Roanoke River Implementation Plan

A plan to reduce bacteria and sediment in the Roanoke River watershed

Prepared For

Virginia Department of Environmental Quality

Prepared By

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A landowner's guide to the Roanoke River

Monitoring performed by the Virginia Department of Environmental Quality determined that the Roanoke River and tributaries are impaired because of high levels of bacteria and sediment. Sources of bacteria include manure deposits on pasture from grazing animals and manure applications on cropland, direct deposition of fecal matter into streams by livestock and wildlife, other nonpoint source runoff from developed lands including pet waste, and failing septic systems and straight pipes. Sediment sources also include runoff from cropland, pasture, and developed land as well as sediment eroded from stream beds and banks.

Practices in this implementation plan, or clean-up plan, focus on pollutants derived from agricultural, residential, and developed land uses. Best Management Practices, or BMPs, work to control pollutants at the source or to mitigate the pollutants before they reach the waterways. Agricultural practices focus on livestock, pasture, and cropland and include livestock exclusion, cover crops, field borders, and pasture management. Residential practices focus on sewage disposal and pet waste issues and include septic pumpouts and repairs and pet waste stations. Urban practices focus on a suite of stormwater management BMPs and include as an example bioretention, rain gardens, and riparian buffers. Outreach and education are an important part of cleaning up the watershed. Outreach on nonpoint source pollution, erosion control, septic system maintenance, pet waste issues, and low impact development are recommended. In this plan, the timelines with goals and milestones for water quality and BMP installation goals are varied depending on watershed size over three stages. The practices and implementation timelines described in this plan are meant to serve as a guide to get clean-up started and to evaluate progress. It is understood that situations change over time and therefore, the specific BMPs and timeframes may need to be adapted to the changing conditions within the watershed.

All citizens within the watershed would benefit from a clean Roanoke River. Clean water improves weight gain in cattle and reduces the occurrence of livestock infections allowing for greater revenue for livestock producers. Benefits to landowners and homeowners include a reduction in damages and costs associated with flooding and septic system issues. A healthy environment benefits the local economy by encouraging recreational pursuits such as fishing, canoeing, and hiking. In addition to economic benefits, there are environmental and human health benefits. Healthy watersheds provide enhanced wildlife habitat and ecosystem services such as water filtration and storage, nutrient cycling, and air filtration. Lastly, these benefits provide an improved quality of life for all residents.

Everyone in the watershed has a role in cleaning up the rivers. State and local governments support water quality monitoring and assess stream health, provide technical assistance and funding, encourage beneficial practices through comprehensive plans and ordinances, and facilitate education and outreach. Local residents and landowners are an important source of information about the watershed and the BMPs that would work in the area. Citizens that are informed about the implementation plan and the pollutant reductions provided by BMPs are crucial to the success of the plan.

Funding for implementation of cleanup practices is a challenge. Various funding and grant sources are available through federal, state and local or regional sources. Examples include federal Section 319 funds,

state cost-share and revolving loan funds, and local projects through the National Fish and Wildlife Foundation and the Virginia Environmental Endowment.

What is needed to clean up the Roanoke River?

The list below highlights the BMPs suggested to restore the water quality of the Roanoke River and its' tributaries. Cleaning up the waterways would allow for safe use of the river for recreation and other uses and improve the biological community which would benefit the fishery. The Roanoke River watershed is very large and encompasses diverse land uses. Therefore, every person in the watershed from private citizens, to farmers and livestock producers, business owners, and other landowners can help make the watershed healthy again.

Agricultural actions:

- Livestock Stream Exclusion Systems (509)

Pasture BMPs:

- Vegetative Cover on Critical Areas (8,078 acres)
- Reforestation of Erodible Pasture (3,647 acres)
- Woodland Buffer Filter Area (912 acres)
- Pasture Management (34,034 acres)
- Grazing Land Management (880 acres)
- Wet Detention Pond (7,315 acres treated)

Cropland BMPs:

- Continuous No-Till (1,306 acres)
- Small Grain Cover Crop (998 acres)
- Permanent Vegetative Cover on Cropland (78 acres)
- Sod Waterway (78 acres)
- Cropland Buffer/Field Borders (67 acres)

Residential actions:

On-site Sewage Disposal Systems:

- Septic tank pump-outs (3,034)
- Sewer connections (2,476)
- Septic system repairs (1,753)
- Septic system installation/replacements (1,899)
- Alternative waste treatment systems (189)

Pet Waste Management:

- Pet waste education campaigns (34)
- Pet waste composters (243)
- Pet waste stations (123)

Urban and stormwater actions:

- Bioretention (13,100 acres treated)
- Rain garden (3,840 acres treated)
- Infiltration trench (3,069 acres treated)
- Manufactured BMP (3,714 acres treated)
- Constructed wetland (54,766 acres treated)

- Detention pond (2,440 acres treated)
- Permeable pavement (70 acres treated)
- Vegetated swale (3,350 acres treated)
- Rain barrel (7,345 barrels)
- Forested riparian buffer (109 acres to 456 acres)
- Grass/shrub riparian buffer (109 acres to 489 acres)
- Urban land use conversion (398 acres)
- Cistern (165 units)
- Detention pond retrofit to infiltration basin (285)
- Detention pond retrofit to constructed wetland (339)
- Street sweeping (11,636 additional miles swept)

Stream restoration actions:

- Stream restoration (28.9 miles)
- Stream stabilization (0.8 miles)

To learn how you can help:

- Technical and financial assistance with agricultural and residential practices
  Blue Ridge Soil and Water Conservation District
  Website: http://brswcd.org/ Phone: (540) 483-5341, Ext. 4

  Mountain Castles Soil and Water Conservation District
  Website: http://www.mountaincastles.org/ Phone: (540) 977-2698, Ext. 3

  Skyline Soil and Water Conservation District
  Phone: (540) 381-0071

- Information about septic system maintenance, repairs, and replacement and sewer issues
  Alleghany Health District (Botetourt and Roanoke Counties, City of Salem, Town of Vinton)
  Website: https://www.vdh.virginia.gov/LHD/Alleghany/ Phone: (540) 857-7800

  New River Health District (Floyd and Montgomery Counties)
  Website: https://www.vdh.virginia.gov/LHD/newriver/INDEX.HTM Phone: (540) 857-7800

  City of Roanoke Health Department
  Website: https://www.vdh.virginia.gov/LHD/Roanoke_City/ Phone: (540) 857-7600

- Information about water quality, citizen monitoring, stormwater, and TMDL implementation
  Virginia Department Environmental Quality
  Website: http://www.deq.virginia.gov/ Phone: (540) 562-6700

- Information about local stormwater management programs

Bedford County
Website: http://www.co.bedford.va.us/res/E+S/stormwaterinfo.htm Phone: (540) 586-7616

Botetourt County
Website: http://www.co.botetourt.va.us/government/stormwater.php Phone: (540) 473-2018

Franklin County
Website: http://www.franklincountyva.gov/planning-erosion-stormwater Phone: (540) 483-3027

Montgomery County
Website: http://www.montgomerycountyva.gov/content/15989/16023/16945/default.aspx
Phone: (540) 394-2090

Roanoke County
Website: http://www.roanokecountyva.gov/index.aspx?NID=306

City of Roanoke
Website: http://www.roanokeva.gov/500/Stormwater and
http://www.roanokeva.gov/513/Stormwater-Resources
Phone: (540) 853-5900

City of Salem
Website: http://www.salemva.gov/departments/engineering/Engineering/StormwaterInformation.aspx
Phone: (540) 375-3032

Town of Blacksburg
Website: http://www.blacksburg.gov/departments/departments-a-k/engineering-and-gis/stormwater

Town of Christiansburg
Website: http://www.christiansburg.org/index.aspx?NID=250

Town of Vinton
Website: http://www.vintonva.gov/FAQ.aspx?FID=52&NID=209 and
http://www.vintonva.gov/index.aspx?NID=209

INTRODUCTION

The Clean Water Act (CWA) requires that streams, rivers, and lakes within the United States meet specified state water quality standards and that states conduct monitoring to identify waterbodies that are polluted and do not meet these standards.

When streams fail to meet the water quality standards, states must develop a Total Maximum Daily Load (TMDL) for each pollutant. A **TMDL, or "pollution budget"**, determines the maximum amount of a pollutant that a waterbody can receive without exceeding the appropriate water quality standards. After a TMDL is developed, states work with local stakeholders to develop an implementation plan to address the pollutant sources impairing the waterbodies and to ultimately meet the TMDL. The implementation plan (IP) proposes various Best Management Practices (BMPs) with the goal of cleaning up streams and ultimately removing the polluted waterbodies from the impaired waters list.

A BMP is an activity, measure, or facility that prevents or reduces the transport of pollutants, controls stormwater volume or rate, or limits the impacts to the storm drainage system.

EPA guidance identifies the following nine elements that must be included in an implementation plan to meet the Clean Water Act Section 319 funding requirements:

1. The causes and sources of pollutants that will need to be controlled to achieve the load reductions estimated in the watershed-based plan;
2. The load reductions needed to achieve water quality standards;
3. The nonpoint source (NPS) management measures that will need to be implemented to achieve the identified load reductions;
4. Necessary technical and financial assistance including costs and sources;
5. An information/education component to enhance public understanding of the project and encourage public participation in the implementation process;
6. A schedule for implementing the NPS management measures;
7. Measurable milestones for determining whether NPS management measures or other control actions are being implemented;

8. Criteria for determining if loading reductions are being achieved and progress is being made towards attaining water quality standards;
9. Monitoring to evaluate the effectiveness of the implementation efforts.

Water Quality Problems in the Roanoke River Watershed

Bacteria Impairment

Required monitoring performed by the Commonwealth of Virginia identified 43 segments within the Roanoke River watershed that did not meet the *Escherichia coli* (*E. coli*) criteria and, therefore, did not protect the primary contact recreational beneficial use. The *E. coli* standard for primary contact recreation in freshwater states that **bacteria** should not exceed a geometric mean of 126 colony forming units (cfu)/100mL or, if there are not enough samples to calculate a mean, that no more than 10.5% of all samples in the assessment period should exceed 235 *E. coli* cfu/100 ml. Not all of the 43 bacteria impaired waters have established TMDLs. However, each segment was directly or indirectly incorporated during development of the two established bacteria TMDL studies. After the development of the TMDLs, other segments were found to be impaired due to violations of *E. coli* and fecal coliform criteria and are incorporated within this implementation plan. Addressing impairments that occurred after approval of the original TMDLs is feasible since these newer impairments occur within the watershed areas that drain to original TMDL segments.

Benthic Impairment

There are no specific numeric criteria for **sediment** but the General Standard defined in Virginia Water Quality Standards provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses, and says: "All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life." Biological monitoring of benthic macroinvertebrate communities identified six segments of the mainstem Roanoke River as not attaining the aquatic life use General Criteria. Benthic macroinvertebrates are organisms large enough to see with the naked eye that live on the sides and undersides of rocks, logs, and stream bottoms. Analysis during TMDL development identified the most probable cause of benthic macroinvertebrate community impairment in the Roanoke River watershed as excessive sedimentation. Therefore, a benthic macroinvertebrate TMDL was developed to address sediment in order to attain the aquatic life use standard in the six river segments (VADEQ, 2006b). Since the development of the TMDL other tributary segments within the watershed have been identified as having benthic communities impaired by excessive sediment and are incorporated within this implementation plan.

