock making them less optimal for grazing or cutting hay. Table 7 shows pasture BMPs needed in order to reduce bacteria to a level at which the streams can be removed from the impaired waters list.

Table 7. Pasture BMPs

BMP	BMP (acres unless otherwise specified)				
	Crooked Run	Stephens Run	West Run	Willow Brook	TOTAL
Improved pasture management	2,528	1,291	3,250	1,399	**8,468**
Grazing land management	181	108	217	117	**623**
Reforestation of erodible pasture	112	44	134	72	**362**
Critical area stabilization	1.1	0.4	1.4	0.7	**4**

IMPLEMENTATION ACTIONS FOR CROPLAND

Bacteria can run off of cropland when soils fertilized with manure are exposed to rainfall. These pollutants will make their way to the stream unless filtering practices like riparian buffers are in place to trap it.

Cropland is a relatively small source of bacteria in the Crooked Run and Willow Brook watersheds due to the low acreage that is present. However, there are still opportunities to reduce the bacteria load to the creeks from cropland. Cover crops are an effective way of limiting runoff of manure. By keeping the soil covered throughout the year, the soil and manure applied to it are more likely to stay put. Many farmers in Frederick, Warren and Clarke Counties are already planting cover crops on an annual basis. Consequently, this plan includes a modest amount of cover crops since the practice is already commonly used in the region. Riparian buffers are another effective practice for filtering polluted runoff. There are limited opportunities for cropland buffers in the watersheds since most of the agricultural land next to the streams is currently in pasture or hay. Table 8 shows the estimated extent of cropland BMPs needed in order to remove the streams from the impaired waters list. Continuous no till is another highly beneficial practice when it comes to improving soil quality and reducing runoff and soil loss.

Table 8. Cropland BMPs needed

BMP	BMP Acres				
	Crooked Run	Stephens Run	West Run	Willow Brook	TOTAL
Cover crops	37	27	49	9	**122**
Permanent vegetative cover on cropland	13	12	15	3	**43**
Continuous no till	4	8	10	1	**23**
Riparian buffers (grass)	0.1	0.15	0.1	0.07	**0.42**

STRAIGHT PIPES AND FAILING SEPTIC SYSTEMS

Since state law requires that failing septic systems and straight pipes be corrected, a 100% reduction in bacteria from these sources is needed.

Estimates of the percentages of households with failing septic systems and straight pipes (pipes directly discharging untreated sewage into the stream) were developed as part of the TMDL study. They are based on the age of homes in the watershed, and in the case of straight pipes, the proximity of homes to the stream. Estimates of needed repairs and replacements of failing systems with conventional and alternative systems were based on input from the Health Department and observations from septic system maintenance projects in the region. Based on existing conditions in the watersheds, it was estimated that of 20% of septic system and straight pipe replacements would be done with conventional septic systems, while 74% would be done with alternative waste treatment systems . In Virginia, owners of alternative systems must have their system inspected and reported to VDH at least once a year by a licensed operator in order to ensure that these more complex systems are functioning as designed. An estimated 1% of homes with failing systems and straight pipes could connect to public sewer. A septic tank pumpout program could be utilized to help educate homeowners in the watersheds about septic system maintenance and to locate and correct failing septic systems. This program could be implemented on a limited basis, targeting homes closest to streams. The estimates shown in Table 9 are based on pumping out septic tanks for 25% of households.

Table 9. Residential wastewater treatment BMPs

Watershed	Connection to public sewer	Septic system repair	Alternative waste treatment system	Septic system replacement (conventional)	Septic system replacement with pump	Septic tank pumpout
Crooked Run	2	79	26	4	3	166
Stephens Run	3	132	44	6	4	209
West Run	0	97	33	6	4	158
Willow Brook	0	32	10	1	1	50
TOTALS	**5**	**340**	**112**	**16**	**12**	**583**

RESIDENTIAL IMPLEMENTATION ACTIONS

In order to treat bacteria running off of developed land, BMPs to reduce and filter residential and urban runoff will be necessary.

A series of urban stormwater and pet waste management BMPs were identified for implementation in the Stephens and Crooked Run watersheds. These are the only two watersheds where reductions in bacteria from residential and developed areas are needed in order to remove the streams from the impaired waters list. This is largely due to the fact that the other watersheds have little to no high density development and a limited degree of low density residential development. A pet waste education program could be implemented in order to encourage pet owners to pick up after their pets. This program could include newspaper articles, radio ads, postcard mailings and brochures to be distributed at local events and businesses frequented by pet owners. A limited number of pet waste digesters/composters are included in the plan based on local interest expressed to date in the watershed regarding composting of pet waste. In addition, several potential locations were identified for pet waste stations. These stations will include baggies and trash receptacles, and could be located in densely developed areas with Homeowners Associations that could help with the cost of emptying the receptacles and keeping bags stocked. Potential sites for pet waste stations included: Northern Stephens Run apartment complex, a new development west of 641 in Stephens Run, Sherando Park, and Forest Lakes Estates in Crooked Run.

In addition to pet waste management BMPs, a series of residential and urban stormwater BMPs were identified. Rain gardens are small landscape features designed to catch runoff from paved surfaces and rooftops and filter out pollutants as the runoff moves down through a special soil mix. Bioretention filters are similar in function, but generally require more complex design work due to their capacity to handle a greater drainage area. These practices are typically used more often in commercial developments. There is also the potential to complete retrofits of several large regional stormwater basins to increase their capacity to filter bacteria and other pollutants out of stormwater runoff. With input from locality staff, several potential retrofit sites were identified in addition to potential rain garden and bioretention filter sites (Figure 3). These larger basin retrofits would be a highly cost effective way to treat stormwater runoff while also improving existing infrastructure. The Native Plant Society and Master Naturalists were identified as two great partners in planting rain gardens and installing attractive residential riparian buffers.

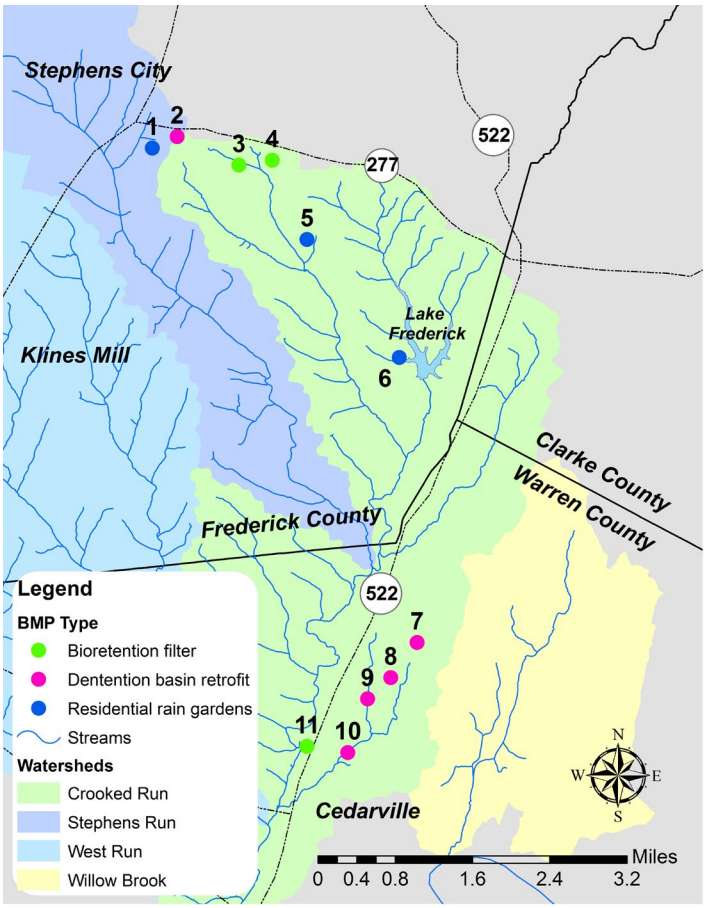


Figure 3. Potential stormwater BMP locations in Stephens and Crooked Runs

Table 9. Potential stormwater BMP site descriptions (see Figure 2 for site numbers)

No.	Site description
1	Ridgefield Ave. subdivision
2	Food Lion/Goodwill
3	Sherando High School
4	Sherando Park
5	Forest Lakes Estates
6	Lake Frederick Estates
7	Ferguson Enterprises
8	Economic Development Authority
9	Sysco North East Distribution
10	VA Inland Port
11	Holiday Inn, Front Royal

Table 10. Residential/urban stormwater and pet waste BMPs

BMP	Units	Extent	
		Crooked Run	Stephens Run
Riparian buffers	acres	0.5	1.5
Rain gardens	acres treated	2	4
Bioretention filters	acres treated	2	2
Detention basin retrofits	acres treated	60	10
Pet waste education program	program	1	1
Pet waste station	stations	2	6
Pet waste composter/digester	composter	10	10

EDUCATION AND OUTREACH

In order to get landowners involved in implementation, education and outreach and assistance with the design and installation of best management practices will be needed.

In order to get landowners involved in implementation, it will be necessary to initiate education and outreach strategies and provide technical assistance with the design and installation of various best management practices. There must be a proactive approach to contact farmers and residents to identify the practices that will help meet the goal of improved water quality while also meeting their needs as private landowners. Economic costs and benefits must be considered in this process. The working groups recommended several education/outreach techniques, which will be utilized during implementation.