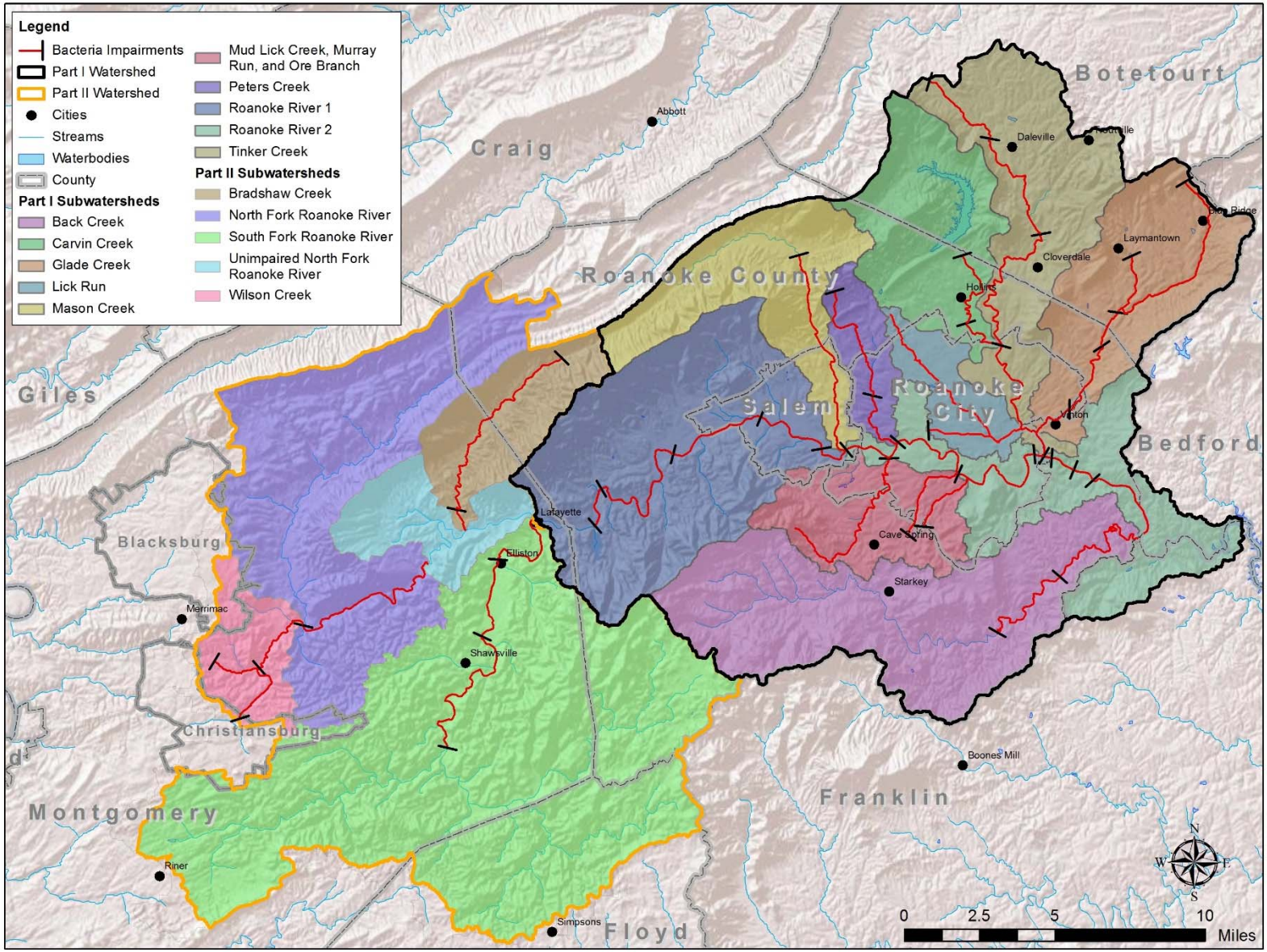

Figure 1. Location of Parts I and II Bacteria Impaired Watersheds/Subwatersheds

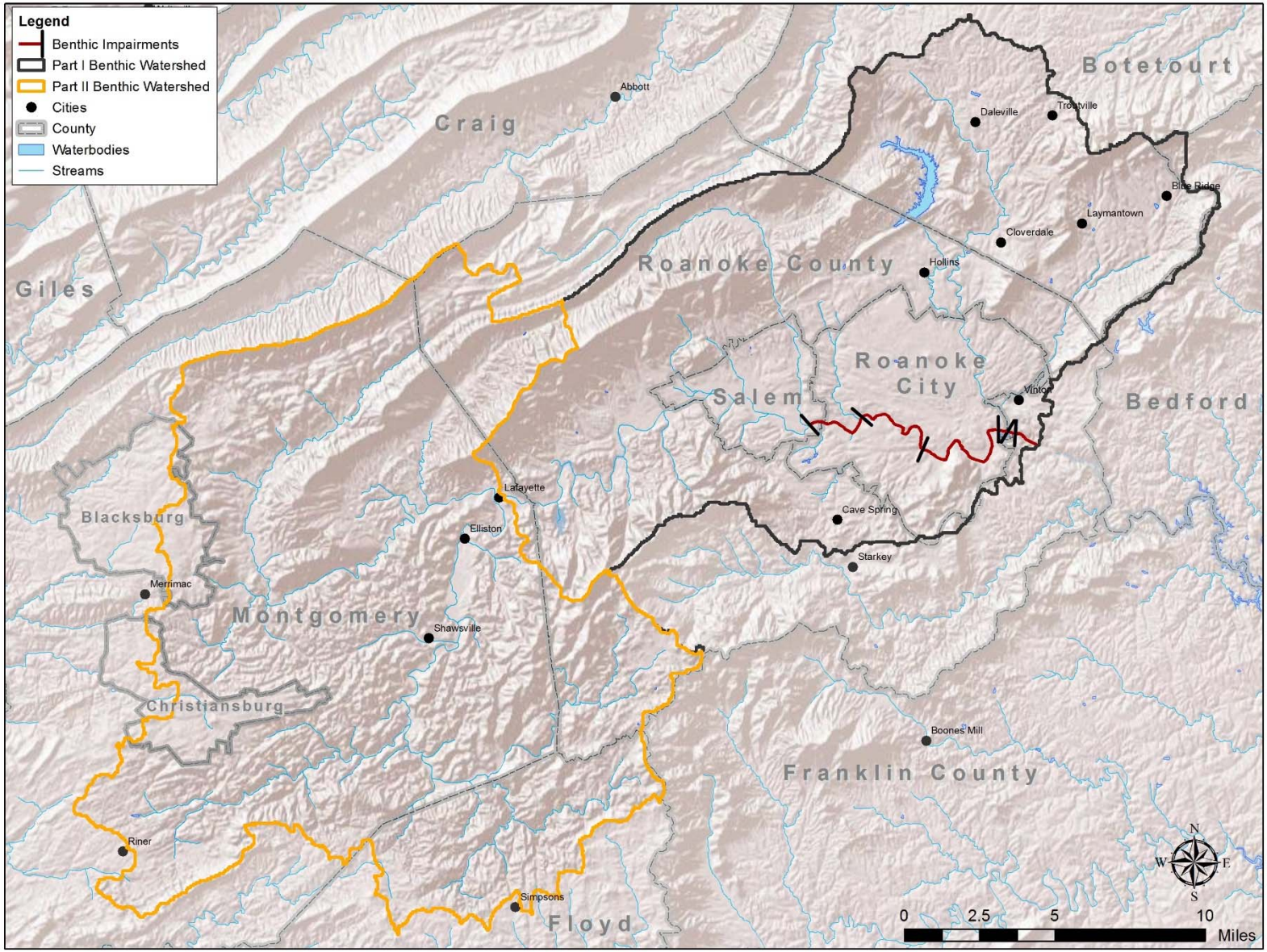

Figure 2. Location of Parts I and II Sediment Impaired Watersheds

REVIEW OF THE TMDL STUDY

The Roanoke River TMDL Implementation Plan is split into two parts based on geography. Part I addresses bacteria impaired portions of Carvin Creek; Glade Creek; Lick Run; Tinker Creek; Back Creek; Mason Creek; Mud Lick Creek, Murray Run, Ore Branch; Peters Creek; Roanoke River 1; and Roanoke River 2 as well as sediment impaired portions of the mainstem Roanoke River. The Part I bacteria area includes the backwaters of Smith Mountain Lake upstream to Lafayette where the North Fork and South Fork Roanoke Rivers come together to form the main stem Roanoke River (Figure 1). The Part I sediment impaired area includes the Roanoke River behind Niagara Dam upstream to the North Fork and South Fork Roanoke Rivers confluence at Lafayette (Figure 2). The boundaries of the benthic impaired watershed and the bacteria impaired watershed are different because of the location of the impaired segments.

Part II addresses the water quality problems located upstream from the Part I waters. The Part II area begins at the confluence of the North Fork and South Fork Roanoke Rivers and incorporates the waters upstream into the headwaters (Figures 1 and 2). These include bacteria impaired portions of Bradshaw Creek, North Fork Roanoke River, South Fork Roanoke River, and Wilson Creek, and the sediment impaired portions of the mainstem Roanoke River. Part II also covers a portion of the North Fork Roanoke River that is unimpaired since monitoring data showed that bacteria levels are not violating water quality standards. This plan provides cleanup scenarios for two bacteria TMDL studies and one benthic macroinvertebrate community (sediment) TMDL study (VADEQ 2004, 2006a, 2006b).

Description of Bacteria Watersheds and Impairments

The bacteria watershed area for Part I covers approximately 317 square miles including ten subwatersheds with **34 impaired segments** in Bedford, Botetourt, Franklin, Montgomery, and Roanoke counties, the Cities of Roanoke and Salem, and the Town of Vinton (Figure 1). The bacteria impaired segments include approximately **116 miles** along the mainstem Roanoke River and tributaries as well as 350 acres of lake throughout the watershed (Table 1). The two reaches of the mainstem Roanoke River run from the Roanoke County Spring Hollow Reservoir intake in western Roanoke County to the mouth of Falling Creek including the Roanoke arm of Smith Mountain Lake in eastern Roanoke County along the boundary with Bedford County. The dominant land use in the Part I watershed is forest followed by developed land with a small amount of land in pasture/hay. Generally, the developed land occurs in the central and eastern portions of the watershed with the forest land surrounding this on the northern, western, and southern portions. Some subwatersheds are almost entirely developed such as Lick Run, Peters Creek, and Mud Lick Creek, Murray Run, and Ore Branch, whereas others such as Back Creek have almost no development. The majority of pasture/hay acreage is located in Tinker Creek and Glade Creek subwatershed in northeastern part of the watershed.

The bacteria watershed area for Part II covers approximately 253 square miles including five subwatersheds with **nine impaired segments** in Floyd, Montgomery, and Roanoke counties and the Towns of Blacksburg and Christiansburg (Figure 1). The watershed and the impaired segments begin just upstream from the Part I watershed at the confluence of the South Fork Roanoke River and North Fork Roanoke River. The bacteria

impaired segments cover approximately **35 miles** of river throughout the watershed including the South Fork Roanoke River, the North Fork Roanoke River and the North Fork tributaries of Bradshaw Creek and Wilson Creek (Table 1). The dominant land use in the Part II watershed is forest followed by pasture/hay land. Most of the pasture/hay land is concentrated along the main valleys running through the watershed. There is very little developed land, however small portions of both the Towns of Blacksburg and Christiansburg are located in the western part of the watershed.

Table 1: Bacteria Impairment Summary

Subwatershed	Total Length of Impaired Segment(s) (miles)	Cause
Part I		
Back Creek	9.87	*Escherichia coli*
Carvin Creek	5.34	*Escherichia coli*
Glade Creek	14.64	*Escherichia coli*
Lick Run	9.37	*Escherichia coli*
Mason Creek	7.56	*Escherichia coli*
Mud Lick Creek, Murray Run, Ore Branch	12.91	*Escherichia coli*/ Fecal coliform
Peters Creek	7.14	*Escherichia coli*
Roanoke River 1	14.28	*Escherichia coli*
Roanoke River 2	15.23 (350 acres)	*Escherichia coli*
Tinker Creek	19.34	*Escherichia coli*
Part II		
Bradshaw Creek	8.72	*Escherichia coli*
North Fork Roanoke River	6.58	*Escherichia coli*
South Fork Roanoke River	12.63	*Escherichia coli*/ Fecal coliform
Wilson Creek	6.92	*Escherichia coli*

Bacteria Sources

Sources of bacteria in the rivers and streams in the Roanoke River watershed were based on land uses and include nonpoint source runoff from various land uses as well as direct contributions to the waterbodies. The top bacteria source in the Part I watershed is urban developed land followed by forest, pasture/hay, and cropland. The direct sources of bacteria are failing septic systems as well as direct deposition of fecal material in streams by livestock and wildlife. For the Part II watershed, the main bacteria source is also developed land followed by pasture/hay and wildlife direct sources with less bacteria attributable to livestock direct, failing septic systems, cropland, and forest.

Bacteria Reduction Goals

The original TMDL studies identified the bacteria reductions necessary to achieve water quality standards. These reduction goals were adjusted using more recent land use data to give a more realistic and practical basis for the cleanup. The adjustments do not replace the existing approved TMDL goals but were made for the purposes of developing this implementation plan. Tables 2 and 3 show the necessary reductions in bacteria to successfully meet the bacteria criterion for Parts I and II, respectively. General goals include

exclusion of all livestock from streams for Part I, correction of all straight pipes and failing septic systems, as well as variable reductions from land-based loads.

Table 2: Bacteria Reductions from Land Uses/Sources for Part I										
Land Use/Source	**Back Creek**	**Carvin Creek**	**Glade Creek**	**Lick Run**	**Mason Creek**	**Mud Lick Creek, Murray Run, and Ore Branch**	**Peters Creek**	**Roanoke River 1**	**Roanoke River 2**	**Tinker Creek**
Developed	98.9%	90.2%	96.3%	98.5%	98.9%	99.6%	98.9%	96.5%	98.2%	98.6%
Cropland	98.9%	-	96.3%	-	98.9%	99.6%	-	96.5%	98.2%	99.8%
Pasture/Hay	98.9%	90.2%	96.3%	91%	98.9%	99.6%	98.9%	96.5%	98.2%	99.8%
Forest	98.9%	85.2%	91.5%	0%	98.9%	99.6%	98.9%	96.5%	98.2%	95%
Water/Wetlands	0%	85.2%	91%	0%	0%	0%	-	0%	0%	95%
Other	98.9%	90.2%	96.3%	-	98.9%	99.6%	98.9%	96.5%	98.2%	98%
Livestock Direct	100%	-	100%	-	100%	100%	-	100%	100%	100%
Wildlife Direct	64.5%	75%	70%	0%	65.1%	87.9%	53.7%	67.1%	66%	0%
Failing Septic Systems and Straight Pipes	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 3: Bacteria Reductions from Land Uses/Sources for Part II				
Land Use/Source	**Bradshaw Creek**	**North Fork Roanoke River**	**South Fork Roanoke River**	**Wilson Creek**
Developed	22%	82%	77%	98%
Cropland	0%	0%	0%	0%
Pasture/Hay	32%	90%	77%	98%
Forest	0%	0%	0%	0%
Water/Wetlands	-	0%	0%	0%
Other	-	-	-	-
Livestock Direct	88%	88%	95%	97%
Wildlife Direct	95%	99%	99%	99%
Failing Septic Systems and Straight Pipes	100%	100%	100%	100%

Description of Benthic Watersheds and Impairments

The overall watershed area for the **six sediment impaired segments** on the mainstem Roanoke River covers approximately 525 square miles in Bedford, Botetourt, Floyd, Montgomery, and Roanoke Counties, the Cities of Roanoke and Salem, and the Towns of Blacksburg and Christiansburg (Figure 2). The impaired segments totaling approximately **11.3 miles** are located on the mainstem of the Roanoke River and flow through the City of Roanoke (Table 4). The drainage area is approximately 252 square miles for the Part I

watershed and approximately 273 square miles for the Part II watershed. The inclusion of the upstream Part II tributaries and associated subwatersheds in the cleanup plan recognizes that even though the tributaries were not specifically identified as having a sediment impairment, they are contributing to the mainstem Roanoke River sediment load.

Table 1: Benthic Impairment Summary

Stream Name	Length (miles)	Cause
Roanoke River, Niagara	0.86	Sediment
Roanoke River	10.45	Sediment

Sediment Sources

Sediment is delivered to the Roanoke River through stormwater runoff and erosion from various land uses, channel and streambank erosion, and background geological processes. Natural sediment generation is accelerated through human-caused land disturbance related to agricultural, urban, and forest land uses. During rain events, exposed sediment particles can be dislodged from the soil and carried in runoff from both pervious and impervious surfaces in the watershed to the stream. Streambank instability from decreased riparian vegetation, increased stormwater runoff, and livestock trampling causes streambank failure and erosion and increases sediment loading. Sediment loading can also result from improperly installed or maintained erosion and sediment control practices.

Sediment Reduction Goals

Sediment reduction goals for the Roanoke River benthic impairments are based on the more recent land use information (as discussed above) and presented in Table 5. The overall goals to meet the TMDL endpoint include a 74% reduction in sediment loading for the Part I watershed and a 72% reduction in sediment for the Part II watershed. Sediment from all land use and instream erosion sources except for forest in Part II would need to be reduced by 75%. There are no loads from water/wetland land uses and therefore no reductions are required.

Table 2: Sediment Reductions from Land Uses and Other Sources for Parts I and II

Land Use/Sources		Percent Reduction	
		Part I	Part II
Land Sources	Developed	75%	75%
	Cropland	75%	75%
	Pasture/Hay	75%	75%
	Forest	75%	0%
	Water/Wetlands	-	-
	Other	75%	75%
Instream Erosion		75%	75%
Point Sources		0%	0%
	Total	**74%**	**72%**

PUBLIC PARTICIPATION

Public involvement in the development of any implementation plan is important in order to educate and inform the local stakeholders about the water quality issues and to receive input on appropriate cleanup solutions from citizens with local knowledge of the watershed. Since the IP was developed in two parts and IP development overlapped slightly, Part I was initiated first at a public meeting followed by a series of working group meetings. The final public meeting for Part I served as the kick-off meeting for Part II. Part II IP development consisted of a series of working group meetings followed by a final public meeting. The process is detailed in the following sections.

Public Meetings

The first public meeting for the Roanoke River watershed cleanup plan was held on June 11, 2013 at the Roanoke Civic Center with approximately 57 people in attendance. This open house kicked off the implementation process by introducing to the public the planned Roanoke River implementation plan, particularly for Part I, and how it is developed, why the watershed must be cleaned up, and finally ways for the public to get involved. The open house featured presentations about cleanup plan activities in other watersheds and information booths hosted by various watershed stakeholders with topics such as water quality improvement and education, advocacy, and stormwater. Input, comments, and questions were solicited from the public and stakeholders present and participants were invited to sign-up for a working group.

The second public meeting for the Roanoke River watershed cleanup plan was held on April 30, 2015 at the Meadowbrook Community Room in Shawsville with 34 participants. The main purpose of the meeting was to present highlights and initiate a 30 day public comment period for the Part I Roanoke River TMDL Implementation Plan as well as to kick-off the plan development process for Part II. Presentations included highlights of the Roanoke Valley Livability Initiative and the Roanoke River Blueways by Roanoke Valley Alleghany Regional Commission and water quality monitoring in relation to the 303(d) list by VADEQ staff. Input from the public was provided through comments and question and answers sessions. Informational materials were available in the form of posters and handouts. Attendees were encouraged to sign up for Part II working groups.

The final public meeting for Part II was held on July 14, 2016 at the Meadowbrook Community Room in Shawsville with 23 participants. A draft of the final implementation plan for Part II was presented. VADEQ staff reviewed the proposed BMPs, outreach efforts, and funding sources and fielded questions from those in attendance. Meeting participants were asked to provide input and comments during a 30 day public comment period. Poster displays and informational materials were available.

Working Group Meetings

The formation of individual working groups is based on general land uses and/or areas of interest in the watershed. The purpose of the individual working groups is to educate the public on the cleanup and management issues associated with each area and to allow those stakeholders with specialized knowledge to provide information and to make recommendations regarding the types and extent of BMPs. The Roanoke River implementation plan included working groups for agricultural, business, government, and residential.

Agricultural and Residential

For the most part, the **agricultural and residential working groups** were combined into one meeting throughout the development of the IP. For Part I, the meetings were held at the VADEQ Blue Ridge Regional office in Roanoke on June 20, 2013 with 17 participants and February 27, 2014 with 14 participants. For Part II, the agricultural and residential working groups meetings were held at the Meadowbrook Community Room in Shawsville on June 16, 2015 with 15 participants and December 3, 2015 with 14 participants. The focus of both the agricultural and residential working groups in Part I was slightly different than in Part II due to differences in types of agriculture and the amount of urbanized areas between the two watersheds.

Over the course of the two Part I meetings, agricultural discussions included tracking non-cost share agricultural practices and bacteria loadings from livestock markets. Residential discussions focused on on-site sewage disposal systems and pet waste and stormwater issues. Specific concerns were related to the difficulty in finding straight pipe locations, the lack of ordinances for septic system maintenance, septage haulers, septic system problems, and pet waste station maintenance. The introduction of pet waste composters as a potential BMP was a new concept for the area. Education and outreach were some of the primary recommendations from both the agricultural and residential working groups in Part I especially for septic system maintenance, pet waste water quality issues, and "scoop the poop" campaigns. Other recommendations focused on on-site sewage disposal systems, a tracking system for septage haulers, targeted areas for sewer extensions, maintenance of pet waste stations, and increased erosion and sediment control inspections. The agricultural recommendations included addressing non-traditional farming constituents and to provide additional information on the availability and requirements of cost-share money.

During the development of Part II, the agricultural working group discussed non-cost share agricultural practices and non-traditional farming operations in the watershed as well as the limitations of cost-share programs and funding for and the use of livestock exclusion fencing in areas with steep slopes. An overall concern is the limited funding and resources available to evaluate and address the water quality problems and solutions. The residential working group discussed aging and leaking sewers, sewer overflows, on-site

sewage disposal systems, pet waste issues, and stormwater management. Although bank erosion is problematic along some stream reaches, it was noted that private landowners may be hesitant to install stream restoration or bank stabilization measures. Additionally, citizens might be less likely to use pet waste stations or composters in more rural areas. Recommendations for Part II also focused on education and outreach especially for septic system maintenance, importance of proper pet waste disposal, and agricultural cost-share funding as well as sediment and erosion control efforts on steep sloped land. Partnerships with existing organizations, agencies, educational institutions, public interest groups, and private landowners who have experience in BMP implementation were suggested to help implement the cleanup plan and the proposed BMPs. Suggested examples for collaboration and outreach were municipal and local agencies, veterinarians, kennels, hunt clubs, Ruritan Club, Isaac Walton League, farmers markets, schools, homeowners associations, and developers as well as the use of mailings, municipal websites, community events, and local newspapers.

Business

Establishment of a working group dedicated specifically to business interests and contributions in the Part I watershed was a first for any IP in the Commonwealth. The purpose of the **business working group** was to discuss problems contributing to excessive sediment and bacteria from commercial areas. The business working group met on June 20, 2013 with 15 participants and on February 27, 2014 with 13 participants. The primary topics discussed at the meetings were water quality issues associated with stormwater runoff as well as concerns about the City of Roanoke stormwater utility fee, the financial burden of BMP implementation, and existing stormwater management infrastructure and associated maintenance issues. The group also touched on pet waste and outreach, and the urban tree canopy data developed by RVARC. The recommendations from the business working group focused on funding, BMP maintenance and associated costs, and education and outreach. Suggestions for education included stormwater retrofits and BMP maintenance, proper disposal of oil and grease, and control of pet waste at veterinarian offices, pet stores, zoos, and the SPCA. The group recommended the promotion and expansion of programs that recognize businesses for excellence in environmental management practices and stewardship. An additional idea was the use of recreational interests as an avenue to reach out to citizens and gain support for watershed cleanup.

Government

The role of the **government working group** was to examine cleanup strategies in relation to local regulations and the responsibilities and resources of local government. During development of the Part I IP, the working group meetings were held at the VADEQ Blue Ridge Regional office in Roanoke on August 27, 2013 with 20 participants and February 28, 2014 with 26 participants. The meetings for Part II of the IP were held on July 29, 2015 at the Town of Christiansburg Administration Building with 13 participants and March 16, 2016 at the Blacksburg Library with 12 participants. Data was requested from localities regarding existing BMPs and working group participants helped identify potential partnerships and funding

sources, technical resources, regulatory controls, and partner agencies for water quality improvement efforts. As with the other working groups, the main concerns and discussion topics revolved around education and outreach, BMP maintenance, and the lack of funding and resources. The discussions focused on several broad topics including on-site sewage disposal systems, retrofitting of detention ponds, pet waste, stream restoration, stormwater programs, water quality related ordinances, agricultural programs especially livestock exclusion, BMP tracking and crediting, and the formation of relationships among watershed stakeholders.

The most in-depth discussion topics for the Part I government working group meetings centered on stormwater management and MS4s. Government working group recommendations to the steering committee during development of the Part I IP included specifics on how to present proposed BMPs and associated information in the IP report and the inclusion of BMP pollutant reduction efficiencies, technical assistance information, targeted BMPs, and land conversion BMPs utilizing Urban Tree Canopy data in the report. There was also potential interest among some of the localities in partnering with the soil and water conservation districts for agricultural-related water quality improvement projects. Septic system maintenance and pet waste effects on water quality, and the roles and responsibilities of stakeholders in relation to all educational programs were several of the educational and outreach recommendations. The group suggested that local governments could help circulate educational and grant information out to the public. During Part II of the IP, the working group suggested avenues for education and outreach, the inclusion of several new BMPs, and revisions to proposed BMPs and associated costs. Consideration of karst topography, steep terrain, and soil types was recommended during BMP development. Highlighted issues included sewer overflows, limited personnel and funding for implementation and monitoring, and specific locations where BMPs would not be feasible.

Steering Committee Meetings

The functions of the **steering committee** were to direct the overall process and review the output from the other working groups and future implementation. There were four steering committee meetings held during the development of the Part I IP; these meetings were held at the VADEQ Blue Ridge Regional office in Roanoke on April 10, 2013 with 27 participants; November 21, 2013 with 32 participants; August 20, 2014 with 28 participants; and April 20, 2015 with 30 participants. The first steering committee meeting during Part II development was held on March 16, 2016 at the Blacksburg Library with 12 participants in combination with the second government working group meeting.

During Part I IP development, much of the discussion of the earlier meetings revolved around MS4 TMDL action plans. Other comments focused on septic system maintenance, regulatory controls, residential bioretention and pet waste BMPs, expanded street sweeping, and the addition of other potential BMP types including “pilot” BMPs and BMP maintenance and retrofits and technical assistance. Additional discussions highlighted outreach and the importance of stakeholder partnerships, funding, public participation, and BMP staging and staging milestones. The main objective for the last steering committee meeting during Part I and the Part II meeting was to present the highlights of the proposed BMPs, costs, staging and associated implementation and water quality milestones for each subwatershed. The suggestions and comments provided by committee members were taken into consideration during the final review and revision of the IP reports.

IMPLEMENTATION ACTIONS

The identification of control measures and management actions required for the Roanoke River watershed to meet the water quality standards is one of the main functions of the implementation plan.

Implementation actions necessary to reduce bacteria and sediment loads were identified through extensive stakeholder input, public participation, and review of land use/source data and pollutant delivery mechanisms. This section focuses on the controllable sources of bacteria and sediment loadings in the watershed including direct deposition of bacteria by livestock, overland runoff from agricultural land (cropland and pasture), overland runoff from residential and urban land, failing septic systems and straight pipes, and streambank erosion. Additionally, the costs and benefits of implementing these actions are also evaluated.

Identification and Quantification of Control Measures

Proposed measures to control bacteria and sediment were identified through multiple sources. Several BMPs were suggested in the original TMDL reports including livestock exclusion, septic system BMPs, riparian buffers, and pet waste management. Appropriate control measures were identified through review of published materials such as stormwater BMP literature and the Virginia Agricultural Cost Share BMP Manual. Stakeholders at working group meetings provided input on existing and potential control measures specific to the watershed. Additionally, some measures have been proposed based on existing Virginia TMDL IPs with similar watershed conditions. Quantifiable BMPs proposed in this plan and associated sediment and bacteria removal efficiencies are listed in Table 6 grouped by land use (i.e., agricultural, residential, or urban) or pollution source associated with the BMPs.

Before selection and quantification of BMPs and management actions, all existing BMPs in the watershed were identified and their pollutant removal capabilities were assessed. Following identification of existing BMPs, additional BMPs were selected to achieve the bacteria and sediment reductions called for in the TMDLs. Specific locations for the proposed BMPs were not determined in this plan.

Table 3: Best Management Practice Efficiency				
BMP Type	**BMP**	**Sediment Removal Efficiency (%)**	**Bacteria Removal Efficiency (%)**	**Reference (Sediment/ Bacteria)**
Agricultural				
Livestock Exclusion	CREP Livestock Exclusion (CRSL-6)	56	100	1/2
	Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	56	100	1/2
	Livestock Exclusion with Riparian Buffers (LE-1T)	56	100	1/2
	Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	56	100	1/2
	Small Acreage Grazing System (SL-6AT)	56	100	1/2
	Stream Protection/Fencing (WP-2/WP-2T)	56	100	1/2
	Manure Storage (WP-4) Dairy	N/A	80	3
	Manure Storage (WP-4) Beef	N/A	80	3
Pasture	Vegetative Cover on Critical Areas (SL-11)	75	75	3
	Reforestation of Erodible Pasture (FR-1)	LU Conversion	LU Conversion	N/A
	Woodland Buffer Filter Area (FR-3)	70	57	3
	Pasture Management (EQIP 528, SL-10T)	30	50	4
	Grazing Land Management (SL-9)	30	50	4
	Wet Detention Pond for Pastureland	50	70	5
Cropland	Continuous No-Till (SL-15)	70	70[1]	3
	Small Grain Cover Crop (SL-8)	20	20	4
	Permanent Vegetative Cover on Cropland (SL-1)	75	75	3
	Sod Waterway (WP-3)	50	50	3
	Cropland Buffer/Field Borders (CP-33 and WQ-1)	50	50	3
Residential				
Waste Treatment	Septic System Pump-Out (RB-1)	N/A	5	3
	Sewer Connection (Targeted Areas and RB-2)	N/A	100	2
	Repaired Septic System (RB-3)	N/A	100	2
	Septic System Installation/Replacement (RB-4, RB-4P)	N/A	100	2
	Alternative Waste Treatment System Installation (RB-5)	N/A	100	2
Pet Waste	Pet Waste Composter	N/A	99	2
	Pet Waste Education Campaign	N/A	50	6
	Pet Waste Station	N/A	Included in Pet Waste Education Campaign	N/A
Urban				
Stormwater	Rain Barrel	6	N/A	7
	Permeable Pavement	80	N/A	5
	Infiltration Trench (including Retrofit)	75	90	5/8
	Bioretention	70	90	5/9
	Rain Garden	70	70	10
	Vegetated Swale	65	0	5
	Constructed Wetland (including Retrofit)	50	80	5
	Manufactured BMP[2]	80	80	4
	Cistern	12	N/A	7
	Detention Pond	50	30	5
	Riparian Buffer: Forest	70	57	3
	Riparian Buffer: Grass/Shrub	50	50	3
Other	Street Sweeping	Variable[3]	5.50E+08[4]	11
	Urban Land use Conversion	LU Conversion	LU Conversion	N/A
	Stream Restoration	310 pounds /feet/year	N/A	Stakeholder Input
	Stream Stabilization	25.5 pounds /feet/year	N/A	12

LU – Land use
CREP – Conservation Reserve Enhancement Program
[1]Based on sediment reduction
[2]Manufactured BMPs or manufactured treatment devices (also referred to as proprietary treatment devices) are commercial products fabricated in manufacturing facilities that provide stormwater pollution treatment. Some examples include hydrodynamic separators and filters. (Source: VA Stormwater BMP Clearinghouse).
[3]Based on type of sweeping
[4]cfu per curb mile per year

BMP References (see column to the right):

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5. VADEQ. 2013. Virginia Stormwater Management Handbook. Available at: *http://www.deq.virginia.gov/fileshare/wps/2013_SWM_Handbook/*
6. 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. 112p.
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8. USEPA.2014. Best Management Practices: Infiltration Trench. Accessed on 1/20/2014 at: *http://water.epa.gov/polwaste/npdes/swbmp/Infiltration-Trench.cfm*
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10. Hunt, W.F., J.T. Smith, and J. Hathaway. 2007. City of Charlotte Pilot BMP Monitoring Program, Mal Marshall Bioretention Final Monitoring Report. Prepared for the City of Charlotte.
11. VADCR. 2010. South River and Christians Creek Water Quality Improvement Plan.
12. VADCR. 2013. Spout Run Water Quality Improvement Plan.

Agricultural Control Measures

Livestock Exclusion and Manure Management

Required bacteria reductions from direct livestock sources are some of the highest source reductions in the plan ranging from **88% to 100%**. There is approximately **12.2 miles of existing livestock exclusion fencing**, mainly in the Part II watershed, which was installed after the development of the TMDL. The bacteria and sediment reductions from these existing exclusion practices were deducted from the necessary livestock direct reductions. Using land use data and aerial imagery, the length of streams with and without adequate riparian buffer was analyzed for all areas of pasture land use. Adjustments to the number of livestock exclusion practices were made following consultation with partners such as the local SWCDs as well as review of the local data from the VADCR Agricultural BMP Database. A total of approximately **272 miles of livestock exclusion** systems are proposed for Parts I and II to accomplish the bacteria and sediment reduction goals.

Proper storage and management of manure from areas where livestock are concentrated prevents potential impacts to water quality. The number of proposed manure storage systems was based on stakeholder input. Stakeholders reported that dairy manure storage was not necessary in the region, and very limited beef storage is necessary. Based on this input, there were two beef manure storage systems proposed for watersheds with the greatest coverage of pastureland.

The proposed livestock exclusion and manure management BMPs necessary to reduce bacteria and sediment to appropriate levels are shown in Tables 7 and 8. There are a variety of livestock exclusion practices funded through federal and state programs.

Photograph courtesy of USFWS

Pasture BMPs

Pollutant inputs on pastures include bacteria from manure deposition and sediment from exposed soils. Stormwater runoff can carry these pollutants from the pasture land into surrounding surface waters. Cost-share funds are available for the planting of woodland buffer, vegetative cover on critical areas, and the reforestation of erodible pasture, which are meant to stabilize exposed soils and prevent the transport of sediment and bacteria off the pasture land during rain storms. Grazing management is a system of livestock, vegetation, and nutrient management to prevent overgrazing and reduce sediment and bacteria in runoff. The practices include maintenance of adequate vegetation cover, location of feeding areas away from sensitive resources and use of BMPs to prevent sediment movement, implementation of appropriate grazing

and pasture recovery periods, use of a nutrient management plan, and maintenance of fencing. Pasture management is a similar BMP funded by the VADEQ TMDL program and the NRCS EQIP program. Wet detention ponds, which intercept and treat bacteria and sediment in stormwater, were proposed if the necessary pollutant reductions on pasture land use could not be accomplished through the other BMPs. The proposed pasture BMPs necessary to reduce bacteria and sediment to appropriate levels are shown in Tables 7 and 8.

Cropland BMPs

Sources of bacteria and sediment on cropland are manure applications and land erosion. The cropland BMPs reduce runoff, allow for filtration processes, and prevent pollutants from entering nearby surface waters. Continuous no-till and small grain cover crop were the primary BMPs proposed for pollutant reductions from cropland. The continuous no-till practice reduces soil disturbance and associated soil erosion while also helping to maintain adequate vegetative cover. The other BMPs use vegetation to prevent erosion and intercept and filter runoff. All BMPs are eligible for cost-share funds and the Cropland Buffer (CP-33) is eligible under the federal Conservation Reserve Program. Tables 7 and 8 show the BMPs proposed to help the impaired waters meet the TMDL reductions.

Table 4: Proposed BMPs for Part I											
BMP	**Back Creek**	**Carvin Creek**	**Glade/ Layman-town Creek**	**Lick Run**	**Mason Creek**	**Mud Lick Creek, Murray Run, and Ore Branch**	**Peters Creek**	**Roanoke River 1**	**Roanoke River 2**	**Tinker Creek**	**Total**
Livestock Exclusion BMPs (systems)											
CREP Livestock Exclusion (CRSL-6)	-	1	4	N/A	1	-	-	2	1	4	**13**
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T/LE-1T)	35	7	55	N/A	7	1	1	14	8	55	**183**
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	4	1	6	N/A	1	-	-	2	1	6	**21**
Small Acreage Grazing System (SL-6AT)	2	-	3	N/A	-	-	-	1	1	3	**10**
Stream Protection/Fencing (WP-2/WP-2T)	1	-	2	N/A	-	-	-	-	-	2	**5**
Manure Storage (WP-4) - Beef	-	-	2	N/A	-	-	-	-	-	2	**4**
Pasture BMPs (acres installed)											
Vegetative Cover on Critical Areas (SL-11)	269	97	724	11	94	9	9	286	263	1,299	**3,061**
Reforestation of Erodible Pasture (FR-1)	142	54	402	6	52	9	18	159	146	722	**1,710**
Pasture Management (EQIP 528, SL-10T)	2,694	487	3,618	53	470	10	162	1,430	1,316	6,497	**16,737**
Wet Detention Ponds (acres treated)	1,450	-	-	15	-	-	-	-	-	-	**1,465**
Cropland BMPs (acres installed)											
Continuous No-Till (SL-15)	62.6	-	50.0	-	9.1	2.5	-	25.0	1.0	-	272.5
Small Grain Cover Crop (SL-8)	62.6	-	45.0	-	9.1	0.3	-	5.0	0.2	-	127.8
Permanent vegetative cover on cropland (SL-1)	-	-	3.3	-	-	0.2	-	2.0	-	-	16.7
Sod Waterway (WP-3) (acres treated)	-	-	6.7	-	-	0.4	-	4.0	-	-	16.7
Cropland Buffer/Field Borders (CP-33 and WQ-1)	-	-	3.3	-	-	0.2	-	2.0	-	-	5.6

Table 5: Proposed BMPs for Part II						
BMP	**Bradshaw Creek**	**North Fork Roanoke River**	**South Fork Roanoke River**	**Unimpaired North Fork Roanoke River**	**Wilson Creek**	**Total**
Livestock Exclusion BMPs (systems)						
CREP Livestock Exclusion (CRSL-6)	3	10	10	3	1	27
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	12	38	38	10	5	103
Livestock Exclusion with Riparian Buffers (LE-1T)	12	38	39	11	5	105
Small Acreage Grazing System (SL-6A)	2	5	5	1	1	14
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	2	5	5	1	1	14
Stream Protection/Fencing (WP-2/WP-2T)	2	5	5	1	1	14
Pasture BMPs (acres installed)						
Vegetative Cover on Critical Areas (SL-11)	36	2,208	2,587	41	145	5,017
Reforestation of Erodible Pasture (FR-1)	37	818	958	43	81	1,937
Woodland Buffer Filter Area (FR-3)	36	368	431	41	36	912
Pasture Management (EQIP 528, SL-10T)	177	7,360	8,622	411	727	17,297
Grazing Land Management (SL-9)	176	176	176	176	176	880
Wet Detention Pond (acres treated)	0	3,800	1,720	0	330	5,850
Cropland BMPs (acres installed)						
Continuous No-Till (SL-15)	41	253	662	51	26	1,033
Small Grain Cover Crop (SL-8)	48	283	452	57	30	870
Permanent Vegetative Cover on Cropland (SL-1)	2	15	39	3	2	61
Sod Waterway (WP-3)	2	15	39	3	2	61
Cropland Buffer/Field Borders (CP-33 and WQ-1)	2	15	39	3	2	61

Residential Bacteria Control Measures

Controlling Bacteria from Failing Septic Systems and Straight Pipes

All failing septic systems and straight pipes must be corrected according to Virginia regulations. Therefore, 100% of the bacteria from these source must be eliminated.