The following additional education and outreach strategies were identified:

Agricultural Programs

- Make contact with landowners in the watersheds to make them aware of cost-share assistance, and voluntary options that are available to agricultural producers interested in conservation.
- Provide technical assistance for agricultural programs (e.g., survey, design, layout).
- Give presentations at local Farm Bureau events including annual membership meetings. Provide information for distribution with semi annual newsletters.
- Organize educational programs for farmers including farm tours in partnership with VA Cooperative Extension and Farm Bureau.
- Work with NRCS and Lord Fairfax SWCD to conduct door to door outreach regarding agricultural BMPs
- Work with VA Cooperative Extension to hold rotational grazing workshops and "fencing school" programs in the watersheds. These have been offered in other areas in the northern Valley and have been well received by the agricultural community
- Contact the VA Department of Corrections to explore options for inmate assistance with livestock exclusion fencing and maintenance. Consider partnering with a non profit organization or local government entity.
- Work with county Boards of Supervisors representatives to contact vast agricultural landowners in the watersheds to discuss water quality issues and potential management strategies

Residential Programs

- Identify straight-pipes and failing septic systems (e.g., contact landowners through mailings)
- Develop and distribute educational materials (e.g., septic system maintenance guide). Emphasize the voluntary nature of residential septic cost share program
- Encourage a partnership between the Department of Health and local realtors to share the capacity of a home's septic system with potential buyers
- Conduct outreach at homeowners association and public service board meetings
- Partner with the Front Royal Tree Stewards and the Garden Club of Warren County on residential rain garden projects
- Launch a newspaper campaign about septic system maintenance. Emphasize the connection between proper maintenance, groundwater science and financial assistance available
- Work with volunteers to conduct Coliscan monitoring in the watersheds, make upstream/downstream water quality comparisons to encourage landowners to participate in cost share programs. McKay Springs was identified as a particular location needing additional monitoring
- Launch a drinking water campaign, "Taste of the Shenandoah." Work with local businesses and the Chamber of Commerce to stress local resources, health and taking care of our children by taking care of our water. Consider involving local schools in monitoring and outreach. Recruit local service organizations such as the Boy Scouts and Girl Scouts
- Use the annual Envirothon competition as an opportunity for community outreach

Staffing Needed for Outreach and Technical Assistance

A critical component in the successful implementation of this plan is the availability of knowledgeable staff to work with landowners on implementing conservation practices. While this plan provides a general list of practices that can be implemented in the watershed, property owners face unique management challenges to implementation of practices. Consequently, technical assistance is a key component to successful BMP implementation. Technical assistance includes helping landowners identify suitable BMPs for their property, designing BMPs and locating funding.

The staffing level needed to implement this plan was estimated based on discussions with stakeholders and the staffing used in similar projects. It was determined that 1 position would be needed for agricultural and residential implementation. The Lord Fairfax Soil and Water Conservation District could partner with Frederick and Warren County staff and the Health Department to implement a comprehensive implementation project that also included BMPs to address stormwater runoff from developed areas and residential properties.

IMPLEMENTATION COSTS

Costs: Agricultural BMPs

The costs of agricultural best management practices included in the implementation plan were estimated based on data for Frederick and Warren Counties from the VADCR Agricultural BMP Database, the NRCS and Lord Fairfax SWCD BMP component cost lists, input from SWCD and NRCS staff, and input from the agricultural working group (Table 11).

The total cost of livestock exclusion systems includes not only the costs associated with streamside fence installation and maintenance, but also the cost of developing alternative water sources for livestock and installing rotational grazing systems. It should be noted that CREP does not pay for cross fencing for rotational grazing; however, this program is commonly combined with state programs that can cover these costs. The agricultural working group discussed concerns about maintenance of exclusion fencing and agreed that associated expenses could be an obstacle to participation in BMP programs for livestock exclusion. When a landowner accepts cost share for a livestock exclusion project, they are required to maintain that fence for the contract period (typically 10 years). In the event of a flood or other extreme event that damages the fence, the landowner may return to the SWCD and request funding to re-build the fence. Their application must be ranked with others under consideration, so there are no guarantees that funds will be available. If funds are awarded, the contract period starts over again at the time of the award. It was estimated that 10% of fencing would need to be replaced over a 15 year contract (e.g. CREP) and 6.5% over a 10 year contract (SL-6T/LE-1T/LE-2T).

The majority of agricultural practices recommended in this plan are included in state and federal cost share programs. These programs offer financial assistance with implementing the practices and may also provide landowners with an incentive payment to encourage participation. However, it should be noted that these programs typically cover 75% of the cost of a BMP and require that the landowner cover the full cost of the practice up front and then receive reimbursement. Reimbursements are usually issued quickly; however, this may still be an obstacle for some landowners interested in participating.

Table 11. Estimated agricultural BMP costs to achieve de-listing goal (Stage 1) by watershed.

Practice	Cost share code	Units	Unit cost	Cost by watershed				TOTAL
				Crooked Run	Stephens Run	West Run	Willow Brook	
Livestock exclusion with riparian buffers (35 ft)	LE-1T/ SL-6T	system	$36,320	$184,001	$66,148	$425,077	$31,592	**$706,819**
Livestock exclusion with riparian buffers (100 ft)	CRSL-6	system	$42,090	$76,976	$23,447	$205,000	$0	**$305,422**
Livestock exclusion with reduced setback	LE-2T	system	$27,595	$49,027	$16,772	$113,902	$0	**$179,702**
Stream protection	WP-2T	system	$11,312	$15,873	$0	$32,296	$0	**$48,169**
Livestock exclusion fence maintenance (10 years)	N/A	feet	$3.50	$10,786	$2,509	$18,925	$619	**$32,840**
Improved pasture management	EQIP (529, 512), SL-10T	acres	$100	$252,800	$129,100	$325,000	$139,900	**$846,800**
Grazing land management	SL-9	acres	$225	$40,725	$24,300	$48,825	$26,325	**$140,175**
Reforestation of erodible pasture	FR-1	acres	$185	$20,720	$8,140	$24,790	$13,320	**$66,970**
Permanent vegetative cover on critical areas (pasture)	SL-11	acres	$2,570	$2,827	$1,028	$3,598	$1,799	**$9,252**
Small grain cover crops	SL-8B	acres	$55	$2,035	$1,485	$2,695	$495	**$6,710**
Long term vegetative cover on cropland	SL-1	acres	$300	$715	$660	$825	$165	**$2,365**
Continuous no till	SL-15A	acres	$100	$220	$440	$550	$55	**$1,265**
Riparian buffers on cropland (grass)	WQ-1	acres	$165	$17	$25	$15	$12	**$68**
TOTAL ESTIMATED COST				$656,721	$274,055	$1,201,499	$214,282	$2,346,557

Table 12. Estimated agricultural BMP costs to achieve TMDL goal of a 0% violation rate (Stage 2) by watershed.

Practice	Cost share code	Units	Unit cost	Cost by watershed				TOTAL
				Crooked Run	Stephens Run	West Run	Willow Brook	
Livestock exclusion with riparian buffers (35 ft)	LE-1T/ SL-6T	system	$36,535	$130,093	$74,982	$38,148	$1,783	**$245,006**
Livestock exclusion with riparian buffers (100 ft)	CRSL-6	system	$43,559	$62,934	$28,765	$14,278	$0	**$105,977**
Livestock exclusion with reduced setback	LE-2T	system	$27,595	$31,595	$20,127	$10,222	$0	**$61,944**
Stream protection	WP-2T	system	$12,299	$11,823	$4,766	$2,092	$0	**$18,681**
Livestock exclusion fence maintenance (10 years)	N/A	feet	$3.50	$6,951	$3,011	$1,698	$0	**$11,777**
Improved pasture management	EQIP (529, 512), SL-10T	acres	$100	$38,600	$38,500	$73,300	$59,000	**$209,400**
Reforestation of erodible pasture	FR-1	acres	$185	$7,030	$4,070	$8,325	$4,440	**$23,865**
TOTAL ESTIMATED COST				$289,026	$174,220	$148,064	$65,340	$6476,650

Costs: Residential BMPs

The costs of recommended residential BMPs (septic systems, stormwater, and pet waste) shown in Table 13 were estimated using input from staff at VDH's Lord Fairfax Health District and the residential working group. It was determined that all residential BMP implementation would be completed in Stage 1 of implementation, thus Stage 2 only includes agricultural BMPs. DEQ awards EPA Section 319 grant funds for the administration of residential septic BMP cost share programs in watersheds with TMDL implementation plans. Typically, local Soil and Water Conservation Districts and local governments apply for these funds. The structure of these programs is similar to that of the agricultural BMP cost share program with 50%-75% cost share available for septic practices including repairs, replacements, pumpouts and connections to public sewer. It should be noted that DEQ does not provide cost share for the installation of discharging alternative waste treatment systems due to federal funding restrictions.