The estimation of failing septic systems was based on the age of houses in Part I and spatial analysis of buildings, sewer system extent, and the stream network in Part II. Straight pipes, which discharge sewage directly into a stream, were based on the proximity to a stream. It was agreed upon by stakeholders that 10% of all existing septic systems should be pumped out on an annual basis. The numbers proposed for septic repair, septic install/replace, and alternative waste treatment systems were calculated using implementation percentages derived from input from the Virginia Department of Health and stakeholders. Corrections to straight pipes are included under the septic install/replace category (RB-4, RB-4P). Quantification of sewer connection (RB-2) was based on consultation with the Virginia Department of Health and stakeholders using a targeted approach to tackle areas with previous or existing septic problems. Only areas with existing sewer systems and the potential for expansion were considered. Areas included neighborhoods in the City of Roanoke, the periphery of the Town of Blacksburg and Shawsville, and parts of Roanoke County. Table 9 details the number and type of BMPs proposed to reduce bacteria loads in the Roanoke River watershed from on-site sewage disposal systems.

Table 6: Proposed On-site Sewage System BMPs (systems)					
BMP	**Total Septic Pumpout (RB-1)**	**Sewer Connection (Target Areas and RB-2)**	**Total Septic Repair (RB-3)**	**Total Septic Install /Replace (RB-4)**	**Total Alternative Waste Treatment System (RB-5)**
Part I					
Back Creek	432	94	328	352	34
Carvin Creek	22	181	16	18	2
Glade Creek/Laymantown Creek	597	265	511	429	45
Lick Run	2	112	1	5	0
Mason Creek	129	563	85	133	11
Mud Lick Creek, Murray Run, and Ore Branch	23	0	20	6	1
Peters Creek	12	94	8	16	1
Roanoke River 1	197	835	134	180	15
Roanoke River 2	153	39	86	86	8
Tinker Creek	688	244	459	558	49
Part II					
Bradshaw Creek	58	N/A	8	9	2
North Fork Roanoke River	203	25	27	30	6
South Fork Roanoke River	416	11	56	62	12
Unimpaired North Fork Roanoke River	31	N/A	4	4	1
Wilson Creek	71	13	9	10	2

Reducing Bacteria from Pet Waste

Municipalities, counties, organizations, homeowner associations, and neighborhoods in the watershed support educational programs and outreach aimed at cleaning up pet waste. There are also existing pet waste disposal signs and stations placed throughout the Part I watershed but not in the Part II watershed. Although education campaigns and disposal stations exist, more can still be done. This plan focused on placing pet waste disposal stations in locations where there is the likelihood of dog walking. Working groups recommended pet waste stations at parks, trails, rest stops, buildings (e.g., pet-friendly hotels, apartments, and restaurants), neighborhoods, and other developed sites.

Appropriate areas for stations were determined through GIS analysis and working group suggestions. Three pet waste education programs were proposed per subwatershed in Part I and one pet waste education campaign per subwatershed in Part II. The campaigns would include mailers to residents and signage in neighborhoods reminding citizens to pick up after their pets because of the water quality issues, as well as a focus on veterinarians and kennels, and outreach through animal control officers and parks and recreation staff. Pet waste composters are in-ground pet waste disposal systems that work like a household septic system and are most appropriate for pet owners in urban areas with limited outdoor space for pets. Pet waste composters were proposed for a percentage of pet-owning households with higher percentages in the more urban watershed of Wilson Creek. Table 10 details the number of pet waste education campaigns, and proposed pet waste stations and pet waste composters for each subwatershed.

Photograph courtesy of Scoopmasters.com

Table 7: Proposed Pet Waste BMPs (units)			
BMP	**Pet Waste Education Campaign**	**Pet Waste Composter**	**Pet Waste Station**
Part I			
Back Creek	3	-	5
Carvin Creek	3	-	7
Glade Creek/Laymantown Creek	3	-	6
Lick Run	3	-	19
Mason Creek	3	-	6
Mud Lick Creek, Murray Run, and Ore Branch	3	-	14
Peters Creek	3	-	1
Roanoke River 1	3	-	11
Roanoke River 2	3	-	22
Tinker Creek	3	-	7
Part II			
Bradshaw Creek	1	11	0
North Fork Roanoke River	1	43	3
South Fork Roanoke River	1	87	6
Unimpaired North Fork Roanoke River	Included in NFRR campaign	6	1
Wilson Creek	1	98	15

Urban Control Measures (Existing/Retrofits/Proposed)

Stormwater runoff from impervious surfaces such as roads, parking lots, and sidewalks picks up bacteria and sediment on its' journey to local streams. The presence of these hard surfaces also increases the velocity of the runoff which can result in more instream erosion.

Stormwater BMPs include measures which mitigate these impacts by filtering and storing stormwater runoff before it reaches the waterbodies. In the Roanoke River watershed, both water quantity and water quality need to be addressed by implementing stormwater BMPs.

Stormwater BMPs – Retrofits

There are over **1,000 existing stormwater management BMPs** within the Roanoke River watershed, mainly in the Part I area. The bacteria and sediment reductions from these existing stormwater practices were considered in the overall pollutant reduction goals.

Photograph courtesy of VADEQ

Retrofitting an existing BMP can be more economically viable because the infrastructure is already in place. Existing detention basins were initially constructed for water quantity control but can be upgraded to also improve water quality. Infiltration basin retrofits are appropriate for well-draining soils because the technique requires the percolation of runoff through the soil. Constructed wetland retrofits are more suitable for poorly draining soils so that the polluted runoff retained in the wetland is treated by soil filtration and uptake by vegetation. The presence of karst topography could result in damage to or the failure of the BMP as well as possible water quality and safety concerns. Tables 11 and 12 show the proposed detention pond retrofits for each watershed, including the quantity and type of BMP and the associated drainage areas.

Table 8: Proposed Detention Pond Retrofits for Part I																				
BMP	**Back Creek**		**Carvin Creek**		**Glade Creek**		**Lick Run**		**Mason Creek**		**Mud Lick, Murray Run, and Ore Branch**		**Peters Creek**		**Roanoke River 1**		**Roanoke River 2**		**Tinker Creek**	
	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated	Number	Acres Treated
Infiltration Basin	37	1,160	35	538	22	421	10	72	17	264	25	661	9	154	53	1,298	29	501	32	348
Constructed Wetland	17	545	34	538	31	577	33	228	10	149	80	2,154	19	309	25	596	21	366	27	293

Table 9: Proposed Detention Pond Retrofits for Part II			
BMP	**North Fork Roanoke River**	**South Fork Roanoke River**	**Wilson Creek**
	Number	Number	Number
Infiltration Basin	3	4	9
Constructed Wetland	5	4	33

Stormwater BMPs –New BMPs

The number of required stormwater BMPs was estimated using the available developed land within the watershed and average BMP drainage areas resulting in a total area treated. Riparian buffers prevent sediment and bacteria carried in runoff from entering streams and absorb some of the runoff volume. The need for buffers is an important control measure for all land uses especially urban areas where impervious surfaces allow for increased pollutants and water velocity.

Photograph courtesy of VADEQ

Riparian buffers naturally vary in width and narrower riparian buffers can still provide bank stabilization and water quality benefits. Therefore, a width range of 25 feet - 100 feet multiplied by the total length of stream with inadequate buffer was used to calculate the total acreage of required buffers which was then evenly separated into the forested and grass/shrub buffer types. Streams that flowed through residential or other developed areas where the addition of riparian buffer would not be feasible were not included.

Urban land use conversion consists of planting trees on tree-less areas. Based on data collected by Data from the Virginia Department of Forestry (VDOF, 2010), which was only available for Part I, 39,867 acres of land are available for potential planting. This plan proposes the conversion of urban land on 1% of this potential conversion within each subwatershed.

Tables 13 and 14 present types of stormwater BMPs and the drainage area required to achieve necessary pollutant reductions except for rain barrels and cisterns showing numbers required and riparian buffers and urban land use conversion showing acres installed.

Photograph courtesy of City of Roanoke

Table 10: Proposed Stormwater BMPs (Acre-Treated) for Part I										
BMP	**Back Creek**	**Carvin Creek**	**Glade Creek**	**Lick Run**	**Mason Creek**	**Mud Lick Creek, Murray Run, and Ore Branch**	**Peters Creek**	**Roanoke River 1**	**Roanoke River 2**	**Tinker Creek**
Bioretention	1,520	590	885	1,950	590	1,500	800	1,375	1,250	1,240
Raingarden	304	118	177	390	118	300	160	275	250	248
Infiltration Trench	303	117	176	388	117	299	159	274	249	247
Manufactured BMP[1]	367	142	214	471	142	362	193	332	302	299
Constructed Wetland	2,580	1,577	4,013	2,150[5]	1,921	4,472	1,634	4,787	5,733	5,504
Detention Pond	196	196	196	196	196	196	196	196	196	196
Permeable Paver	-	5	5	5	5	5	5	5	5	5
Vegetated Swale	-	150	150	150	150	150	150	150	150	150
Rain Barrel[2]	-	147	245	246	86	345	180	370	430	358
Riparian Buffer (Forested)[3]	10-38	4-16	4-16	6-23	1-2	4-15	3-11	8-30	7-28	7-26
Riparian Buffer (Grass/Shrub)[3]	10-38	4-16	4-16	6-23	1-2	4-15	3-11	8-30	7-28	7-26
Urban Land Use Conversion[4]	81	28	30	31	16	48	20	70	50	24

[1]Manufactured BMPs or manufactured treatment devices (also referred to as proprietary treatment devices) are commercial products fabricated in manufacturing facilities that provide stormwater pollution treatment. Some examples include hydrodynamic separators and filters. (Source: VA Stormwater BMP Clearinghouse).
[2]Units
[3]Acre-Installed (based on a range of buffer widths from 25-100 feet)
[4]Acre-Installed
[5] Comments were received regarding proposed Lick Run subwatershed Constructed Wetland BMPs. Note that comments were acknowledged but BMP quantification was not adjusted as a result due to timing of the BMP modeling. Stakeholders are encouraged to accept this IP as one path to water quality goal achievement and to make adjustments in implementation based on site specific evaluation.

Table 11: Proposed Stormwater BMPs (Acre-Treated) for Part II					
BMP	**Bradshaw Creek**	**North Fork Roanoke River**	**South Fork Roanoke River**	**Unimpaired North Fork Roanoke River**	**Wilson Creek**
Bioretention	50	300	600	150	300
Rain Garden	50	300	700	150	300
Infiltration Trench	20	200	400	20	100
Manufactured BMP[1]	20	150	400	20	300
Constructed Wetland	20	200	500	20	300
Detention Pond	10	100	200	20	150
Cistern[2]	6	23	41	3	91
Permeable Pavement	5	5	5	5	5
Vegetated Swale	200	400	600	300	500
Rain Barrel[2]	174	694	1,243	91	2,736
Riparian Buffer (Forested)[3]	2-8	15-71	27-124	2-11	8-38
Riparian Buffer (Grass/Shrub)[3]	2-9	15-80	27-140	2-13	8-42

[1]Manufactured BMPs or manufactured treatment devices (also referred to as proprietary treatment devices) are commercial products fabricated in manufacturing facilities that provide stormwater pollution treatment. Some examples include hydrodynamic separators and filters. (Source: VA Stormwater BMP Clearinghouse).
[2]Units
[3]Acre-Installed (based on a range of buffer widths from 25-100 feet)

Street Sweeping

Street sweeping is one of the most economical BMPs utilized with respect to reductions of sediment.

Street sweeping frequency and equipment vary by locality in the Roanoke River watershed. Several localities currently operate a street sweeping program including the Cities of Roanoke and Salem and the Towns of Blacksburg and Christiansburg. The cleanup plan proposes the creation of a street sweeping program for roadways located within the boundaries of Montgomery and Roanoke Counties and expansion of the existing street sweeping programs. The proposed expansions shown in Table 15 include an increase in the sweeping frequency from an average of 3.2 cycles per year to 4 cycles per year on residential streets and from an average of 12 cycles per year to 18 cycles per year for arterial streets for the City of Roanoke, from an average of 12 cycles per year to 18 cycles per year for the City of Salem, from an average of 12 cycles per year to 24 cycles per year (i.e. approximately once every two weeks for the Town of Blacksburg, and from an average of once per year to 12 times per year (i.e., once per month) for the Town of Christiansburg. The newly created street sweeping programs propose to sweep a percentage of the existing county roads once every five weeks for Montgomery County and once every month for Roanoke County. The new and expanded programs would sweep an additional **11,636 miles** of streets and remove an additional **6,127 tons of sediment and 9.78E+12 cfu of bacteria** per year. Table 15 shows the additional proposed street sweeping mileage for existing programs, the mileage from new programs, and the amount of sediment removed.

Photograph courtesy of VA Stormwater Handbook

Table 12: Street Sweeping Programs - Existing and Proposed

Location	Existing Program		Proposed Program		Total Annual Sediment Reduction (tons)
	Miles Swept Annually	Average Annual Sediment Reduction (tons)	Additional Miles Swept Annually	Annual Additional Sediment Reduction (tons)	
Part I					
City of Roanoke	10,763	9,226	2,526	2,165	11,391
City of Salem	2,115	533	1,058	267	800
Roads within Roanoke County	-	-	5,092	2,824	2,824
Part II					
Town of Blacksburg	542	150	542	150	299
Town of Christiansburg	37	3	404	34	37
Roads within Montgomery County	-	-	1,559	437	437
Roads within Roanoke County	-	-	455	250	250

Stream Restoration

Stream restoration and stabilization throughout the watershed aims to reduce the sediment erosion from stream beds and banks. Stream restoration projects are those that use instream engineering methods and/or natural stream design techniques to protect and restore the stream and associated hydrology and enhance riparian plant communities, which will reduce erosion and sediment transport. Stream stabilization projects are those that use vegetation and/or harder materials to stabilize and protect the streambanks. Using the total reduction of sediment required from instream sediment load and the sediment reduction efficiency of stream restoration and stabilization projects, the total amount of stream length necessary to achieve the instream sediment reduction goals for the Roanoke River was calculated as **33 miles**. The percentage of stream length within each subwatershed, minus any existing restoration projects, was used to distribute the restoration length among the subwatersheds. Stream stabilization was not split from restoration projects in Part I but was proposed for 5% of the stream miles in Part II. Table 16 shows the restoration and stabilization estimates.

Table 13: Planned and Proposed Stream Restoration Lengths

Subwatershed	Total Estimated Stream Length for Restoration (feet)	Planned, Ongoing, Completed Projects (feet)	Additional Proposed Stream Restoration (feet)	Additional Proposed Stream Stabilization (feet)
Part I				
Carvin Creek	12,433	0	12,433	-
Glade Creek	11,818	4,720	7,098	-
Lick Run	1,203	0	1,203	-
Mason Creek	10,264	0	10,264	-
Mud Lick Creek, Murray Run, and Ore Branch	5,482	4,360	1,122	-
Peters Creek	2,245	0	2,245	-
Roanoke River 1	22,506	0	22,506	-
Roanoke River 2	2,674	1,000	1,674	-
Tinker Creek	14,999	4,665	10,334	-
Part II				
Bradshaw Creek	9,844	0	9,844	492
North Fork Roanoke River	22,793	6,785	16,008	1,140
South Fork Roanoke River	48,140	0	48,140	2,407
Unimpaired North Fork Roanoke River	6,063	0	6,063	303
Wilson Creek	3,773	0	3,773	189

Innovative Pollution Control Strategies

Working group meetings included discussions about innovative strategies that ultimately could not be tied directly to pollutant reductions for a variety of reasons but that would likely improve water quality in the watershed. These measures include:

- Enhanced erosion and sediment control especially at construction sites
- Tracking program for septic haulers
- Adopt-an-Inlet program
- Recognition for installation of residential water quality improvements
- Incentivize homeowners to be good environmental stewards
- Off-stream watering systems without fencing

Outreach and Educational Programs

- *Sanitary Sewer Educational Program:* A program to increase awareness of the sanitary sewer system and sewage related issues and to change public habits to benefit the system. Specifically mentioned were issues related to disposable wipes causing sanitary sewer overflows. The program should also educate the public about the need to report sewage smells and sewer overflow problems.
- *Collaborative Programs:* Partnerships between neighboring municipalities and counties to improve educational outreach related to water quality issues. Stakeholders suggested incorporating stormwater and bacteria and sediment issues into local school curriculums.
- *Non-traditional Farmer Outreach:* Non-traditional agriculture and hobby farmers are becoming more prevalent in the watershed. Stakeholders mentioned the need for outreach to these operations to educate them on how they can help maintain a healthy watershed and the types of practices and programs available to them.
- *Erosion Control on Steep Slopes:* Enhanced outreach to landowners concerning the importance of erosion control and the use of proper practices in mountainous and other steep slope areas.
- *Residential Low Impact Development Educational Program:* A program to educate citizens on what they can do on their own properties to improve water quality, and educate them in general about the issues with stormwater runoff and LID techniques.
- Opportunities at local festivals, meetings, expos, river clean-ups, and municipality websites and mailers, and local media public service announcements

Technical Assistance and Staffing Needs

Additional technical assistance other than that currently offered by local programs and services will be necessary to provide to help the stakeholders implement agricultural, residential, and stormwater BMPs proposed in this plan. Technical assistance includes (1) performing administrative and organizational tasks, (2) providing outreach and education about BMPs and available funding, and (3) assisting with the design and installation of BMPs. Technical assistance for agricultural BMPs would be provided through the Blue Ridge, Mountain Castles, and Skyline Soil and Water Conservation Districts (SWCDs). Technical assistance for residential BMPs could possibly be provided through SWCDs, Health Department, regional planning commission or county governments, dependent upon available grant funding. In addition, there

will be a need for technical assistance for stormwater BMP implementation, which could be handled through a regional planning commission or county governments.