Table 13. Estimated residential BMP costs to achieve de-listing goal (Stage 1) for Crooked, Stephens and West Runs and Willow Brook

Practice	Cost share code	Units	Unit cost	Cost by watershed				
				Crooked Run	Stephens Run	West Run	Willow Brook	TOTAL
Septic tank pumpout	RB-1	pumpout	$325	$49,875	$62,775	$47,400	$15,000	**$175,050**
Connection to public sewer	RB-2	system	$12,430	$22,126	$43,009	$0	$0	**$65,135**
Septic system repair	RB-3	repair	$2,000	$158,200	$264,600	$193,200	$63,000	**$679,000**
Conventional septic system replacement	RB-4	system	$8,000	$30,320	$50,458	$48,000	$14,400	**$143,200**
Conventional septic system replacement w/pump	RB-4P	system	$12,000	$31,920	$49,080	$51,480	$16,200	**$148,680**
Alternative waste treatment system	RB-5	system	$25,000	$641,000	$1,098,000	$817,500	$247,500	**$2,804,000**
Riparian buffers	N/A	acres	$3,500	$1,750	$5,250	$0	$0	**$7,000**
Bioretention filters	N/A	ac treat.	$10,000	$20,000	$20,000	$0	$0	**$40,000**
Rain gardens	N/A	ac treat.	$10,000	$20,000	$40,000	$0	$0	**$60,000**
Detention basin retrofits	N/A	ac treat.	$3,500	$210,000	$35,000	$0	$0	**$245,000**
Pet waste education program	N/A	program	$2,000	$1,000	$1,000	$0	$0	**$2,000**
Pet waste stations	PW-1	station	$350	$700	$2,100	$0	$0	**$2,800**
Pet waste composters/digesters	PW-2	digester	$100	$1,000	$1,000	$0	$0	**$2,000**
TOTAL ESTIMATED COST				$1,187,391	$1,672,294	$1,157,580	$356,100	**$4,373,865**

Costs Benefit Analysis

The relative benefits of various BMPs must be considered when implementing a watershed restoration plan at this scale. In order to identify the practices that provide the greatest "bang for the buck," an analysis was performed comparing relative costs to average pollutant reductions for each BMP across all four watersheds. Table 14 shows the total estimated bacteria reductions associated with each BMP, the total estimated BMP cost, and the average bacteria reduction expected for every $1,000 invested in each practice. The cost benefit column ranks the practices from 1 to 24, with 1 being the practice producing the greatest average bacteria reduction per every $1,000 spent.

Table 14. Cost benefit analysis of BMPs. Table shows total bacteria reductions and costs for all four watersheds. : Highly cost effective : Moderately cost effective : Least cost effective

Practice	Total bacteria reduction (cfu)	Total BMP cost	Average bacteria reduction per $1,000 (cfu)	Cost benefit ranking
Agricultural				
Livestock exclusion with riparian buffers (35 ft)	1.72E+14	$969,489	1.98E+11	12
Livestock exclusion with riparian buffers (100 ft)	6.26E+13	$406,832	1.49E+11	13
Livestock exclusion with reduced setback	4.69E+13	$246,912	1.38E+11	14
Stream protection	3.13E+13	$24,890	4.64E+11	10
Improved pasture management	5.22E+15	$1,056,200	5.25E+12	3
Grazing land management	2.75E+14	$140,175	1.96E+12	4
Reforestation of erodible pasture	5.15E+14	$90,835	5.67E+12	2
Permanent vegetative cover on critical areas (pasture)	1.48E+11	$9,252	1.60E+10	20
Small grain cover crops	2.07E+12	$6,710	3.09E+11	11
Long term vegetative cover on cropland	3.08E+12	$2,365	1.30E+12	6
Continuous no till	1.07E+12	$1,265	8.46E+11	7
Riparian buffers on cropland (grass)	4.39E+10	$68	6.40E+11	8
Residential septic				
Connection to public sewer	4.32E+11	$65,135	7.78E+09	23
Septic system repair	3.26E+13	$679,000	4.81E+10	16
Conventional septic system replacement	1.50E+12	$143,200	1.20E+10	21
Conventional septic system replacement w/pump	1.43E+12	$148,680	8.01E+09	22
Alternative waste treatment system	1.13E+13	$2,804,000	4.02E+09	24
Residential/Urban stormwater				
Riparian buffers	2.99E+11	$7,000	4.27E+10	17
Rain gardens	1.07E+12	$60,000	1.78E+10	19
Bioretention filters	8.24E+11	$40,000	2.06E+10	18
Detention basin retrofits	1.69E+13	$245,000	6.89E+10	15
Pet waste education program	1.97E+13	$2,000	9.87E+12	1
Pet waste stations	1.31E+12	$2,800	4.69E+11	9
Pet waste composters/digesters	3.29E+12	$2,000	1.64E+12	5

Table 15 Total estimated costs of BMP implementation to achieve de-listing and TMDL goals (Stages 1 and 2).

BMP Type	Crooked Run	Stephens Run	West Run	Willow Brook	TOTAL
Agricultural	$945,848	$448,275	$1,349,563	$279,621	$3,023,308
Residential	$1,187,891	$1,672,294	$1,157,580	$356,100	$4,373,865
TOTAL	$2,133,739	$2,120,570	$2,507,143	$635,721	$7,397,173

Costs: Technical Assistance

Technical assistance costs were estimated for Phase 1 (years 1-10) of the project one position using a cost of $60,000/per year. A half time position was used to calculate costs for the last five years of the project since the residential and urban programs will have been completed by this point in the project. These figures based on the existing staffing costs for Soil and Water Conservation Districts who are currently administering TMDL implementation projects in the Commonwealth. Based on the ten year timeline for achieving de-listing goals (described in great detail in the Implementation Timeline section of this plan), this would make the total cost of technical assistance approximately $750,000. When factored in to the cost estimate for BMP implementation shown in Table 15, this would make the total cost of implementation approximately $8.15M.

IMPLEMENTATION BENEFITS

The primary benefit of implementing this plan will be cleaner water in Crooked Run, Willow Brook and their tributaries. This may lead to enhanced quality of life for the local community as well as potential economic benefits.

Specifically, *E. coli* contamination in the creeks will be reduced to meet water quality standards. It is hard to gage the impact that reducing *E. coli* contamination will have on public health, as most cases of waterborne infection are not reported or are falsely attributed to other sources. However, the incidence of infection from *E. coli* sources through contact with surface waters should be reduced considerably following the implementation of the measures outlined in this plan.

An important objective of the implementation plan is to foster continued economic vitality within the Crooked Run and Willow Brook watershed communities. This objective is based on the recognition that healthy waters improve economic opportunities for Virginians, and a healthy economic base provides the resources and funding necessary to pursue restoration and enhancement activities. The agricultural and residential practices recommended in this document will provide economic benefits to the community, as well as numerous environmental benefits. By implementing BMPs such as installation of alternative (clean) water sources, exclusion of cattle from streams, and rotational grazing, agricultural producers can experience significant economic gains through improved forage production and herd health. Residential property owners can increase their property value through proper septic system maintenance as well. Additionally, money spent by landowners and other stakeholders in the process of implementing this plan will stimulate the local economy.

Benefits: Agricultural Practices

It is recognized that every farmer faces unique management challenges that may make implementation of some BMPs more cost effective than others. Consequently, costs and benefits of the BMPs recom-

mended in this plan must be weighed on an individual basis. The benefits highlighted in this section are based on general research findings.

Restricting livestock access to streams and providing them with a clean water source has been shown to improve weight gain and milk production in cattle (Zeckoski et al., 2007). Studies have shown that increasing livestock consumption of clean water can lead to increased milk and butterfat production and increased weight gain (Landefeld et al, 2002). Table 16 shows an example of how this can translate into economic gains for producers. In addition, keeping cattle in clean, dry areas has been shown to reduce the occurrence of mastitis and foot rot. The VCE (1998) reports that mastitis costs producers $100 per cow in reduced quantity and quality of milk produced. Installation of streamside fencing and well managed loafing areas will reduce the amount of time that cattle have access to these areas. Implementing a prescribed grazing management strategy in conjunction with a providing livestock with a clean water source will also provide economic benefits for the producer. Standing forage utilized directly by the grazing animal is less costly and of higher quality than forage harvested with equipment and fed to the animal. According to the 2012 Census of Agriculture, farmers across the state spent over $1 billion purchasing feed for livestock, far exceeding any other reported operational expenditure (USDA, 2012). Consequently, improving forage production through improved pasture management and rotational grazing could offer producers considerable economic benefits.

Table 16. Example of increased revenue due to installing off-stream waterers (Surber et al., 2005)

Typical calf sale weight	Additional weight gain due to off-stream waterer	Price	Increased revenue due to off stream waterer
500 lb/calf	5% or 25 lb	$0.60 per lb	$15 per calf

Note: Table from Zeckoski et al. (2007)

Benefits: Residential Practices

The residential program will play an important role in improving water quality since human waste can carry human viruses in addition to bacterial and protozoan pathogens. In terms of economic benefits to homeowners, an improved understanding of on-site sewage treatment systems, including knowledge of what steps can be taken to keep them functioning properly, will give homeowners the tools needed for extending the life of their systems and reducing the overall cost of ownership. The average septic system will last 20 to 25 years if properly maintained. Proper maintenance includes: knowing the location of the system components and protecting them (e.g., not driving or parking on top of them), not planting trees where roots could damage the system, keeping hazardous chemicals out of

the system, and pumping out the septic tank every 3 to 5 years. The cost of proper maintenance, as outlined here, is relatively inexpensive ($325 per pumpout) in comparison to repairing or replacing a system ($3,000 to $25,000).

In addition to the benefits to individual landowners, the local economy will be stimulated through expenditures made during implementation, and the infusion of dollars from funding sources outside of the watersheds. Building contractors and material suppliers who deal with septic system pump-outs, private sewage system repair and installation, fencing, and other BMP components can expect to see an increase in business during implementation.