Technical assistance for agricultural programs includes survey, design, layout, and approval of BMP installation as well as coordination of existing programs and suggesting modifications. Educational outreach associated with agricultural, residential, and stormwater BMP implementation programs includes contacting landowners regarding cleanup plan goals and available funding, administering cost-share assistance, tracking BMP implementation and assessing progress, developing educational materials and programs and providing these where necessary. Education and outreach specific to agricultural programs includes pasture walks, presentations at field days or grazing club events, and articles in Farm Bureau newsletters. **Technical assistance for residential programs** includes contacting landowners in areas with on-site sewage system problems based on age of homes, poor soils, and high number of system repairs and replacements. Specific educational outreach associated with residential programs includes demonstrations on septic pump-outs and information on TMDLs and on-site sewage disposal systems. **Technical assistance for stormwater BMP implementation** survey, design, layout, and approval of BMP installation as well as helping to identify grant opportunities and write grants to fund BMP implementation. Specific educational outreach associated with stormwater BMP implementation includes developing educational materials and local workshops on rain barrels, rain gardens, vegetated buffers, turf to trees, etc. Quantification of technical assistance is in Full Time Equivalents (FTEs). The technical assistance shown in Table 17 reflects the differences in BMP implementation goals across the implementation timeline and experiences from TMDL watershed implementation projects statewide.

Table 14: Full Time Equivalent Positions by BMP Category

	Total (Year 1-20)
Part I	
Agricultural	3
Residential	5
Non-MS4 Urban	2.5
Part II	
Agricultural	3
Residential	4
Non-MS4 Urban	1.25

COSTS OF CONTROL MEASURES

The costs for the control measures were derived from multiple sources including the VADCR Agricultural BMP Database, cost-share data, other implementation plans, input form working groups, and available literature. Table 18 shows the cost of each BMP per system/unit/program, acre installed, or acre treated and the source of each cost. Tables 19 and 20 show the costs of agricultural, residential, urban, and stream restoration BMPs for Part I and Part II, respectively. All costs are based on BMP installation and do not include maintenance, unless otherwise noted. Pet waste station costs include the unit and bag and trash can liner refills for five years. The cost of creating the new street sweeping programs shown in Table 21 includes the one-time purchase of a street sweeper for each program as well as operational costs.

Technical Assistance Costs

The amount of technical assistance needed would differ over the implementation timeline and the BMP category. Table 22 shows the estimated total costs of technical assistance.

Table 23 summarizes the cost for all subwatersheds to attain the bacteria and sediment reduction necessary to meet the water quality based goals.

Table 15: Best Management Practice Costs			
Agricultural			
BMP Type	**BMP**	**Cost (per system or acre)**	**Reference**
Livestock Exclusion	CREP Livestock Exclusion (CRSL-6)	$27,000	1
	Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	$40,000-45,000	2
	Livestock Exclusion with Riparian Buffers (LE-1T)	$21,000	2
	Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	$17,000	3
	Small Acreage Grazing System (SL-6AT)	$9,000	3
	Stream Protection/Fencing (WP-2/WP-2T)	$21,000	1
Pasture	Vegetative Cover on Critical Areas (SL-11)	$3,500-5,000	2
	Reforestation of Erodible Pasture (FR-1)	$1,000	2
	Woodland Buffer Filter Area (FR-3)	$700	2
	Pasture Management (EQIP 528, SL-10T)	$75	3
	Grazing Land Management (SL-9)	$200	1
	Wet Detention Pond for Pastureland	$150	4
Cropland	Continuous No-Till (SL-15)	$100	11
	Small Grain Cover Crop (SL-8)	$30	11
	Permanent Vegetative Cover on Cropland (SL-1)	$175	1
	Sod Waterway (WP-3)	$1,600	1
	Cropland Buffer/Field Borders (CP-33 and WQ-1)	$1,000	1
Residential			
BMP Type	**BMP**	**Cost (per system or program)**	**Reference**
Waste Treatment	Septic System Pump-Out (RB-1)	$300	1
	Sewer Connection (Targeted Areas and RB-2)	$9,500	5
	Repaired Septic System (RB-3)	$3,600	1
	Septic System Installation/Replacement (RB-4, RB-4P)	$6,000-$8,000	1
	Alternative Waste Treatment System Installation (RB-5)	$16,000	1
Pet Waste	Pet Waste Education Campaign (program)	$5,000	6
	Pet Waste Composter	$100	15
	Pet Waste Station	$4,070	7
Urban			
BMP Type	**BMP**	**Cost (per acre-treated)**	**Reference**
Stormwater	Rain Barrel	$150	8
	Permeable Pavement	$240,000	9
	Infiltration Trench (including Retrofit)	$6,000	8
	Bioretention	$10,000	10
	Rain Garden	$5,000	10
	Vegetated Swale	$18,150	11
	Constructed Wetland (including Retrofit)	$2,900	11
	Manufactured BMP	$20,000	12
	Cistern	$1,000	8
	Detention Pond	$3,800	11
	Riparian Buffer: Forest	$3,500	13
	Riparian Buffer: Grass/Shrub	$360	10
Other	Street Sweeping	$520 per curb mile	14
	Stream Restoration	$300 per linear foot	Stakeholder Input
	Stream Stabilization	$75 per linear foot	Stakeholder Input

References:

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12. VADCR. 2013. Spout Run Water Quality Improvement Plan.
13. Rivanna River Basin Commission. 2012. Moores Creek Bacteria Implementation Plan 2012 Update.
14. Schilling, J.G. 2005. Street Sweeping – Report No. 1, State of the Practice. Prepared for Ramsey- Washington Metro Watershed District (*http://www.rwmwd.org*). North St. Paul, Minnesota. June 2005.
15. Pet Solutions Website (*http://www.petsolutions.com/C/Dog-Lawn-Care/I/Doggie-Dooley-Model-3000.aspx*).

Table 16: BMP Category Costs for Part I										
BMP Category	**Back Creek**	**Carvin Creek**	**Glade/ Layman-town Creek**	**Lick Run**	**Mason Creek**	**Mud Lick Creek, Murray Run, and Ore Branch**	**Peters Creek**	**Roanoke River 1**	**Roanoke River 2**	**Tinker Creek**
Agricultural										
Livestock Exclusion	$842,000	$191,000	$1,550,000	-	$191,000	$21,000	$21,000	$391,000	$221,000	$1,550,000
Pasture	$821,870	$183,165	$1,365,270	$22,785	$177,170	$16,590	$33,030	$539,490	$496,060	$2,450,395
Cropland	$8,190	-	$21,075	-	$1,170	$300	-	$11,400	$100	-
Residential										
On-site Sewage Systems	$4,859,400	$1,923,700	$7,830,200	$1,098,200	$6,667,200	$130,900	$1,037,400	$9,794,000	$1,370,000	$8,308,800
Pet Waste	$35,900	$44,260	$40,080	$94,420	$40,080	$73,520	$19,180	$60,980	$106,960	$44,260
Urban										
Urban Retrofits	$8,540,500	$4,788,200	$4,199,300	$1,093,200	$2,016,100	$10,212,600	$1,820,100	$9,516,400	$4,067,400	$2,937,700
Urban Stormwater	$34,534,980	$19,454,410	$31,579,510	$44,334,480	$20,346,820	$43,447,750	$23,159,360	$42,374,900	$42,924,580	$41,968,960
Stream Restoration										
Stream Restoration	-	$3,729,900	$2,129,400	$360,900	$3,079,200	$336,600	$673,500	$6,751,800	$502,200	$3,100,200

Table 17: BMP Category Costs for Part II					
BMP	**Bradshaw Creek**	**North Fork Roanoke River**	**South Fork Roanoke River**	**Unimpaired North Fork Roanoke River**	**Wilson Creek**
Agricultural					
Livestock Exclusion	$967,000	$3,013,000	$3,034,000	$809,000	$404,000
Pasture	$288,550	$13,271,970	$15,132,850	$343,490	$972,170
Cropland	$12,180	$75,070	$187,900	$15,010	$7,860
Residential					
On-site Sewage Systems	$148,596	$731,880	$1,129,530	$70,770	$296,340
Pet Waste	$16,066	$31,460	$48,090	$4,630	$85,840
Urban					
Urban Retrofits	-	$340,733	$424,083	-	$2,519,340
Urban Stormwater	$6,258,340	$18,777,359	$35,350,060	$9,650,500	$23,465,070
Stream Restoration					
Stream Restoration	$2,989,994	$4,887,800	$14,622,490	$1,841,750	$1,146,120

Table 18: Cost of Additional Street Sweeping		
Location	**Street Sweeper Equipment Cost**	**Total Cost (per year)**
Part I		
City of Roanoke	NA	$1,313,520
City of Salem	NA	$550,160
Roads within Roanoke County	$175,000	$2,647,840
	Total per year	$4,686,520
	Total Cost for Part I	$82,140,230
Part II		
Town of Blacksburg	NA	$281,631
Town of Christiansburg	NA	$210,114
Roads within Montgomery County	$175,000	$810,760
Roads within Roanoke County	$175,000	$236,435
	Total per year	$1,538,939
	Total Cost for Part II	$28,410,280

Table 19: Technical Assistance for Roanoke River IP	
BMP Category	**Total**
Part I	
Agricultural	$1,320,000
Residential	$2,160,000
Urban/Stormwater	$1,350,000
Total Cost for Part I	**$4,830,000**
Part II	
Agricultural	$1,320,000
Residential	$1,680,000
Urban/Stormwater	$675,000
Total Cost for Part II	**$3,675,000**

Table 20: Total Estimated Cost of Full BMP Implementation					
BMP Category	**Agricultural**	**Residential**	**Urban**	**Stream Restoration**	**Total**
Part I					
Back Creek	$1,672,060	$4,895,300	$43,075,480	-	$49,642,840
Carvin Creek	$374,165	$1,967,960	$24,242,610	$3,729,900	$30,314,635
Glade Creek	$2,936,345	$7,870,280	$35,778,810	$2,129,400	$48,714,835
Lick Run	$22,785	$1,192,620	$45,427,680	$360,900	$47,003,985
Mason Creek	$369,340	$6,707,280	$22,362,920	$3,079,200	$32,518,740
Mud Lick, Murray Run, and Ore Branch	$37,890	$204,420	$53,660,350	$336,600	$54,239,260
Peters Creek	$54,030	$1,056,580	$24,979,460	$673,500	$26,763,570
Roanoke River 1	$941,890	$9,854,980	$51,891,300	$6,751,800	$69,439,970
Roanoke River 2	$717,160	$1,476,960	$46,991,980	$502,200	$49,688,300
Tinker Creek	$4,000,395	$8,353,060	$44,906,660	$3,100,200	$60,360,315
Subtotals	***$11,126,060***	***$43,579,440***	***$393,317,250***	***$20,663,700***	$468,686,450
Additional Street Sweeping					$82,140,230
Technical Assistance					$4,830,000
Total Cost for Part I					**$555,656,680**
Part II					
Bradshaw Creek	$1,267,730	$164,662	$6,258,340	$2,989,994	$10,680,725
North Fork Roanoke River	$16,360,040	$763,340	$18,865,747	$4,887,800	$40,876,927
South Fork Roanoke River	$18,354,750	$1,177,620	$35,335,183	$14,622,490	$69,490,043
Unimpaired North Fork Roanoke River	$1,167,500	$75,400	$9,610,120	$1,841,750	$12,694,770
Wilson Creek	$1,384,030	$382,180	$25,982,550	$1,146,120	$28,894,880
Subtotals	***$38,534,050***	***$2,563,202***	***$96,051,940***	***$25,488,154***	***$162,637,345***
Additional Street Sweeping					$28,410,280
Technical Assistance					$3,675,000
Total Cost for Part II					**$194,722,625**

BENEFITS OF CONTROL MEASURES

The main benefit of implementation of the various control measures is the improvement of the water quality of the Roanoke River and its tributaries.

Bacteria and sediment reductions would allow the waterbodies to meet water quality standards and provide a healthy environment for humans, wildlife, and livestock. Benefits are derived not only from the resulting clean water but also directly from the actual control measures themselves such as enriched recreational opportunities and improved local economies from the enhanced natural resources.

Benefit: Human Health and Safety

Human, livestock, and wildlife waste can carry viruses and bacteria that are harmful to human health. Although the full range of effects from reduced bacteria loadings on public health is uncertain, the improved water quality should, at a minimum, reduce the incidence of infection derived from contact with surface waters (VADCR, 2003). The Centers for Disease Control (CDC) estimates that nationally at least 73,000 cases of illnesses and 61 deaths per year are caused by *E. coli* bacteria (CDC, 2001). Reducing bacteria in the Roanoke River and tributaries should considerably reduce the chances of *E. coli* infections through contact with surface waters in the watershed. In addition to preventing infection and disease, strategies in this plan addressing stormwater could help mitigate and prevent future flooding and associated human injuries and fatalities.

Benefit: Healthy Aquatic Communities

The health of the whole aquatic ecosystem is dependent in part on its physical habitat. Excessive sediment in a stream can smother aquatic flora, clog the spaces between river bed substrates that provide habitat for benthic macroinvertebrates, and change the composition of the benthic macroinvertebrate community by favoring tolerant taxa over intolerant types (Harrison et al., 2007). These "bugs" are often a major food source for freshwater fish and a decrease in their availability can ripple through the food web. Reducing sediment in the Roanoke River watershed will help restore the health of aquatic communities for the benefit of the flora, fauna, and human residents. Implementation of many BMPs would protect and enhance existing natural resources and habitats such as riparian areas, forests, wetlands, and urban vegetated areas used by wildlife. For example, streamside buffers of trees and shrubs help reduce erosion and shade the stream. Shading helps keep water temperatures lower and allows for a greater amount of dissolved oxygen in the stream resulting in benefits to macroinvertebrates and fish. Buffers can also improve habitat for wildlife and migratory songbirds that also benefit from having access to a healthy, thriving aquatic community.

Benefit: Improved Agricultural Production

In general, many of the agricultural BMPs recommended in this plan will provide both environmental and economic benefits to farmers. Restricting cattle access to streams and providing them with a clean water source can improve weight gain (Surber et al., 2005; Landefeld and Bettinger, 2002) and increased weight can translate into increased profit for producers as shown in Table 24 (Zeckoski et al., 2007). Improved pasture management can allow a producer to feed less hay in winter months, increase stocking rates by 30% to 40% and, consequently, improve the profitability of the operation. Feed costs are typically responsible for 70% to 80% of the cost of growing or maintaining an animal. Therefore, increasing the amount of time that cattle are fed on pasture is clearly a financial benefit to producers (VCE, 1996). Standing forage utilized directly by the grazing animal is always less costly and of higher quality than the same forage harvested with equipment and fed to the animal. Lastly, cattle that are closely confined allows for quicker examination and handling, thereby saving time and money.

Table 21: Production gains associated with provision of clean water for cattle

Typical calf sale weight	Additional weight gain with access to clean water	Price	Increased revenue
500 lb/calf	5% (25lb)	$0.60/lb	$15/calf

Source: Surber et al., 2005

Benefit: Advantages for Landowners

Stormwater and residential BMPs can be incorporated into a landscape design as an amenity on private and public properties. Many BMPs such as vegetated swales, buffer strips, and infiltration trenches are inexpensive and easy to install given limited space and other constraints. Installation of these BMPs on public land provides educational opportunities to increase awareness of water quality strategies and green initiatives. Potential economic benefits of stormwater BMPs include reduced wastewater and water treatment costs, increased property values, and added lifespan to existing infrastructure (Wise, 2007). Implementation activities in the plan will help give individual homeowners and residents the knowledge and tools needed to properly maintain and extend the life of their septic systems. Overall home ownership costs could also be reduced such as through regular septic pump-outs which cost about $300 compared to $3,000-$25,000 for the repair or replacement of a septic system. Localized and widespread flooding can be expensive at the residential level because of property damage and taxpayer costs. BMPs that reduce stormwater runoff onsite can reduce losses from flood damage by $6,700-$9,700 per acre for a 100-year flood event (Medina et al., 2011). Property owners can help mitigate flood water damages and associated costs by reducing stormwater volume and flow rates through installation of infiltration type BMPs such as rain gardens and vegetated swales.

Benefit: Regional Economic Vitality

Clean water and improved habitats will benefit the overall regional economy by encouraging outdoor pursuits that stimulate the local economy and employment such as fishing, canoeing, kayaking, hiking, and other recreational tourism. Healthy watersheds provide many ecosystem services necessary for a community's well-being including water filtration and storage, air filtration, carbon storage, energy, nutrient cycling, removal of pollutants, soil formation, recreation, food, timber, and open space amenities. Many of these services are hard to quantify in terms of dollars and are often under-valued (Bockstael et al.,

2000). However, many of these services are also difficult to replace and often are expensive to artificially engineer. Improvement of water quality also indirectly provides greater economic opportunities through the employment of local contractors involved in the repair and installation of septic systems, building of livestock exclusion systems, and installation and retrofits of stormwater BMPs. In a 2009 study, researchers estimated that every $1 million invested in environmental efforts such as reforestation, land and watershed restoration, and sustainable forest management, would create approximately 39 jobs (Heintz et al., 2009). Lastly, the combined economic and natural resource benefits provide for a better quality of life for local and regional residents now and in the future.

Cost-Effectiveness

Tables 5-25 and 5-26 (Part I) and Tables 27 and 28 (Part II) present the cost-effectiveness of each proposed BMP which has quantifiable bacteria and sediment reductions. The cost-effectiveness is based on the amount of bacteria (in cfu) and sediment (in pounds) reduced per $1,000 spent. For bacteria, the effectiveness values are based on the bacteria loading from the one subwatershed in Part I and Part II. Because the bacteria loading within each subwatershed varies, the bacteria loads reduced per $1,000 spent would be slightly different for other subwatersheds.

Table 22: BMP Cost-Effectiveness for Bacteria Reduction in Part I	
BMP	**Rank**
Continuous No-Till (SL-15)	1
Small Grain Cover Crop (SL-8)	2
Permanent vegetative cover on cropland (SL-1)	3
Cropland Buffer/Field Borders (CP-33 and WQ-1)	4
Sod Waterway (WP-3)	5
Pasture Management (EQIP 528, SL-10T)	6
Wet Detention Pond	7
Small Acreage Grazing System (SL-6AT)	8
Reforestation of Erodible Pasture (FR-1)	9
Riparian Buffer: Grass/Shrub	10
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	11
Livestock Exclusion (SL-6/SL-6T/LE-1T)	12
Stream Protection/Fencing (WP-2/WP-2T)	13
Livestock Exclusion (CRSL-6)	14
Vegetative Cover on Critical Areas (SL-11)	15
Constructed Wetland	16
Riparian Buffer: Forest	17
Infiltration Trench	18
Urban Land Use Conversion	19
Rain Gardens	20
Repaired Septic System (RB-3)	21
Bioretention	22
Street Sweeping	23
Septic System Pump-Out (RB-1)	24
Septic System Installation/Replacement (RB-4, RB-4P)	25
Detention Pond	26
Sewer Connection (RB-2)	27
Pet Waste Education Campaign	28
Manufactured BMPs	29
Alternative Waste Treatment System Installation (RB-5)	30

Table 23: BMP Cost-Effectiveness for Sediment Reduction in Part I	
BMP	**Rank**
Continuous No-Till (SL-15)	1
Small Grain Cover Crop (SL-8)	2
Permanent vegetative cover on cropland (SL-1)	3
Street Sweeping	4
Cropland Buffer/Field Borders (CP-33 and WQ-1)	5
Stream Restoration	6
Sod Waterway (WP-3)	7
Riparian Buffer: Grass/Shrub	8
Pasture Management (EQIP 528, SL-10T)	9
Wet Detention Pond	10
Rain Barrel	11
Reforestation of Erodible Pasture (FR-1)	12
Urban Land Use Conversion	13
Riparian Buffer: Forest	14
Vegetative Cover on Critical Areas (SL-11)	15
Constructed Wetland	16
Rain Gardens	17
Detention Pond	18
Infiltration Trench	19
Bioretention	20
Manufactured BMPs	21
Vegetated Swale	22
Small Acreage Grazing System (SL-6AT)	23
Livestock Exclusion with Reduced Setback (LE-2,LE-2T)	24
Livestock Exclusion (SL-6/SL-6T/LE-1T)	25
Stream Protection/Fencing (WP-2/WP-2T)	26
Livestock Exclusion (CRSL-6)	27
Permeable Pavement	28

Table 24: BMP Cost-Effectiveness for Bacteria Reduction in Part II	
BMP	**Rank**
Repaired Septic System (RB-3)	1
Septic System Pump-Out (RB-1)	2
Septic System Installation/Replacement (RB-4, RB-4P)	3
Sewer Connection (RB-2)	4
Alternative Waste Treatment System Installation (RB-5)	5
Pet Waste Composter	6
Stream Protection/Fencing (WP-2/WP-2T)	7
Pasture Management (EQIP 528, SL-10T)	8
Small Acreage Grazing System (SL-6AT)	9
Wet Detention Pond	10
Continuous No-Till (SL-15)	11
Small Grain Cover Crop (SL-8)	12
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	13
Riparian Buffer: Grass/Shrub	14
CREP Livestock Exclusion (CRSL-6)	15
Permanent Vegetative Cover on Cropland (SL-1)	16
Grazing Land Management (SL-9)	17
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	18
Livestock Exclusion with Riparian Buffers (LE-1T)	19
Woodland Buffer Filter Area (FR-3)	20
Constructed Wetland (including retrofit)	21
Street Sweeping	22
Riparian Buffer: Forest	23
Infiltration Trench (including retrofit)	24
Rain Garden	25
Sod Waterway (WP-3)	26
Pet Waste Education Campaign	27
Bioretention	28
Detention Pond	29
Cropland Buffer/Field Borders (CP-33 and WQ-1)	30
Vegetative Cover on Critical Areas (SL-11)	31
Manufactured BMP	32

Table 25: BMP Cost-Effectiveness for Sediment Reduction in Part II	
BMP	**Rank**
Continuous No-Till (SL-15)	1
Small Grain Cover Crop (SL-8)	2
Permanent Vegetative Cover on Cropland (SL-1)	3
Street Sweeping1	4
Stream Restoration2	5
Cropland Buffer/Field Borders (CP-33 and WQ-1)	6
Sod Waterway (WP-3)	7
Stream Stabilization2	8
Riparian Buffer: Grass/Shrub	9
Pasture Management (EQIP 528, SL-10T)	10
Wet Detention Pond	11
Grazing Land Management (SL-9)	12
Rain Barrel	13
Woodland Buffer Filter Area (FR-3)	14
Reforestation of Erodible Pasture (FR-1)	15
Constructed Wetland (including Retrofit)	16
Rain Garden	17
Detention Pond	18
Infiltration Trench (including Retrofit)	19
Cistern	20
Bioretention	21
Vegetative Cover on Critical Areas (SL-11)	22
Manufactured BMP2	23
Vegetated Swale	24
Stream Protection/Fencing (WP-2/WP-2T)	25
Small Acreage Grazing System (SL-6AT)	26
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	27
CREP Livestock Exclusion (CRSL-6)	28
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	29
Livestock Exclusion with Riparian Buffers (LE-1T)	30
Permeable Pavement	31

MEASUREABLE GOALS AND MILESTONES

The primary goals of the Roanoke River TMDL IP are to restore water quality in the impaired waterbodies and to take the impaired segments off the Virginia 303(d) List of Impaired Waters.

Expected progress in BMP implementation is established with two types of milestones: **implementation milestones** and **water quality milestones**. Implementation milestones establish the amount of control measures that should be installed within prescribed timeframes, while water quality milestones establish the corresponding improvements in water quality that can be expected as the implementation milestones are met. The implementation of proposed BMPs will take place over three stages within either a 15 or 20 year timeline. The period of implementation varies by the size and urban coverage of the subwatershed.

- Implementation actions for smaller and/or more rural subwatersheds will occur over a **15-year timeline**. The first two stages will be implemented over 6 years each and the final stage will be implemented over 3 years. This approach is recommended for the following subwatersheds: *Carvin Creek, Peters Creek, Mason Creek, and Back Creek* for Part 1 and *Bradshaw Creek and North Fork Roanoke River* for Part II.

- Implementation actions for larger and/or more urbanized subwatersheds will occur over a **20-year timeline**. The first two stages will be implemented over 8 years each and the final stage will be implemented over 4 years. This approach is recommended for the following subwatersheds: *Glade Creek, Tinker Creek, Lick Run, Mud Lick/Murray/Ore Branch, Roanoke River 1 and Roanoke River 2* for Part I and *Wilson Creek and South Fork Roanoke River* for Part II.

The first stage focuses on implementing the more cost-effective and commonly implemented actions such as livestock exclusion practices, crop and pasture BMPs, and septic system repairs. The second stage focuses on implementing the majority of the remaining BMPs needed to reach the goal of delisting the bacteria impaired segments. The delisting goal is achieved for Bradshaw Creek and South Fork Roanoke River watersheds in stage 1 and for Carvin Creek, Back Creek, Lick Run, Roanoke River 2, North Fork Roanoke River, and Wilson Creek watersheds in stage 2. The third stage goals are to implement the remainder of the proposed BMPs, to reach the goal of delisting the bacteria impaired segments for *Glade Creek; Mud Lick Creek, Murray Run and Ore Branch; Mason Creek; Peters Creek; Roanoke River 1, and Tinker Creek,* and to not violate the bacteria geometric mean criterion required by the TMDLs. At the end of stage 3, all 10 watersheds in Part I have a bacteria violation rate of less than 10.5% for the single sample maximum but do not meet the single sample maximum criterion (0% violation rate) required by the TMDLs because of bacteria loadings attributed to wildlife sources which are not addressed in this plan. All four watersheds in Part II have a bacteria violation rate of less than 10% for the single sample maximum and also meet the geometric mean criterion (0% violation rate) required by the TMDLs at the end of stage 3. Implementations milestones in all stages also address the required sediment reductions from the TMDLs.

Tables 29 to 43 present the implementation and water quality milestones by subwatershed for each stage. In these tables, the BMP numbers and costs represent the cumulative total of BMPs implemented at the end of the stage except for street sweeping which shows values and costs per year over the staged timeline. The Unimpaired North Fork Roanoke River is not impaired and does not have water quality milestones to meet, but implementation milestones are shown in Table 42. This subwatershed would have a lower priority for implementation funds in comparison to the impaired watersheds.

Table 26: Back Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y6)	Stage II (Y7-Y12)	Stage III (Y13-Y15)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	216	432	-
Sewer Connection (RB-2)	System	47	94	-
Repaired Septic System (RB-3)	System	164	328	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	176	352	-
Alternative Waste Treatment System Installation (RB-5)	System	17	34	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	4	5	-
	Total Cost	$2,450,375	$2,439,925	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	28	37	-
Constructed Wetlands	System	13	17	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	1,434	1,434	1,434
	Total Cost	$10,880,625	$6,610,375	$2,237,620
Stormwater BMPs				
Bioretention	Acre Treated	380.0	1,368.0	1,520.0
Rain Gardens	Acre Treated	152.0	273.6	304.0
Infiltration Trench	Acre Treated	75.8	272.7	303.0
Manufactured BMPs	Acre Treated	183.5	330.3	367.0
Constructed Wetland	Acre Treated	645.0	2,322.0	2,580.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Riparian Buffer: Forest	Acre Installed	19.0	38.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	19.0	38.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	20.3	72.9	81.0
	Total Cost	$10,885,415	$20,210,735	$3,438,830
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	63.0	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	63.0	-	-
	Total Cost	$8,190	-	-
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	26	35	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	4	-	-
Small Acreage Grazing System (SL-6AT)	System	2	-	-
Stream Protection/Fencing (WP-2/WP-2T)	System	1	-	-
	Total Cost	$658,250	$183,750	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	106.5	142.0	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	1,347.0	2,694.0	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	134.5	269.0	-
Wet Detention Pond	Acre Treated	0.0	0.0	1,450.0
	Total Cost	$322,065	$282,305	$217,500
	Total Cost Per Stage	**$25,204,920**	**$29,727,090**	**$5,898,950**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**7.3%**	**2.1%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**21.9%**	**10.9%**	**9.6%**
	Bacteria Load Per Stage (cfu/year)	**3.32E+13**	**1.89E+13**	**1.11E+13**

Table 27: Carvin Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y6)	Stage II (Y7-Y12)	Stage III (Y13-Y15)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	22	-	-
Sewer Connection (RB-2)	System	181	-	-
Repaired Septic System (RB-3)	System	16	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	18	-	-
Alternative Waste Treatment System Installation (RB-5)	System	2	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	5	7	-
	Total Cost	$1,950,645	$12,315	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	26	35	-
Constructed Wetlands	System	26	34	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	564	564	564
	Total Cost	$5,351,450	$2,957,350	$880,150
Stormwater BMPs				
Bioretention	Acre Treated	147.5	531.0	590.0
Rain Gardens	Acre Treated	59.0	106.2	118.0
Infiltration Trench	Acre Treated	29.3	105.3	117.0
Manufactured BMPs	Acre Treated	71.0	127.8	142.0
Constructed Wetland	Acre Treated	394.3	1419.3	1577.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	74	147	-
Riparian Buffer: Forest	Acre Installed	12	16	-
Riparian Buffer: Grass/Shrub	Acre Installed	12	16	-
Urban Tree Canopy/Land use Conversion	Acre Converted	7	25	28
	Total Cost	$5,757,495	$11,579,855	$2,117,060
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (CRSL-6)	System	1	-	-
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	7	-	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	1	-	-
	Total Cost	$191,000	$0	$0
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	27.0	54.0	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	487.0	-	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	48.5	97.0	-
	Total Cost	$109,845	$73,320	$0
Stream Restoration				
Stream Restoration	Feet	6,217	12,433	-
	Total Cost	$1,864,950	$1,864,950	$0
	Total Cost Per Stage	**$15,225,385**	**$16,487,790**	**$3,002,210**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**0.0%**	**0.0%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**17.8%**	**15.1%**	**10.3%**
	Bacteria Load Per Stage (cfu/year)	**2.67E+13**	**1.45E+13**	**8.05E+12**

Table 28: Glade Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	448	597	-
Sewer Connection (RB-2)	System	133	265	-
Repaired Septic System (RB-3)	System	383	511	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	322	429	-
Alternative Waste Treatment System Installation (RB-5)	System	34	45	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	5	6	-
	Total Cost	$5,267,085	$2,598,195	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	17	22	-
Constructed Wetlands	System	23	31	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	325	325	325
	Total Cost	$4,502,395	$2,402,745	$676,460
Stormwater BMPs				
Bioretention	Acre Treated	221.3	796.5	885.0
Rain Gardens	Acre Treated	88.5	159.3	177.0
Infiltration Trench	Acre Treated	44.0	158.4	176.0
Manufactured BMPs	Acre Treated	107.0	192.6	214.0
Constructed Wetland	Acre Treated	1,003.3	3,611.7	4,013.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	123	245	-
Riparian Buffer: Forest	Acre Installed	12.0	16.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	12.0	16.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	7.5	27.0	30.0
	Total Cost	$9,226,195	$19,025,215	$3,328,100
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	50.0	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	45.0	-	-
Permanent vegetative cover on cropland (SL-1)	Acre Installed	3.0	-	-
Sod Waterway (WP-3)	Acre Installed	7.0	-	-
Cropland Buffer/Field Borders (CP-33 and WQ-1)	Acre Installed	3.0	-	-
	Total Cost	$21,075	$0	$0
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (CRSL-6)	System	3	4	-
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	41	55	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	3	6	-
Small Acreage Grazing System (SL-6AT)	System	3	-	-
Stream Protection/Fencing (WP-2/WP-2T)	System	2	-	-
Manure Storage (WP-4)	System	2	-	-
	Total Cost	$1,183,250	$366,750	$0
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	201.0	402.0	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	1809.0	3618.0	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	362.0	724.0	-
	Total Cost	$682,635	$682,635	$0
Stream Restoration				
Stream Restoration	Feet	7,098	-	-
	Total Cost	$2,129,400	$0	$0
	Total Cost Per Stage	**$23,012,035**	**$25,075,540**	**$4,009,560**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**51.0%**	**17.7%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**40.3%**	**28.3%**	**9.7%**
	Bacteria Load Per Stage (cfu/year)	**3.06E+13**	**1.11E+13**	**3.11E+12**