Benefits: Residential and Urban Stormwater Practices

The primary benefits of stormwater management practices to private property owners include flood mitigation and improved water quality. A 2004 study assessing the economic benefits of stormwater management showed that these services can be valued at 0-5% of the market value of a home (Braden and Johnston, 2004). In addition, urban BMPs have a number of economic benefits to localities. Increased retention of stormwater on site can lower peak discharges, thereby reducing the drainage infrastructure needed to prevent flooding. This can result in cost savings to local governments through reduced engineering and land acquisition costs, and reduced materials and installation costs for stormwater culverts and streambank armoring to prevent scour. Lastly, implementation of urban BMPs greatly reduces soil erosion and sediment transport to our rivers, streams and lakes. A 1993 study of the economic cost of erosion-related pollution showed that national off-site damages from urban sediment sources cost between $192 million and $2.2 billion per year in 1990 dollar values (Paterson et al, 1993). This cost range would be far greater today if adjusted for inflation.

Benefits: Watershed Health

Focusing on reducing bacteria in Crooked Run, Willow Brook and their tributaries will not only make the river safer for swimming, it will improve the overall health of the watershed. Reductions in streambank erosion, excessive nutrient runoff, and water temperature are additional benefits associated with streamside buffer plantings and livestock stream exclusion. In turn, reduced nutrient loading and erosion and cooler water temperatures improves habitat for fisheries, which provides benefits to anglers and the local economy.

Riparian buffers can also improve habitat for wildlife such as ground-nesting quail and other sensitive species. Data collected from Breeding Bird Surveys in Virginia indicate that the quail population declined 4.2% annually between 1966 and 2007. Habitat loss has been cited as the primary cause of this decline. As a result, Virginia has experienced significant reductions in economic input to rural communities from quail hunting. The direct economic contribution of quail hunters to the Virginia economy was estimated at nearly $26 million in 1991, with the total economic impact approaching $50 million. Between 1991 and 2004, the total loss to the Virginia economy was more than $23 million from declining quail hunter expenditures (VDGIF, 2009).

GOALS AND MILESTONES

The end goal of implementation is restored water quality in Crooked, Stephens and West Runs and Willow Brook. It is expected that this will occur over a 10-year period.

Two types of milestones will be used to evaluate progress over the implementation period: implementation milestones and water quality milestones. The implementation milestones establish goals for the extent of the different best management practices installed within certain time frames, while the water quality milestones establish the corresponding goals for improvements in water quality.

Following the idea of a staged implementation approach, resources and finances will be concentrated on the most cost-efficient control measures and areas of highest interest first. For instance, the TMDL study indicated that runoff from pasture is the source of approximately 41% of total bacteria in Crooked Run. Concentrating on implementing pasture management practices within the first several years may provide the highest return on water quality improvement with less cost to landowners.

While the focus of this plan is to remove these streams from the impaired waters list, full achievement of the TMDL must also be considered as part of the overall TMDL process. This means that the BMPs needed to accomplish a 0% violation rate of the bacteria standard must be explored, along with associated costs and a time line. It should be noted that estimates of the impact of the BMPs included in this plan on water quality are conservative, meaning that continued monitoring following implementation could demonstrate accomplishment of water quality goals at lower than expected levels of BMP implementation. BMP goals and associated water quality milestones will be evaluated throughout the project time line allowing for adjustments to goals and milestones as needed.

Based on input from the working groups regarding BMP adoption rates, it is estimated that it would take a total of 10 years to implement the BMPs needed to remove these streams from Virginia's impaired waters list. The overall time line for implementation has been divided into two stages: 2017–2026 and 2027–2031. Implementation of practices included in Stage 1 is expected to result in removal of the creeks from the impaired waters list, while Stage 2 goals demonstrate what it would take to accomplish the TMDL goal of a 0% violation rate for the bacteria water quality standard in the creeks.

Table 17 shows the cost of BMP implementation in each watershed at each stage while Tables 18-21 show implementation and water quality improvement goals for each watershed in each implementation stage.

Table 17. BMP implementation costs by stage

Watershed	Stage 1 (Years 1-10)	Stage 2 (Years 11-15)	TOTAL
Crooked Run	$1,844,713	$289,026	$1,844,713
Stephens Run	$1,946,349	$174,220	$2,120,570
West Run	$2,359,079	$148,064	$2,507,143
Willow Brook	$570,382	$65,340	$635,721

Table 18. Timeline for implementation in the Crooked Run watershed

BMP Type	BMP	Units	Stage 1		Stage 2		Total	
			Extent	% Land use treated	Extent	% Land use treated	Extent	% Land use treated
Livestock stream exclusion	Livestock exclusion w/riparian buffers (35 ft)	feet/systems	16,949/4	25%	10,923/3	16%	27,871/7	41%
	Stream protection	feet/systems	3,082/1	5%	1,986/1	3%	5,068/2	7%
	Livestock exclusion w/riparian buffers (100 ft)	feet/systems	6,163/2	9%	3,972/2	6%	10,135/3	15%
	Livestock exclusion w/reduced setback	feet/systems	4,622/1	7%	2,979/1	4%	7,601/2	11%
	Fence maintenance	feet	3,087	N/A	1,986	N/A	5,068	N/A
Pasture	Improved pasture management	acres	2,528	70%	386	12%	2,914	82%
	Grazing land management	acres	181	5%	0	0%	181	5%
	Reforestation of erodible pasture	acres	112	3%	38	1%	150	4%
	Critical area stabilization	acres	1.1	0.03%	0	0%	0	0.03%
Cropland	Small grain cover crops	acres	37	9%	0	0%	37	9%
	Long term vegetative cover	acres	13	3%	0	0%	13	3%
	Continuous no till	acres	4	1%	0	0%	4	1%
	Riparian buffers (grass)	acres	0.1	0.07%	0	0%	0.1	0.07%
Residential*	Septic tank pumpout	pumpout	166	25%	0	0%	166	25%
	Connection to public sewer	connection	2	2%	0	0%	1	2%
	Septic system repair	repair	79	69%	0	0%	79	69%
	Conventional septic system	system	4	4%	0	0%	4	4%
	Conventional septic system w/pump	system	3	3%	0	0%	3	3%
	Alternative waste treatment	system	26	23%	0	0%	26	23%
	Riparian buffers	acres	0.5	0.06%	0	0%	0.5	0.06%
	Rain gardens	ac. treated	2	0.1%	0	0%	2	0.1%
	Bioretention filters	ac. treated	2	0.1%	0	0%	2	0.1%
	Detention basin retrofits	ac. treated	60	4%	0	0%	60	4%
	Pet waste education program	program	1	5%	0	0%	1	5%
	Pet waste stations	station	2	0.14%	0	0%	2	0.14%
	Pet waste composter/digester	composter	10	0.5%	0	0%	10	0.5%
Average annual *E.coli* load (cfu/yr)			7.22×10^{13}		6.64×10^{13}		N/A	
% Violation of Single Sample *E. coli* criterion (235 cfu/100mL)			10.4%		9.2%		N/A	
% Violation of Geometric mean *E. coli* standard (126 cfu/100mL)			3.3%		0.0%		N/A	

*For all septic system practices, % land use treated is based on total number of failing septic systems & straight pipes with exception of pumpouts (based on the number of septic systems)

Table 19. Timeline for implementation in the Stephens Run watershed

BMP Type	BMP	Units	Stage 1		Stage 2		Total	
			Extent	% Land use treated	Extent	% Land use treated	Extent	% Land use treated
Livestock stream exclusion	Livestock exclusion w/riparian buffers (35 ft)	feet/systems	4,625/2	11%	4,732/2	13.2%	9,357/4	24.2%
	Stream protection	feet/systems	35/0	0%	860/0	0%	5,407/3	4.4%
	Livestock exclusion w/riparian buffers (100 ft)	feet/systems	1,434/1	4%	1,721/1	4.8%	3,155/1	8.8%
	Livestock exclusion w/reduced setback	feet/systems	1,075/1	3%	1,291/1	3.6%	2,366/1	6.6%
	Fence maintenance	feet	717	N/A	860	N/A	1,577	N/A
Pasture	Improved pasture management	acres	1,291	60%	385	19%	1,676	79%
	Grazing land management	acres	108	5%	0	0%	108	5%
	Reforestation of erodible pasture	acres	44	2%	22	1%	66	3%
	Critical area stabilization	acres	0.4	0.02%	0	0%	0.4	0.02%
Cropland	Small grain cover crops	acres	27	7%	0	0%	27	7%
	Long term vegetative cover	acres	12	3%	0	0%	12	3%
	Continuous no till	acres	8	2%	0	0%	8	2%
	Riparian buffers (grass)	acres	0.15	0.12%	0	0%	0.15	0.12%
Residential*	Septic tank pumpout	pumpout	209	25%	0	0%	209	25%
	Connection to public sewer	connection	3	1%	0	0%	3	1%
	Septic system repair	repair	132	69%	0	0%	132	%
	Conventional septic system	system	6	4%	0	0%	6	%
	Conventional septic system w/pump	system	4	3%	0	0%	4	%
	Alternative waste treatment	system	44	23%	0	0%	44	%
	Riparian buffers	acres	1.5	0.3%	0	0%	1.5	0.3%
	Bioretention filters	ac. treated	2	0.4%	0	0%	2	0.4%
	Rain gardens	ac. treated	4	0.2%	0	0%	4	0.2%
	Detention basin retrofits	ac. treated	10	1%	0	0%	10	1%
	Pet waste education program	program	1	5%	0	0%	1	5%
	Pet waste stations	station	6	1%	0	0%	6	1%
	Pet waste digester/composter	composter	10	1%	0	0%	10	1%
Average annual *E.coli* load (cfu/yr)			1.56×10^{13}		1.44×10^{13}		N/A	
% Violation of Single Sample *E. coli* criterion (235 cfu/100mL)			10.3%		9.3%		N/A	
% Violation of Geometric mean *E. coli* standard (126 cfu/100mL)			3.3%		0.0%		N/A	