Table 29: Lick Run Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	2	-	-
Sewer Connection (RB-2)	System	84	112	-
Repaired Septic System (RB-3)	System	1	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	5	-	-
Alternative Waste Treatment System Installation (RB-5)	System	-	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	14	19	-
	Total Cost	$896,765	$290,855	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	8	10	-
Constructed Wetlands	System	25	33	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	788	788	788
	Total Cost	$4,096,540	$3,549,940	$1,638,320
Stormwater BMPs				
Bioretention	Acre Treated	487.5	1755.0	1950.0
Rain Gardens	Acre Treated	195.0	351.0	390.0
Infiltration Trench	Acre Treated	97.0	349.2	388.0
Manufactured BMPs	Acre Treated	235.5	423.9	471.0
Constructed Wetland	Acre Treated	537.5	1935.0	2150.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	123	246	-
Riparian Buffer: Forest	Acre Installed	17.3	23.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	17.3	23.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	7.8	27.9	31.0
	Total Cost	$13,979,735	$25,753,865	$4,600,880
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	6.0	-	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	53.0	-	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	11.0	-	-
Wet Detention Pond	Acre Treated	-	-	15.0
	Total Cost	$20,535	$0	$2,250
Stream Restoration				
Stream Restoration	Feet	1,203	-	-
	Total Cost	$360,900	$0	$0
	Total Cost Per Stage	**$19,354,475**	**$29,594,660**	**$6,246,450**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**0.0%**	**0.0%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**15.8%**	**13.9%**	**10.0%**
	Bacteria Load Per Stage (cfu/year)	**2.77E+13**	**1.24E+13**	**5.76E+12**

Table 30: Mud Lick Creek, Murray Run, and Ore Branch Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	23	-	-
Repaired Septic System (RB-3)	System	20	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	6	-	-
Alternative Waste Treatment System Installation (RB-5)	System	1	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	11	14	-
	Total Cost	$179,790	$19,630	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	19	25	-
Constructed Wetlands	System	60	80	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	1,241	1,241	1,241
	Total Cost	$12,821,280	$7,714,980	$2,580,910
Stormwater BMPs				
Bioretention	Acre Treated	375.0	1,350.0	1,500.0
Rain Gardens	Acre Treated	150.0	270.0	300.0
Infiltration Trench	Acre Treated	74.8	269.1	299.0
Manufactured BMPs	Acre Treated	181.0	325.8	362.0
Constructed Wetland	Acre Treated	1,118.0	4,024.8	4,472.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	173	345	-
Riparian Buffer: Forest	Acre Installed	11.3	15.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	11.3	15.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	12.0	43.2	48.0
	Total Cost	$13,088,825	$25,845,115	$4,513,810
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	3.0	-	-
	Total Cost	$300	-	-
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	1	-	-
	Total Cost	$21,000	-	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	9.0	-	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	10.0	-	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	9.0	-	-
	Total Cost	$16,590	-	-
Stream Restoration				
Stream Restoration	Feet	1,122	-	-
	Total Cost	$336,600	-	-
	Total Cost Per Stage	**$26,464,385**	**$33,579,725**	**$7,099,720**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**1.0%**	**1.0%**	**1.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**20.0%**	**19.2%**	**19.0%**
	Bacteria Load Per Stage (cfu/year)	**4.96E+13**	**2.61E+13**	**2.00E+13**

Table 31: Mason Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y6)	Stage II (Y7-Y12)	Stage III (Y13-Y15)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	129	-	-
Sewer Connection (RB-2)	System	140.75	422.25	563.00
Repaired Septic System (RB-3)	System	85	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	133	-	-
Alternative Waste Treatment System Installation (RB-5)	System	11	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	5	6	-
	Total Cost	$2,679,635	$2,685,520	$1,342,125
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	13	17	-
Constructed Wetlands	System	8	10	-
Street Sweeping (additional miles to be swept annually)	Program	668	668	668
	Total Cost	$3,596,375	$2,588,325	$1,042,150
Stormwater BMPs				
Bioretention	Acre Treated	147.5	531.0	590.0
Rain Gardens	Acre Treated	59.0	106.2	118.0
Infiltration Trench	Acre Treated	29.3	105.3	117.0
Manufactured BMPs	Acre Treated	71.0	127.8	142.0
Constructed Wetland	Acre Treated	480.3	1728.9	1921.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	86	-	-
Riparian Buffer: Forest	Acre Installed	2.0	-	-
Riparian Buffer: Grass/Shrub	Acre Installed	2.0	-	-
Urban Tree Canopy/Land use Conversion	Acre Converted	4	14	16
	Total Cost	$5,959,670	$12,174,530	$2,212,620
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	9.0	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	9.0	-	-
	Total Cost	$1,170		
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (CRSL-6)	System	1	-	-
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	7	-	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	1	-	-
	Total Cost	$191,000		
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	52.0	-	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	470.0	-	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	94.0	-	-
	Total Cost	$177,170	$0	$0
Stream Restoration				
Stream Restoration	Feet	5,132	10,264	-
	Total Cost	$1,539,600	$1,539,600	$0
	Total Cost Per Stage	**$14,144,620**	**$18,987,975**	**$4,596,895**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**5.2%**	**4.2%**	**1.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**22.7%**	**20.8%**	**10.4%**
	Bacteria Load Per Stage (cfu/year)	**1.19E+13**	**6.31E+12**	**1.93E+12**

Table 32: Peters Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y6)	Stage II (Y7-Y12)	Stage III (Y13-Y15)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	12	-	-
Sewer Connection (RB-2)	System	94	-	-
Repaired Septic System (RB-3)	System	8	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	16	-	-
Alternative Waste Treatment System Installation (RB-5)	System	1	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	1	-	-
	Total Cost	$1,046,580	$5,000	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	7	9	-
Constructed Wetlands	System	14	19	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	442	442	442
	Total Cost	$2,744,305	$1,834,255	$689,620
Stormwater BMPs				
Bioretention	Acre Treated	200.0	720.0	800.0
Rain Gardens	Acre Treated	80.0	144.0	160.0
Infiltration Trench	Acre Treated	39.8	143.1	159.0
Manufactured BMPs	Acre Treated	96.5	173.7	193.0
Constructed Wetland	Acre Treated	408.5	1470.6	1634.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	135	180	-
Riparian Buffer: Forest	Acre Installed	8.3	11.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	8.3	11.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	5	18	20
	Total Cost	$6,989,570	$13,680,800	$2,488,990
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	1	-	-
	Total Cost	$21,000	-	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	18.0	-	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	162.0	-	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	9.0	-	-
	Total Cost	$33,030	-	-
Stream Restoration				
Stream Restoration	Feet	2,245	-	-
	Total Cost	$673,500	-	-
	Total Cost Per Stage	**$11,507,985**	**$15,520,055**	**$3,183,610**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**0.0%**	**0.0%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**22.7%**	**20.6%**	**10.3%**
	Bacteria Load Per Stage (cfu/year)	**1.67E+13**	**6.90E+12**	**2.78E+12**

Table 33: Roanoke River 1 Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	148	197	-
Sewer Connection (RB-2)	System	209	418	835
Repaired Septic System (RB-3)	System	101	134	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	135	180	-
Alternative Waste Treatment System Installation (RB-5)	System	11	15	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	8	11	-
	Total Cost	$3,418,735	$2,464,995	$3,971,250
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	40	53	-
Constructed Wetlands	System	19	25	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	1,707	1,707	1,707
	Total Cost	$14,236,410	$9,478,210	$3,549,560
Stormwater BMPs				
Bioretention	Acre Treated	343.8	1237.5	1375.0
Rain Gardens	Acre Treated	137.5	247.5	275.0
Infiltration Trench	Acre Treated	68.5	246.6	274.0
Manufactured BMPs	Acre Treated	166.0	298.8	332.0
Constructed Wetland	Acre Treated	1196.8	4308.3	4787.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	278	370	-
Riparian Buffer: Forest	Acre Installed	15.0	30.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	15.0	30.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	17.5	63.0	70.0
	Total Cost	$12,654,175	$25,320,365	$4,400,360
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	25.0	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	5.0	-	-
Permanent vegetative cover on cropland (SL-1)	Acre Installed	2.0	-	-
Sod Waterway (WP-3)	Acre Installed	4.0	-	-
Cropland Buffer/Field Borders (CP-33 and WQ-1)	Acre Installed	2.0	-	-
	Total Cost	$11,400	-	-
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (CRSL-6)	System	2	-	-
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	14	-	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	2	-	-
Small Acreage Grazing System (SL-6AT)	System	1	-	-
	Total Cost	$391,000	-	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	79.5	159.0	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	1430.0	-	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	143.0	286.0	-
	Total Cost	$323,370	$216,120	-
Stream Restoration				
Stream Restoration	Feet	11,253	22,506	-
	Total Cost	$3,375,900	$3,375,900	-
	Total Cost Per Stage	**$34,410,990**	**$40,855,590**	**$11,921,170**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**1.0%**	**1.0%**	**1.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**18.4%**	**17.9%**	**10.5%**
	Bacteria Load Per Stage (cfu/year)	**6.14E+13**	**4.31E+13**	**3.35E+12**

Table 34: Roanoke River 2 Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	153	-	-
Sewer Connection (RB-2)	System	29	39	-
Repaired Septic System (RB-3)	System	86	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	86	-	-
Alternative Waste Treatment System Installation (RB-5)	System	8	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	17	22	-
	Total Cost	$1,351,345	$120,615	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	22	29	-
Constructed Wetlands	System	16	21	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	1,074	1,074	1,074
	Total Cost	$7,518,930	$5,485,230	$2,234,190
Stormwater BMPs				
Bioretention	Acre Treated	312.5	1125.0	1250.0
Rain Gardens	Acre Treated	125.0	225.0	250.0
Infiltration Trench	Acre Treated	62.3	224.1	249.0
Manufactured BMPs	Acre Treated	151.0	271.8	302.0
Constructed Wetland	Acre Treated	1433.3	5159.7	5733.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	215	430	-
Riparian Buffer: Forest	Acre Installed	21.0	28.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	21.0	28.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	12.5	45.0	50.0
	Total Cost	$12,623,810	$25,845,570	$4,455,200
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	1.0	-	-
	Total Cost	$100	-	-
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (CRSL-6)	System	1	-	-
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	8	-	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	1	-	-
Small Acreage Grazing System (SL-6AT)	System	1	-	-
	Total Cost	$221,000	-	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	73.0	146.0	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	1316.0	-	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	131.5	263.0	-
	Total Cost	$297,380	$198,680	-
Stream Restoration				
Stream Restoration	Feet	1,674	-	-
	Total Cost	$502,200	-	-
	Total Cost Per Stage	**$22,514,765**	**$31,650,095**	**$6,694,390**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**0.0%**	**0.0%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**14.4%**	**11.4%**	**9.9%**
	Bacteria Load Per Stage (cfu/year)	**5.79E+13**	**2.98E+13**	**1.87E+13**

Table 35: Tinker Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	516	688	-
Sewer Connection (RB-2)	System	183	244	-
Repaired Septic System (RB-3)	System	344	459	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	419	558	-
Alternative Waste Treatment System Installation (RB-5)	System	37	49	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	5	7	-
	Total Cost	$6,258,545	$2,089,515	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	24	32	-
Constructed Wetlands	System	20	27	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	432	432	432
	Total Cost	$4,001,405	$2,532,555	$899,070
Stormwater BMPs				
Bioretention	Acre Treated	310.0	1116.0	1240.0
Rain Gardens	Acre Treated	124.0	223.2	248.0
Infiltration Trench	Acre Treated	61.8	222.3	247.0
Manufactured BMPs	Acre Treated	149.5	269.1	299.0
Constructed Wetland	Acre Treated	1376.0	4953.6	5504.0
Detention Pond	Acre Treated	49.0	176.4	196.0
Permeable Paver	Acre Treated	1.3	3.8	5.0
Vegetated Swale	Acre Treated	37.5	135.0	150.0
Rain Barrel	System	179	358	-
Riparian Buffer: Forest	Acre Installed	19.5	26.0	-
Riparian Buffer: Grass/Shrub	Acre Installed	19.5	26.0	-
Urban Tree Canopy/Land use Conversion	Acre Converted	6.0	21.6	24.0
	Total Cost	$12,360,845	$25,246,625	$4,361,490
Livestock Exclusion Systems and Manure Management				
Livestock Exclusion (CRSL-6)	System	4	-	-
Livestock Exclusion (SL-6/SL-6T/LE-1T)	System	41	55	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	6	-	-
Small Acreage Grazing System (SL-6AT)	System	3	-	-
Stream Protection/Fencing (WP-2/WP-2T)	System	2	-	-
Manure Storage (WP-4)	System	2	-	-
	Total Cost	$1,261,250	$288,750	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	361.0	722.0	-
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	3248.5	6497.0	-
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	649.5	1299.0	-
	Total Cost	$1,225,198	$1,225,198	
Stream Restoration				
Stream Restoration	Feet	7,499	14,999	-
	Total Cost	$1,550,100	$1,550,100	-
	Total Cost Per Stage	**$26,657,343**	**$32,932,743**	**$5,265,560**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**22.9%**	**16.7%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**33.6%**	**25.3%**	**9.7%**
	Bacteria Load Per Stage (cfu/year)	**5.43E+13**	**2.57E+13**	**7.20E+12**

Table 36: Bradshaw Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y6)	Stage II (Y7-Y12)	Stage III (Y13-Y15)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	58	-	-
Sewer Connection (RB-2)	System	0	-	-
Repaired Septic System (RB-3)	System	8	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	9	-	-
Alternative Waste Treatment System Installation (RB-5)	System	2	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	0	-	-
Pet Waste Composters	Unit	11	-	-
	Total Cost	$154,662	$5,000	$5,000
Existing BMPs				
Street Sweeping (additional miles to be swept annually)	Miles Swept	148	148	148
	Total Cost	$460,270	$460,270	$230,130
Stormwater BMPs				
Bioretention	Acre Treated	13	45	50
Rain Gardens	Acre Treated	25	45	50
Infiltration Trench	Acre Treated	5	18	20
Manufactured BMPs	Acre Treated	10	18	20
Constructed Wetland	Acre Treated	5	18	20
Detention Pond	Acre Treated	3	9	10
Permeable Pavement	Acre Treated	1	4	5
Vegetated Swale	Acre Treated	100	180	200
Rain Barrel	System	87	174	-
Riparian Buffer: Forest	Acre Installed	4	8	-
Riparian Buffer: Grass/Shrub	Acre Installed	4	9	-
Cistern	System	0	0	6
	Total Cost	$2,647,270	$2,805,670	$805,400
Livestock Exclusion Systems				
CREP Livestock Exclusion (CRSL-6)	System	2	2	3
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	System	6	9	12
Livestock Exclusion with Riparian Buffers (LE-1T)	System	6	9	12
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	1	2	2
Small Acreage Grazing System (SL-6AT)	System	1	2	2
Stream Protection Fencing (WP-2/WP-2T)	System	1	2	2
	Total Cost	$483,500	$241,750	$241,750
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	9	28	37
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	9	27	36
Woodland Buffer Filter Area (FR-3)	Acre Installed	9	27	36
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	89	177	0
Wet Detention Ponds	Acre Treated	0	0	0
Grazing Land Management (SL-9)	Acre Installed	44	132	176
	Total Cost	$75,458	$144,275	$68,818
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	41	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	48	-	-
Permanent Vegetative Cover on Cropland (SL-1)	Acre Installed	2	-	-
Sod Waterway (WP-3)	Acre Installed	2	-	-
Cropland Buffer/Field Borders (CP-33 and WQ-1)	Acre Installed	2	-	-
	Total Cost	$12,180	-	-
Stream Restoration				
Stream Restoration	Feet	4,922	9,844	-
Stream Stabilization	Feet	246	492	-
	Total Cost	$1,494,997	$1,494,997	-
	Total Cost Per Stage	**$5,328,336**	**$5,151,962**	**$1,351,098**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**1.4%**	**1.4%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**9.6%**	**7.0%**	**6.2%**
	Bacteria Load Per Stage (cfu/year)	**2.99E+13**	**2.42E+13**	**2.30E+13**