*For all septic system practices, % land use treated is based on total number of failing septic systems & straight pipes with exception of pumpouts (based on the number of septic systems)

Table 20. Timeline for implementation in the West Run watershed

BMP Type	BMP	Units	Stage 1		Stage 2		Total	
			Extent	% Land use treated	Extent	% Land use treated	Extent	% Land use treated
Livestock stream exclusion	Livestock exclusion w/riparian buffers (35 feet)	feet/systems	29,740/12	42.9%	2,669/1	3.9%	32,409/13	46.8%
	Stream protection	feet/systems	5,407/3	7.8%	485/0	0.7%	5,893/3	8.5%
	Livestock exclusion w/riparian buffers (100 feet)	feet/systems	10,815/4	15.6%	971/0	1.4%	11,785/5	17%
	Livestock exclusion w/reduced setback	feet/systems	8,111/3	11.7%	728/0	1%	8,839/4	12.8%
	Fence maintenance	feet	5,407	N/A	485	N/A	5,893	N/A
Pasture	Improved pasture management	acres	3,250	75%	733	18%	93%	%
	Grazing land management	acres	217	5%	0	0%	217	5%
	Reforestation of erodible pasture	acres	134	3%	45	1%	179	4%
	Critical area stabilization	acres	1.4	0.03%	0	0%	1.4	0.03%
Cropland	Small grain cover crops	acres	49	10%	0	0%	49	10%
	Long term vegetative cover	acres	15	3%	0	0%	15	3%
	Continuous no till	acres	10	2%	0	0%	10	2%
	Riparian buffers (grass)	acres	0.09	0.05%	0	0%	0.09	0.05%
Residential*	Septic tank pumpout	pumpout	158	25%	0	0%	158	25%
	Connection to public sewer	connection	0	0%	0	0%	0	0%
	Septic system repair	repair	97	69%	0	0%	97	69%
	Conventional septic system	system	6	4%	0	0%	6	4%
	Conventional septic system w/pump	system	4	3%	0	0%	4	3%
	Alternative waste treatment	system	33	23%	0	0%	33	23%
Average annual *E.coli* load (cfu/yr)			2.55×10^{13}		2.30×10^{13}		N/A	
% Violation of Single Sample *E. coli* criterion (235 cfu/100mL)			10.4%		9.3%		N/A	
% Violation of Geometric mean *E. coli* standard (126 cfu/100mL)			3.3%		0.0%		N/A	

Table 21. Timeline for implementation in the Willow Brook watershed

BMP Type	BMP	Units	Stage 1		Stage 2		Total	
			Extent	% Land use treated	Extent	% Land use treated	Extent	% Land use treated
Livestock stream exclusion	Livestock exclusion w/riparian buffers (35 feet)	feet/systems	1,770/1	80%	332/0	15%	2,101/1	95%
	Stream protection	feet/systems	0	0%	0	0%	0	0%
	Livestock exclusion w/riparian buffers (100 feet)	feet/systems	0	0%	0	0%	0	0%
	Livestock exclusion w/reduced setback	feet/systems	0	0%	0	0%	0	0%
	Fence maintenance	feet	287	N/A	0	N/A	287	N/A
Pasture	Improved pasture management	acres	1,399	60%	590	26%	1,989	86%
	Grazing land management	acres	117	5%	0	0%	117	5%
	Reforestation of erodible pasture	acres	72	3%	24	1%	96	4%
	Critical area stabilization	acres	0.7	0.03%	0	0%	0.7	0.03%
Cropland	Small grain cover crops	acres	9	9%	0	0%	9	9%
	Long term vegetative cover	acres	3	3%	0	0%	3	3%
	Continuous no till	acres	1	1%	0	0%	1	1%
	Riparian buffers (grass)	acres	0.07	0.22%	0	0%	0.07	0.22
Residential*	Septic tank pumpout	pumpout	50	25%	0	0%	50	25%
	Connection to public sewer	connection	0	0%	0	0%	0	1%
	Septic system repair	repair	32	69%	0	0%	32	69%
	Conventional septic system	system	2	4%	0	0%	2	4%
	Conventional septic system w/pump	system	1	3%	0	0%	1	3%
	Alternative waste treatment	system	10	23%	0	0%	10	23%
Average annual *E.coli* load (cfu/yr)			1.35×10^{13}		1.15×10^{13}		N/A	
% Violation of Single Sample *E. coli* criterion (235 cfu/100mL)			10.4%		9.5%		N/A	
% Violation of Geometric mean *E. coli* standard (126 cfu/100mL)			10.0%		0.0%		N/A	

Estimates of Phase I implementation goals were broked down by each county in the watershed area (Table 22) in order to show an estimate of the proportion of BMP implementation needed in each jursidiction. This information may be of interest to localities as they complete planning to meet both local and Chesapeake Bay TMDL implementation goals as well as local permits requirements. Table 22 also illustrates the small portion of the watershed that is located in Clarke County, which is nearly

Table 22. Phase I implementation goals by county. Note: Subwatersheds were broken out by county in order to develop BMP estimates. As part of this analysis, it was assumed that land use proportions were equal between counties. Total values may not match what is shown in the previous BMP tables due to rounding.

BMP Type	BMP	Units	Clarke	Frederick	Warren
Livestock stream exclusion	Livestock exclusion w/riparian buffers (35 ft)	systems	1	8	10
	Stream protection	systems	0	1	3
	Livestock exclusion w/riparian buffers (100 ft)	systems	0	4	3
	Livestock exclusion w/reduced setback	systems	0	2	3
	Fence maintenance	feet	516	4,313	4,678
Pasture	Improved pasture management	acres	176	4,364	3,928
	Grazing land management	acres	13	318	292
	Reforestation of erodible pasture	acres	8	174	180
	Critical area stabilization	acres	0.1	1.7	1.8
Cropland	Small grain cover crops	acres	2	73	47
	Long term vegetative cover	acres	1	27	15
	Continuous no till	acres	0	16	7
	Riparian buffers (grass)	acres	0.02	0.22	0.18
Residential septic	Septic tank pumpout	pumpout	6	393	184
	Connection to public sewer	connection	0	3	2
	Septic system repair	repair	3	222	115
	Conventional septic system	system	0	10	6
	Conventional septic system w/pump	system	0	10	5
	Alternative waste treatment	system	1	73	38
Residential/ urban	Riparian buffers	acres	0	2	0
	Rain gardens	acres treated	0	6	0
	Bioretention filters	acres treated	0	3	1
	Detention basin retrofits	acres treated	0	22	48
	Pet waste education program	program	0	0.75	0.25
	Pet waste stations	station	0	7	1
	Pet waste composter/digester	composter	1	14	5

Water Quality Monitoring

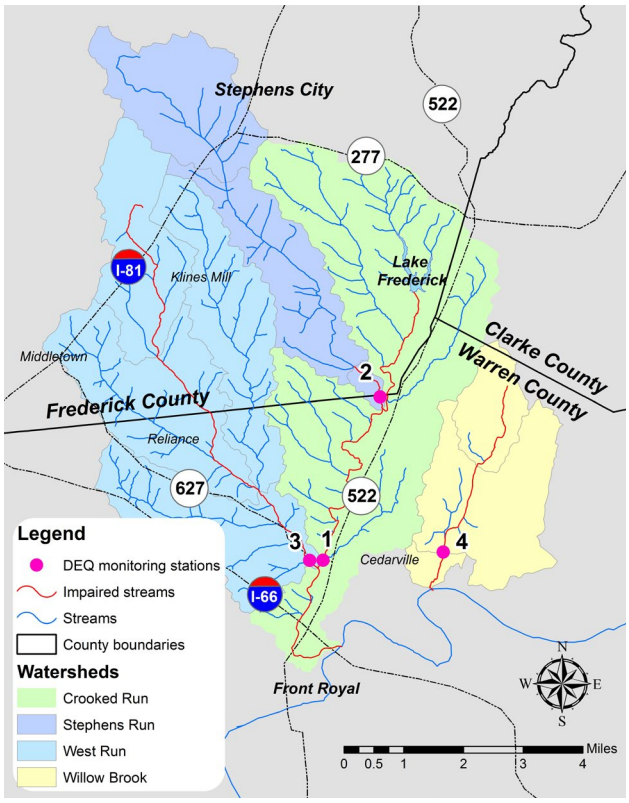


Figure 4. VADEQ monitoring stations. See Table 23 for station location descriptions.

Improvements in water quality will be evaluated through water quality monitoring conducted at the VADEQ monitoring stations shown in Figure 4. The map shows stations that are part of VADEQ's Ambient Monitoring Program, wherein bi-monthly watershed monitoring takes place on a rotating basis for two consecutive years. Monitoring will begin no sooner than the second odd numbered calendar year following the initiation of TMDL implementation efforts in the watersheds. This will help ensure that sufficient time has passed for BMPs to have become functional and improvements in water quality are detectable. At a minimum, the frequency of sample collections will be every other month for two years. After two years of bi-monthly monitoring an assessment will be made to determine if the segments are no longer impaired. Once full restoration has been achieved, monitoring will be suspended.

There is the potential for additional monitoring at a subset of stations in the watersheds where continual VADEQ monitoring is conducted on a bi-monthly basis beginning on the next odd number calendar year after the initiation of implementation. This will require additional funding and can only be accomplished with sufficient resources to support needs of the data users, and only if watershed conditions and stakeholder support are suitable to this strategy. These monitoring stations will be located in the watersheds based on TMDL implementation funds, either state, federal, or other sources, becoming available.

Citizen monitoring is another very useful tool for measuring improvements in water quality. The Friends of the Shenandoah River (FOSR) has an extensive water quality monitoring program throughout the Shenandoah River watershed including a number of stations in the project area watersheds. Currently, FOSR is analyzing samples collected from these station for nitrogen, phosphorous, dissolved oxygen, pH, temperature and turbidity. However, *E. coli* could be included within these testing parameters in order to assist in evaluating water quality improvements associated with BMP implementation in the watersheds. Ad-

Table 23. DEQ station location descriptions

Station #	Stream	River mile	Description
1	Crooked Run	2.75	Off Rte. 627
2	Stephens Run	0.20	Near Rt. 639 Bridge
3	West Run	0.20	Near Rt. 609 Bridge
4	Willow Brook	0.71	Near Rt. 658 Bridge

ditional funding for *E. coli* testing would be necessary since FOSR is volunteer-based, non profit organization. FOSR has Level 3 certification, meaning that the data that they collect can be used for the purposes of listing or de-listing a stream (removing it from the impaired waters list). Therefore, they could serve as a key partner in evaluating project success. Consequently, DEQ worked closely with FOSR during implementation planning to develop a proposed monitoring plan through which FOSR could identify reaches of streams that could be improved through additional livestock exclusion, and to show water quality improvements resulting from these practices. Monitoring activities would include:

1. Bacterial sampling monthly during non-flood events and collecting one additional bacterial sample in June, July, August, and September at each site. Sampling would occur during the implementation plan and 2 years after the implementation period.
2. Each site would be photographed during sampling to show stream bank and bottom conditions, water clarity and plant growth or lack of plant growth, land use, and if cattle are in the stream upstream of the sampling site within sight of the sampling location.
3. Water temperature, dissolved oxygen concentration, specific conductance, and pH would be measured when the bacterial samples are collected.
4. Stream discharge would be measured 4 times at each sampling site at different stream stages in order to understand the hydrology and bacteria sources of Crooked Run and Willow Brook. The discharge measurements would be made early (within the 1st year) in the monitoring

FOSR staff developed a monitoring program budget during the planning process. Based on the sampling frequency described above, FOSR could complete a four year monitoring program at seven sites within the watersheds for approximately $21,000. These funds would have to be secured through grants, foundations and other private funding sources in order to implement the program, which project partners are committed to pursue.

Targeting Implementation:
Livestock exclusion

Implicit in the process of a staged implementation is targeting of best management practices. Targeting ensures optimal utilization of limited technical and financial resources. Excluding livestock from streams can be very resource intensive with varying results with respect to water quality depending on characteristics of the site where livestock are excluded. Therefore, a targeting strategy was developed in order to maximize potential water quality benefits of livestock stream exclusion installed in the watersheds. As part of this process, each watershed was divided up into a series of smaller subwatersheds, and an analysis of the water quality benefits of livestock exclusion was performed for each subwatershed based on 1) the extent of pasture next to the stream 2) the number of livestock in the watershed and 3) the proximity of the stream segment to the headwaters. Based on input from the agricultural working group, the subwatersheds that included the mainstem of each stream were assigned a higher priority than subwatershed that included the headwaters, which tend to have a greater number of intermittent stream segments that are not commonly accessed by livestock or used for recreation by the local community. The subwatersheds were then ranked in ascending order based on the ratio of bacteria loading per fence length, and proximity to the headwaters (Figure 5). The ratio of livestock to pasture next to the stream constituted 50% of the ranking, while proximity to headwaters constituted the other 50%. So for example, a subwatershed closest to a watershed outlet with the highest ratio of livestock to pasture next to the stream would be assigned the highest priority for livestock exclusion. This prioritization may prove useful should the demand for technical and financial assistance with livestock exclusion in the watersheds exceed the capacity of local conservation partners to assist landowners.

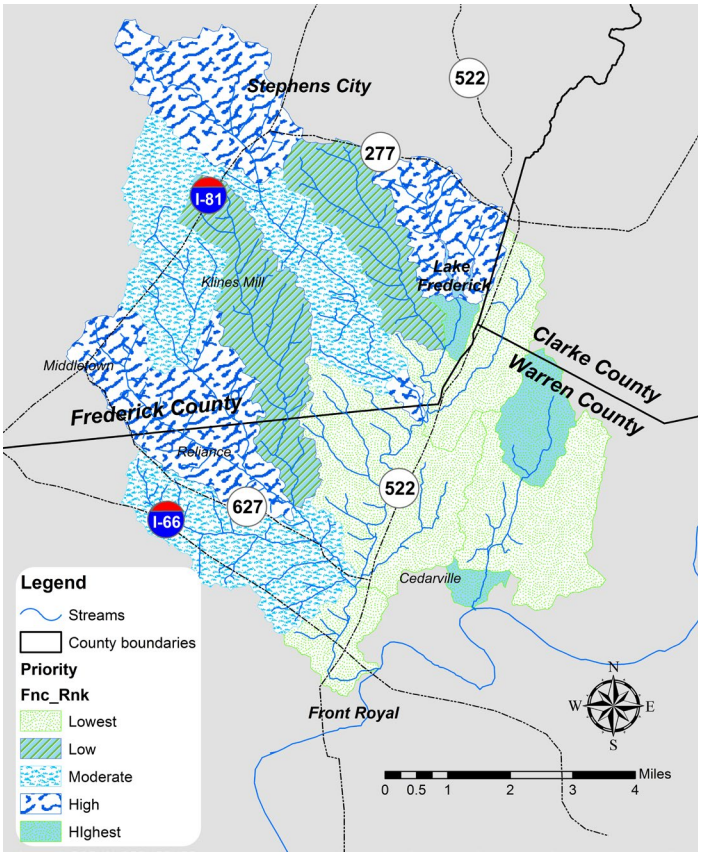


Figure 5. Livestock stream exclusion prioritization

Targeting Implementation:
Septic system maintenance

Outreach to encourage landowners to properly maintain septic systems is frequently conducted through mailings to homeowners including postcards and brochures. Experience with septic system maintenance outreach and cost share programs in the region has shown that often times, landowners must be contacted 2-4 times before they follow up on opportunities for technical and financial assistance with septic system maintenance. This can prove costly when conducting mailings in large watersheds like Crooked Run where there are approximately 2,900 households (including Stephens and West Runs). Identifying areas in the watershed with older homes and aging septic systems to target with outreach materials can be helpful in maximizing response rates from homeowners and corrections of failing septic systems. In order to prioritize subwatersheds for septic system maintenance outreach, subwatersheds were ranked based on the estimated number of failing septic systems (Figure 6). This information was taken from the Shenandoah River Tributaries TMDL study, which used the age of homes to predict septic system failure rates. The rankings shown in Figure 4 could be used for follow up outreach after a large watershed mailing if funds were not available for repeated watershed-wide mailings. The residential working group discussed additional targeting strategies including multiple mailings starting with property owners in high priority subwatersheds that live within a certain distance of the stream. These homeowners could be contacted first with offers of assistance since correcting these systems would offer the greatest opportunity for water quality improvement.

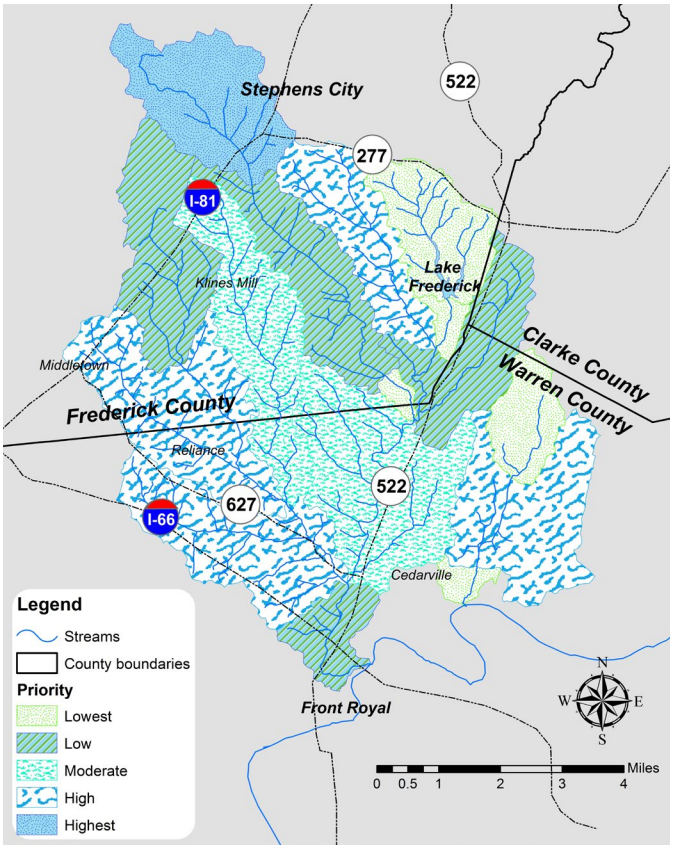


Figure 6. Septic system BMP prioritization

PARTNERS AND THEIR ROLE IN IMPLEMENTATION

Agricultural and Residential Landowners

SWCD and NRCS conservation staff often consider characteristics of farms and farmers in the watersheds that will affect the decisions farmers make when it comes to implementing conservation practices. For example, the average size of farms is an important factor to consider, since it affects how much cropland or pasture a farmer can give up for a riparian buffer. The age of a farmer may also influence their decision to implement best management practices. Table 24 provides a summary of relevant characteristics of farms and producers in Frederick and Warren Counties from the 2012 Agricultural Census. These characteristics were considered when developing implementation scenarios, and should be utilized to develop suitable education and outreach strategies.

Table 24. Characteristics of farms and farmers in Frederick and Warren Counties, VA (USDA, 2012)

Characteristic		Frederick	Warren
Number of farms		681	346
Land in farms (acres): full owners		38,157	26,806
Land in farms (acres): part owners	Rented land in farms	30,274	10,615
	Owned land in farms	27,590	7,903
Operators identifying farming as their primary occupation		251	149
Operators identifying something other than farming as their primary occupation		430	197
Average age of primary operator		60	59
Average size of farm (acres)		148	139
Average market value of farmland and buildings ($/acre)		$5,903	$7,138
Average net cash farm income of operation ($)		$5,167	-$5,083
Average farm production expenses ($)		$49,850	$24,194
Farms with internet access		452	273

In addition to local farmers, participation from homeowners, local government staff and elected officials is critical to the success of this plan. Elected officials make important decisions with respect to land use and development that are likely to affect water quality. It is critical that the goals of this plan are considered as these decisions are evaluated. Residential property owners will need to ensure that their septic systems are regularly pumped and inspected (every 3-5 years). Though the amount of bacteria coming from failing septic systems and straight pipes is minimal compared to livestock, human waste carries with it pathogens that can cause considerable health problems

Lord Fairfax Soil and Water Conservation District and USDA Natural Resource Conservation Service

Both the SWCD and NRCS are continually reaching out to farmers in the watersheds and providing them technical assistance with conservation practices. Currently, dedicated staff is not available to work solely in the watersheds that are covered in this plan, meaning that agricultural BMP implementation goals cannot be met without additional resources. SWCD and NRCS staff responsibilities include promoting available funding for BMPs, and providing assistance in the design and layout of agricultural BMPs. SWCD and NRCS staff can assist with conducting outreach activities in the watersheds to encourage participation in conservation programs; however, staff time for very targeted outreach is limited. Should funding for additional staff become available for outreach in these watersheds, the Lord Fairfax SWCD would be well suited to administer an agricultural BMP program. In addition, the SWCD has recently developed an urban BMP program and is prepared to work with landowners to pursue grant opportunities to implement stormwater BMPs in the region.

Dedicated staff is currently not available to lead efforts to correct failing septic systems and straight pipes. A residential septic system maintenance cost share program could be administered by a number of different entities including the Lord Fairfax SWCD, the VA Department of Health, or one of the localities in the watersheds.

Frederick and Warren Counties

Decisions made by local government staff and elected officials regarding land use and zoning will play an important role in the implementation of this plan. This makes the Frederick and Warren County key partners in long term implementation efforts. Approximately 2.4% of the total watershed is located in Clarke County, making the county a partner in implementation moving forward, but in a more limited capacity based on the watershed area. Currently, both Frederick and Warren Counties administer conservation easement programs, which have helped to encourage land conservation across the counties. Two agricultural forestal districts have been established in the watersheds, the Rockland District in Warren County and the Double Church District in Frederick County. This designation protects agricultural and forest land from development. Based on feedback from the agricultural working group, suburban encroachment is a significant issue in the watershed, with the number of large working farms in the area significantly declining in recent years. Local government support of land conservation will become increasingly important as greater numbers of conservation measures are implemented across the watersheds. Both counties will also serve as key partners in residential stormwater BMP outreach and implementation. In addition, they may assist with the promotion of pet waste BMPs including composters and pet waste stations.

Virginia Department of Environmental Quality

The Virginia Department of Environmental Quality has a lead role in the development of TMDL implementation plans. VADEQ also provides available grant funding and technical support for TMDL implementation. VADEQ will work closely with project partners to track implementation progress

for best management practices. In addition, VADEQ will work with interested partners on grant proposals to generate funds for projects included in the implementation plan. When needed, VADEQ will facilitate additional meetings of the steering committee to discuss implementation progress and make necessary adjustments to the implementation plan.

VADEQ is also responsible for monitoring state waters to determine compliance with water quality standards. VADEQ will continue monitoring water quality in Crooked Run, Willow Brook and their tributaries in order to assess water quality and determine when restoration has been achieved and the streams can be removed

Virginia Department of Conservation and Recreation

The Virginia Department of Conservation and Recreation (VADCR) administers the Virginia Agricultural Cost Share Program, working closely with Soil and Water Conservation Districts to provide cost share and operating grants needed to deliver this program at the local level and track implementation. In addition, VADCR administers the state's Nutrient Management Program, which provides technical assistance to producers in appropriate manure storage and manure and commercial fertilizer.

Virginia Department of Health

The Virginia Department of Health (VDH) is responsible for adopting and implementing regulations for onsite wastewater treatment and disposal. The Sewage Handling and Disposal Regulations require homeowners to secure permits for handling and disposal of sewage (e.g. repairing a failing septic system or installing a new treatment system). VDH staff provide technical assistance to homeowners with septic system maintenance and installation, and respond to complaints regarding failing septic systems and straight pipes.

Other Potential Local Partners

There are numerous additional opportunities for future partnerships in the implementation of this plan. Additional potential partners in implementation include:

- VA Cooperative Extension (VCE)
- Friends of the Shenandoah River
- VA Master Naturalists
- Local Ruritan and Rotary Clubs
- Northern Shenandoah Valley Regional Comm.
- Frederick & Warren County Builders Assoc.'s
- Frederick and Warren County Farm Bureaus
- Friends of the North Fork Shenandoah River
- VA Master Gardeners
- Garden Club of Warren County
- Local realtor associations
- Native Plant Society

INTEGRATION WITH OTHER WATERSHED PLANS

Each watershed in the state is under the jurisdiction of a multitude of water quality programs and activities, many of which have specific geographic boundaries and goals. Coordination of implementation efforts with these programs could make additional resources available and increase participation by local landowners.

Frederick and Warren County Conservation Easement and Ag Forestal District Programs

In 2005, Frederick County established a Conservation Easement Authority in order to protect and preserve farm and forest land, historic sites and water resources. Ten years later, the county reported that they had over 8,000 acres of land in conservation easements. The county also worked with Potomac Conservancy to produce a series of educational videos for landowners in 2015, which explain the benefits of conservation easements. Warren County also has established a conservation easement program, with a current total of 11,351 acres under easement to date. Conservation easement programs allow the counties to co-hold easements that protect agricultural and forested lands in perpetuity. In addition, both counties offer programs that allow landowners to establish Ag Forestal Districts. In Frederick County, one of these districts has been established in the watershed, the Double Church District, which includes 934 acres of land. This designation will remain in place from 2015 through 2020, after which point it may be renewed. The Rockland District has been established in the Warren County portion of the watersheds, and is the largest of the county's three districts at 9,464 acres. These rural conservation areas are protected from development for a limited period of time and in return, landowners can take advantage of property tax incentives. The preservation of agricultural land in the watersheds will help to extend the life span of agricultural BMPs installed by landowners, while protection of forest land will provide numerous water quality benefits including the filtration of pollutants from adjacent developed lands.

Frederick and Warren County Comprehensive Plans

Both Frederick and Warren Counties have adopted Comprehensive Plans intended to guide development and natural resource management within their jurisdictions. Both plans stress the importance of the preservation of rural areas, and encourage development in development core areas. Frederick County has identified water quality and stormwater management as two priority natural resource issues to focus on through 2030. The county's comprehensive plan stresses the importance of streamside buffers, proper maintenance of alternative waste treatment systems, and a collaborative approach to educating the community about the role that citizens play in protecting and improving water quality. Frederick County also identified bioretention filters as a critical tool in stormwater management in the region with respect to treating large impervious areas such as parking lots. Low impact development and green infrastructure planning are both included in the plan as key stormwater management strategies as well (Frederick County, 2011). For more information: http://www.fcva.us/departments/o-z/planning-development/planning-documents-plans/2030-comprehensive-plan

Similarly, Warren County has included the protection of surface waters as a key objective in its comprehensive plan. Other related objectives in the plan include evaluation of problems related to failing septic systems, requirement of regular septic pumpouts and alternative waste treatment system maintenance using state recommendations, protection of wetlands, springs and groundwater from contamination, and protection of the natural function of waterways through preservation of natural vegetation. The county's Comprehensive Plan stresses the importance of county-wide education and outreach regarding the relationship between local land use decisions and local ecology (Warren County, 2013). For more information: http://www.warrencountyva.net/resources3/county-plans/comprehensive-plan.html#

Virginia's Phase II Chesapeake Bay Watershed Implementation Plan

Virginia's Watershed Implementation Plan (WIP) outlines a series of BMPs, programs and regulations that will be implemented across the state in order to meet nitrogen, phosphorous, and sediment loading reductions called for in the Chesapeake Bay TMDL, completed in December 2010. The TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay are in place by 2025, with at least 60 percent of the actions completed by 2017. A number of the BMPs included in this implementation plan are also found in Virginia's WIP. Consequently, Frederick and Warren Counties will be able to track and receive credit for progress in meeting Phase II WIP goals while also working towards implementation goals established in this plan to improve local water quality. For more information about Virginia's Phase II WIP, please visit VADEQ's Bay TMDL web page: http://www.deq.virginia.gov/Programs/Water/ChesapeakeBay.aspx

FUNDING FOR IMPLEMENTATION

A list of potential funding sources available for implementation has been developed. Detailed descriptions can be obtained from the Lord Fairfax SWCD, VADCR, Natural Resources Conservation Service, and Virginia Cooperative Extension. While funding is being provided to the Lord Fairfax SWCD for agricultural BMPs and technical assistance for farmers, an additional funding commitment is needed to fully implement the agricultural, residential and urban practices included in the plan.

Virginia Agricultural Best Management Practices Cost-Share Program

This program is funded with state and federal monies through local SWCDs. SWCDs administer the program to encourage landowners to use BMPs on their land to better control transportation of pollutants into our waters due to excessive surface flow, erosion, leaching, and inadequate animal waste management. Program participants are recruited by SWCDs based upon those factors, which have a great impact on water quality. Cost-share is typically 75% of the actual cost, not to exceed local caps.
For more information: http://lfswcd.org/best-management-practices/

Virginia Agricultural Best Management Practices Tax Credit Program

For all taxable years, any individual or corporation engaged in agricultural production for market, who has in place a soil conservation plan approved by the local SWCD, is allowed a credit against the tax imposed by Section 58.1-320 of the Code of Virginia equaling 25% of the first $70,000 expended for agricultural BMPs by the individual. The amount of the credit cannot exceed $17,500 or the total amount of the tax imposed by this program (whichever is less) in the year the project was completed. This program can be used in conjunction with other cost-share programs on the landowner's portion of BMP costs. It is also approved for use in supplementing the cost of repairs to streamside fencing.
For more information: http://lfswcd.org/best-management-practices/

Virginia Agricultural Best Management Practices Loan Program

Loan requests are accepted through VADEQ. The interest rate is 3% per year and the term of the loan coincides with the life span of the practice. To be eligible for the loan, the BMP must be included in a conservation plan approved by the local SWCD Board. The minimum loan amount is $5,000 with no maximum limit. Eligible BMPs include structural practices such as animal waste control facilities, and grazing land protection systems. Loans are administered through participating lending institutions.
For more information: http://www.deq.virginia.gov/programs/water/cleanwaterfinancingassistance/agriculturalbmp.aspx

Virginia Conservation Assistance Program (VCAP)

VCAP is a relatively new program that can provide reimbursements to landowners who install stormwater BMPs. The program is administered by Soil and Water Conservation Districts, who accept and review BMP plans submitted by landowners, verify project eligibility, and issue and track reimbursements for completed projects. All non agricultural property owners in eligible districts may apply.

This includes businesses, public and private lands. A manual has been developed for the program, which includes standards and specifications for BMPs eligible for reimbursement. The Lord Fairfax SWCD has a staff member available to apply for funds through this program in order to work with interested property owners on residential/urban stormwater BMPs. ***For more information:*** http://vaswcd.org/vcap

Virginia Small Business Environmental Assistance Fund Loan Program

The Fund, administered through VADEQ, is used to make or guarantee loans to small businesses for the purchase and installation of environmental pollution control equipment, or equipment and structures to implement agricultural BMPs. Loans are available up to $50,000 and will carry an interest rate of 3%, with repayment terms based on the borrower's ability to repay and the life of the equipment or BMP. To be eligible for assistance, a business must employ 100 or fewer people and be classified as a small business under the federal Small Business Act. ***For more information:*** http://www.deq.virginia.gov/portals/0/deq/air/smallbusinessassistance/autobody/appendix13.pdf

Virginia Water Quality Improvement Fund

This is a permanent, non-reverting fund established by the Commonwealth of Virginia in order to assist local stakeholders in reducing point and nonpoint nutrient loads to surface waters. Eligible recipients include local governments, SWCDs, and individuals. Grants for point and nonpoint sources are administered through VADEQ. ***For more information:*** http://www.deq.virginia.gov/Programs/Water/CleanWaterFinancingAssistance/WaterQualityImprovementFund.aspx

Conservation Reserve Program (CRP)

Through this program, cost-share assistance is available to establish cover of trees or herbaceous vegetation on cropland. To be eligible for consideration, the following criteria must be met: 1) cropland was planted or considered planted in an agricultural commodity for two of the five most recent crop years, and 2) cropland is classified as "highly-erodible" by NRCS. The payment to the participant is up to 50% of the cost for establishing ground cover. ***For more information:*** http://www.nrcs.usda.gov/wps/portal/nrcs/main/va/programs/

Conservation Reserve Enhancement Program (CREP)

This program is an "enhancement" of the existing Farm Service Agency (FSA) CRP Continuous Sign-up. It has been "enhanced" by increasing the rental rates, and offering incentive payments to place the enrolled area under a 10-15 year contract. The average cost share payment in this program is 75%; however, additional incentives are available to raise this rate if a landowner is willing to install addtional control measures. Buffers consisting of native, warm-season grasses on cropland, and mixed hardwood trees on pasture, must be established in widths ranging from the minimum of 30% of the floodplain or 35 feet, whichever is greater, to a maximum average of 300 feet. Federal cost-sharing (50%) is available to help pay for fencing to exclude livestock from the riparian buffer, watering facilities, hardwood tree planting, filter strip establishment, and wetland restoration. The Lord Fairfax SWCD also provides a cost share payment. The State of Virginia will make an additional payment to landowners who elect

to place a perpetual easement on the enrolled area. ***For more information:*** https://www.fsa.usda.gov/Internet/FSA_File/va_crep_infosheet.pdf

Environmental Quality Incentives Program (EQIP)

Approximately 65% of the EQIP funding for the state of Virginia is directed toward "Priority Areas." These areas are selected from proposals submitted by a locally led conservation work group. The remaining 35% of the funds are directed toward statewide priority concerns of environmental needs. EQIP offers up to 10-year contracts to landowners and farmers to provide financial assistance, and/or incentive payments to implement conservation practices and address the priority concerns statewide or in the priority area. Eligibility is limited to persons who are engaged in agricultural production. ***For more information:*** http://www.nrcs.usda.gov/wps/portal/nrcs/main/va/programs/financial/eqip/

EPA Section 319 Grant Project Funds

Through Section 319 of the Federal Clean Water Act, Virginia is awarded grant funds to implement NPS programs. The VADEQ administers the money annually on a competitive grant basis to fund TMDL implementation projects, outreach and educational activities, water quality monitoring, and technical assistance for staff of local sponsor(s) coordinating implementation. In order to meet eligibility criteria established for 319 funding, all proposed project activities must be included in the TMDL implementation plan covering the project area. In addition, this plan must include the nine key elements of a watershed based plan (noted on page 2). ***For more information:*** http://www.deq.virginia.gov/Programs/Water/CleanWaterFinancingAssistance/NonpointSourceFunding.aspx

Regional Conservation Partnership Program (RCPP)

This 5-year program promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. The RCPP competitively awards funds to conservation projects designed by local partners specifically for their region. Partners such as SWCD's and non profit organizations can then work with interested landowners to utilize these funds for BMP implementation. The Chesapeake Bay watershed is one of eight "Critical Conservation Areas" identified in this program. ***For more information:*** http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/farmbill/rcpp/?cid=stelprdb1254053

Wildlife Habitat Incentive Program (WHIP)

WHIP is a voluntary program for landowners who want to develop or improve wildlife habitat on private agricultural lands. Participants work with NRCS to prepare a wildlife habitat development plan. This plan describes the landowner's goals for improving wildlife habitat and includes a list of practices and a schedule for installation. A 10-year contract provides cost-share and technical assistance to carry out the plan. Cost-share assistance of up to 75% of the total cost of installation (not to exceed $10,000 per applicant) is available for establishing habitat. Types of practices include: prescribed burning, converting fescue to warm season grasses, and creating habitat for waterfowl. ***For more information:*** http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/whip/

Southeast Rural Community Assistance Project (SER-CAP)

The mission of this project is to promote, cultivate, and encourage the development of water and wastewater facilities to serve low-income residents at affordable costs and to support other development activities that will improve the quality of life in rural areas. They can provide (at no cost): on-site technical assistance and consultation, operation and maintenance/management assistance, training, education, facilitation, volunteers, and financial assistance. Financial assistance includes $1,500 toward repair/replacement/ installation of a septic system and $2,000 toward repair/replacement/installation of an alternative waste treatment system. Funding is only available for families making less than 125% of the federal poverty level. ***For more information:*** http://www.sercap.org/se_loan_fund.htm

National Fish and Wildlife Foundation (NFWF)

NFWF administers the Chesapeake Bay Stewardship Fund, which is dedicated to the protection and restoration of the Chesapeake Bay. The Stewardship Fun is supported through partnerships with government agencies and private corporations, and typically awards $8 million to $12 million per year through two competative grant programs (Innovative Nutrient and Sediment Reduction Grants and Small Watershed Grants) and a technical assistance program. A request for proposals is typically issued in the spring and awards are made in the fall. ***For more information:*** http://www.nfwf.org/chesapeake/Pages/home.aspx

Clean Water State Revolving Fund

EPA awards grants to states to support their Clean Water State Revolving Funds. The states then make loans for priority water quality activities. As recipients make payments, money is available for new loans to be issued to other recipients. Eligible projects include point source, nonpoint source and estuary protection projects. Point source projects typically include building wastewater treatment facilities, combined sewer overflow and sanitary sewer overflow correction, urban stormwater control, and water quality aspects of landfill projects. Nonpoint source projects include agricultural, silvicultural, rural, and some urban runoff control; on-site wastewater disposal systems (septic tanks); land conservation and riparian buffers; leaking underground storage tank remediation, etc. ***For more information:*** http://www.deq.virginia.gov/programs/water/cleanwaterfinancingassistance.aspx

Wetland and Stream Mitigation Banking

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

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