Table 37: North Fork Roanoke River Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y6)	Stage II (Y7-Y12)	Stage III (Y13-Y15)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	203	-	-
Sewer Connection (RB-2)	System	25	-	-
Repaired Septic System (RB-3)	System	27	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	30	-	-
Alternative Waste Treatment System Installation (RB-5)	System	6	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	3	-	-
Pet Waste Composters	Unit	43	-	-
	Total Cost	$753,340	$5,000	5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	21	29	-
Constructed Wetlands	System	44	58	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	844	844	844
	Total Cost	$3,014,120	$2,843,753	$1,379,280
Stormwater BMPs				
Bioretention	Acre Treated	75	270	300
Rain Gardens	Acre Treated	150	270	300
Infiltration Trench	Acre Treated	50	180	200
Manufactured BMPs	Acre Treated	75	135	150
Constructed Wetland	Acre Treated	50	180	200
Detention Pond	Acre Treated	25	90	100
Permeable Pavement	Acre Treated	1	4	5
Vegetated Swale	Acre Treated	200	360	400
Rain Barrel	System	347	694	-
Riparian Buffer: Forest	Acre Installed	36	71	-
Riparian Buffer: Grass/Shrub	Acre Installed	40	80	-
Cistern	System	0	0	23
	Total Cost	$7,660,937	$8,848,937	$2,015,140
Livestock Exclusion Systems				
CREP Livestock Exclusion (CRSL-6)	System	5	8	10
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	System	19	29	38
Livestock Exclusion with Riparian Buffers (LE-1T)	System	19	29	38
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	3	4	5
Small Acreage Grazing System (SL-6AT)	System	3	4	5
Stream Protection Fencing (WP-2/WP-2T)	System	3	4	5
	Total Cost	$1,506,500	$753,250	$753,250
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	204	613	818
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	552	1,656	2,208
Woodland Buffer Filter Area (FR-3)	Acre Installed	92	276	368
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	3,680	7,360	0
Wet Detention Ponds	Acre Treated	0	0	3,800
Grazing Land Management (SL-9)	Acre Installed	44	132	176
	Total Cost	$3,313,485	$6,350,985	$3,607,500
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	253	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	283	-	-
Permanent Vegetative Cover on Cropland (SL-1)	Acre Installed	15	-	-
Sod Waterway (WP-3)	Acre Installed	15	-	-
Cropland Buffer/Field Borders (CP-33 and WQ-1)	Acre Installed	15	-	-
	Total Cost	$75,050	-	-
Stream Restoration				
Stream Restoration	Feet	8,004	16,008	-
Stream Stabilization	Feet	570	1,140	-
	Total Cost	$2,443,900	$2,443,900	-
	Total Cost Per Stage	**$18,777,352**	**$21,245,825**	**$7,760,170**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**4.2%**	**1.4%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**16.3%**	**5.7%**	**3.4%**
	Bacteria Load Per Stage (cfu/year)	**2.02E+14**	**1.16E+14**	**6.23E+13**

Table 38: South Fork Roanoke River Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	416	-	-
Sewer Connection (RB-2)	System	11	-	-
Repaired Septic System (RB-3)	System	56	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	62	-	-
Alternative Waste Treatment System Installation (RB-5)	System	12	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	6	-	-
Pet Waste Composters	Unit	87	-	-
	Total Cost	$1,167,620	$5,000	5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	36	47	-
Constructed Wetlands	System	36	48	-
Street Sweeping (additional miles to be swept annually)	Miles Swept	1,326	1,326	1,326
	Total Cost	$5,834,012	$5,621,971	$2,757,970
Stormwater BMPs				
Bioretention	Acre Treated	150	540	600
Rain Gardens	Acre Treated	350	630	700
Infiltration Trench	Acre Treated	100	360	400
Manufactured BMPs	Acre Treated	200	360	400
Constructed Wetland	Acre Treated	125	450	500
Detention Pond	Acre Treated	50	180	200
Permeable Pavement	Acre Treated	1	4	5
Vegetated Swale	Acre Treated	300	540	600
Rain Barrel	System	622	1,243	-
Riparian Buffer: Forest	Acre Installed	62	124	-
Riparian Buffer: Grass/Shrub	Acre Installed	70	140	-
Cistern	System	0	0	41
	Total Cost	$14,482,325	$16,787,325	$3,641,450
Livestock Exclusion Systems				
CREP Livestock Exclusion (CRSL-6)	System	5	8	10
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	System	19	29	38
Livestock Exclusion with Riparian Buffers (LE-1T)	System	20	29	39
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	3	4	5
Small Acreage Grazing System (SL-6AT)	System	3	4	5
Stream Protection Fencing (WP-2/WP-2T)	System	3	4	5
	Total Cost	$1,517,000	$758,500	$758,500
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	240	719	958
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	647	1,940	2,587
Woodland Buffer Filter Area (FR-3)	Acre Installed	108	323	431
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	4,311	8,622	0
Wet Detention Ponds	Acre Treated	0	0	1,720
Grazing Land Management (SL-9)	Acre Installed	44	132	176
	Total Cost	$3,880,378	$7,437,425	$3,815,048
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	662	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	452	-	-
Permanent Vegetative Cover on Cropland (SL-1)	Acre Installed	39	-	-
Sod Waterway (WP-3)	Acre Installed	39	-	-
Cropland Buffer/Field Borders (CP-33 and WQ-1)	Acre Installed	39	-	-
	Total Cost	$187,900	-	-
Stream Restoration				
Stream Restoration	Feet	24,070	48,140	-
Stream Stabilization	Feet	1,203	2,407	-
	Total Cost	$7,311,245	$7,311,245	-
	Total Cost Per Stage	**$34,380,480**	**$37,921,466**	**$10,977,968**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**2.8%**	**1.4%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**2.9%**	**7.6%**	**3.9%**
	Bacteria Load Per Stage (cfu/year)	**2.76E+14**	**1.61E+14**	**1.26E+14**

Table 39: Unimpaired North Fork Roanoke River Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y6)	Stage II (Y7-Y12)	Stage III (Y13-Y15)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	31	-	-
Sewer Connection (RB-2)	System	0	-	-
Repaired Septic System (RB-3)	System	4	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	4	-	-
Alternative Waste Treatment System Installation (RB-5)	System	1	-	-
Pet Waste Education Campaign	Program	0	-	-
Pet Waste Station	Unit	1	-	-
Pet Waste Composters	Unit	6	-	-
	Total Cost	$75,400	$0	$0
Existing BMPs and Detention Pond Retrofits				
Street Sweeping (additional miles to be swept annually)	Miles Swept	141	141	141
	Total Cost	$441,030	$441,030	$220,510
Stormwater BMPs				
Bioretention	Acre Treated	38	135	150
Rain Gardens	Acre Treated	75	135	150
Infiltration Trench	Acre Treated	5	18	20
Manufactured BMPs	Acre Treated	10	18	20
Constructed Wetland	Acre Treated	5	18	20
Detention Pond	Acre Treated	5	18	20
Permeable Pavement	Acre Treated	1	4	5
Vegetated Swale	Acre Treated	150	270	300
Rain Barrel	System	45	91	-
Riparian Buffer: Forest	Acre Installed	6	11	-
Riparian Buffer: Grass/Shrub	Acre Installed	6	13	-
Cistern	System	0	0	3
	Total Cost	$4,065,045	$4,407,145	$1,137,930
Livestock Exclusion Systems				
CREP Livestock Exclusion (CRSL-6)	System	3	-	-
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	System	10	-	-
Livestock Exclusion with Riparian Buffers (LE-1T)	System	11	-	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	1	-	-
Small Acreage Grazing System (SL-6AT)	System	1	-	-
Stream Protection Fencing (WP-2/WP-2T)	System	1	-	-
	Total Cost	$809,000	-	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	11	32	43
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	10	31	41
Woodland Buffer Filter Area (FR-3)	Acre Installed	10	31	41
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	205	411	0
Wet Detention Ponds	Acre-treated	0	0	0
Grazing Land Management (SL-9)	Acre Installed	44	132	176
	Total Cost	$93,578	$171,745	$78,168
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	51	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	57	-	-
Permanent Vegetative Cover on Cropland (SL-1)	Acre Installed	3	-	-
Sod Waterway (WP-3)	Acre Installed	3	-	-
Cropland Buffer/Field Borders (CP-33 and WQ-1)	Acre Installed	3	-	-
	Total Cost	$15,010	-	-
Stream Restoration				
Stream Restoration	Feet	3,032	6,063	-
Stream Stabilization	Feet	152	303	-
	Total Cost	$920,875	$920,875	-
	Total Cost Per Stage	**$6,419,938**	**$5,940,795**	**$1,436,608**

Table 40: Wilson Creek Implementation Timeline				
Best Management Practice	Unit	Stage I (Y1-Y8)	Stage II (Y9-Y16)	Stage III (Y17-Y20)
Residential BMPs				
Septic System Pump-Out (RB-1)	Pump Out	71	-	-
Sewer Connection (RB-2)	System	13	-	-
Repaired Septic System (RB-3)	System	9	-	-
Septic System Installation/Replacement (RB-4, RB-4P)	System	10	-	-
Alternative Waste Treatment System Installation (RB-5)	System	2	-	-
Pet Waste Education Campaign	Program	1	1	1
Pet Waste Station	Unit	15	-	-
Pet Waste Composters	Unit	98	-	-
	Total Cost	$372,180	$5,000	$5,000
Existing BMPs and Detention Pond Retrofits				
Infiltration Trench	System	109	146	
Constructed Wetlands	System	426	568	
Street Sweeping (additional miles to be swept annually)	Miles Swept	772	772	772
	Total Cost	$5,102,465	$3,842,795	$1,606,480
Stormwater BMPs				
Bioretention	Acre Treated	75	270	300
Rain Gardens	Acre Treated	150	270	300
Infiltration Trench	Acre Treated	25	90	100
Manufactured BMPs	Acre Treated	150	270	300
Constructed Wetland	Acre Treated	75	270	300
Detention Pond	Acre Treated	38	135	150
Permeable Pavement	Acre Treated	1	4	5
Vegetated Swale	Acre Treated	250	450	500
Rain Barrel	System	1,368	2,736	-
Riparian Buffer: Forest	Acre Installed	19	38	-
Riparian Buffer: Grass/Shrub	Acre Installed	21	42	-
Cistern	System	0	0	91
	Total Cost	$10,126,015	$10,784,515	$2,552,680
Livestock Exclusion Systems				
CREP Livestock Exclusion (CRSL-6)	System	1	-	-
Livestock Exclusion with Grazing Land Management for TMDL IP (SL-6/SL-6T)	System	5	-	-
Livestock Exclusion with Riparian Buffers (LE-1T)	System	5	-	-
Livestock Exclusion with Reduced Setback (LE-2/LE-2T)	System	1	-	-
Small Acreage Grazing System (SL-6AT)	System	1	-	-
Stream Protection Fencing (WP-2/WP-2T)	System	1	-	-
	Total Cost	$404,000	-	-
Pasture BMPs				
Reforestation of Erodible Pasture (FR-1)	Acre Installed	20	61	81
Vegetative Cover on Critical Areas (SL-11)	Acre Installed	36	109	145
Woodland Buffer Filter Area (FR-3)	Acre Installed	9	27	36
Pasture Management (EQIP 528, SL-10T, SL-9)	Acre Installed	363	727	0
Wet Detention Ponds	Acre Treated	0	0	330
Grazing Land Management (SL-9)	Acre Installed	44	132	176
	Total Cost	$244,295	$461,335	$266,540
Cropland BMPs				
Continuous No-Till (SL-15)	Acre Installed	26	-	-
Small Grain Cover Crop (SL-8)	Acre Installed	30	-	-
Permanent Vegetative Cover on Cropland (SL-1)	Acre Installed	2	-	-
Sod Waterway (WP-3)	Acre Installed	2	-	-
Cropland Buffer/Field Borders (CP-33 and WQ-1)	Acre Installed	2	-	-
	Total Cost	$7,860	-	-
Stream Restoration				
Stream Restoration	Feet	1,887	3,773	-
Stream Stabilization	Feet	94	189	-
	Total Cost	$573,060	$573,060	-
	Total Cost Per Stage	**$16,829,875**	**$15,666,705**	**$4,430,700**
	Percent Exceedance Geometric Mean (126 cfu/100 mL)	**0.0%**	**0.0%**	**0.0%**
	Percent Exceedance Single Sample Maximum (235 cfu/100mL)	**12.4%**	**5.7%**	**5.1%**
	Bacteria Load Per Stage (cfu/year)	**1.07E+14**	**6.49E+13**	**5.60E+13**

Implementation Tracking

Implementation actions are tracked to ensure that BMPs are adequately installed and maintained and to evaluate changes in the watershed. BMP tracking involves inventorying the numbers and locations of BMPs installed within the watershed. Management measures, such as types of outreach education activities (e.g., workshops, mailings, and field days) and number of participants, should also be tracked. The agricultural practices supported by cost-share funds will be tracked through the local Soil and Water Conservation Districts and be included in the Virginia Agricultural Cost-share Database. Stormwater BMPs will be tracked by municipalities as required by their MS4 permits. A subset of the IP steering committee could reconvene and collaborate on implementation tracking throughout the implementation timeline.

Monitoring Plan

Water quality monitoring will occur during the staged timeline of the IP to evaluate progress toward meeting water quality milestones and assessing implementation impacts. The primary goal of the IP is to de-list the impaired segments for both bacteria and aquatic life. Therefore, VADEQ will focus monitoring efforts on the original listing stations. For Part I, these include 23 stations for bacteria impairments and 10 stations for benthic impairments as shown in Figure 3. For Part II, there are 11 bacteria stations and two benthic stations as shown in Figure 4. VADEQ supported monitoring will occur at original listing stations only after BMPs have been implemented in the subwatershed for at least two years to allow for pollutant reductions to begin to have effect. In the interim, key stakeholders could meet with VADEQ to discuss monitoring start times and implementation activities. Monitoring will occur bi-monthly at bacteria and water chemistry stations and twice annually for biomonitoring stations, typically in the spring and fall. Additional monitoring could be scheduled if VADEQ is unable to de-list the impaired segments over the timeframes detailed in this plan.

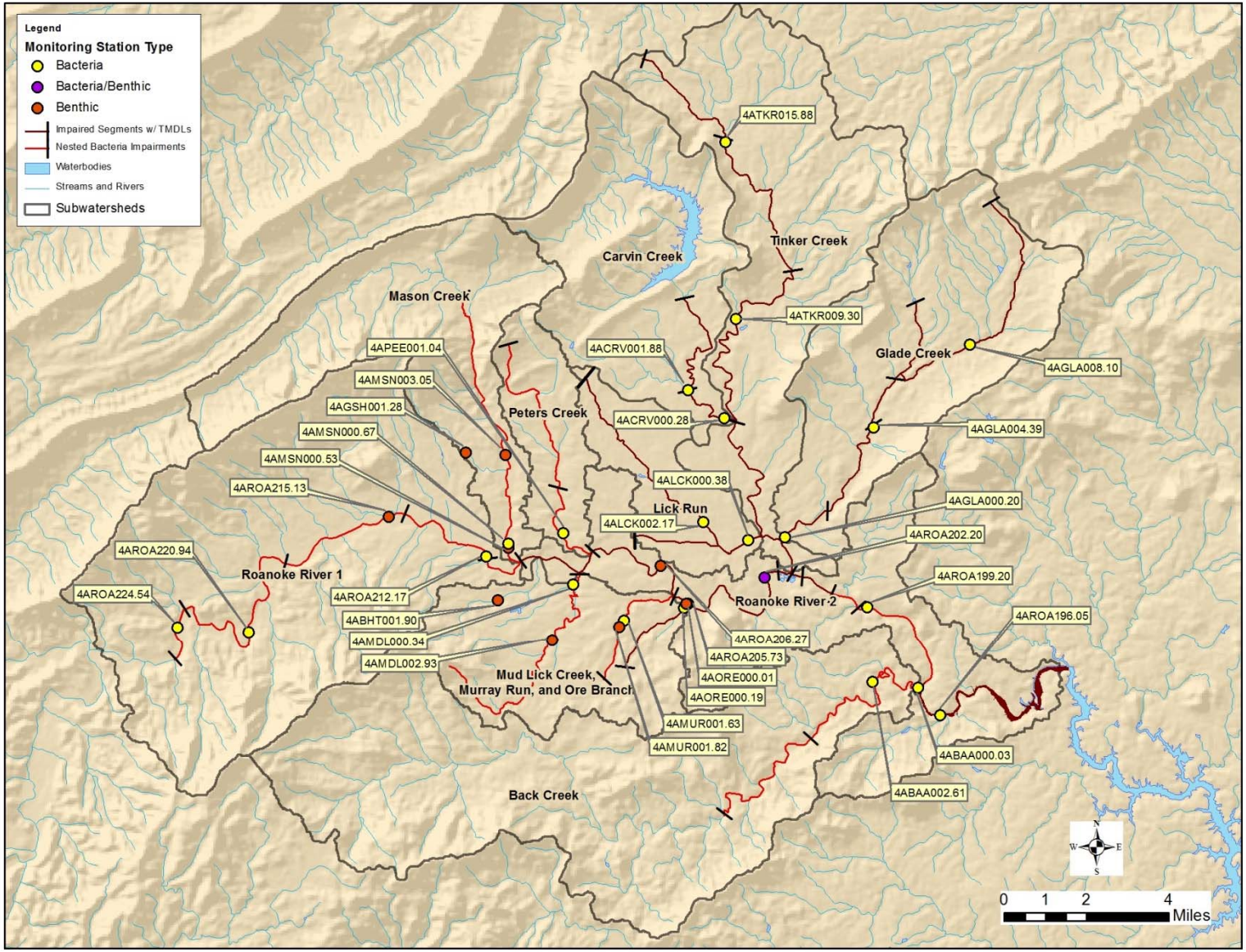

Figure 3. Water Quality Monitoring Stations for Part I

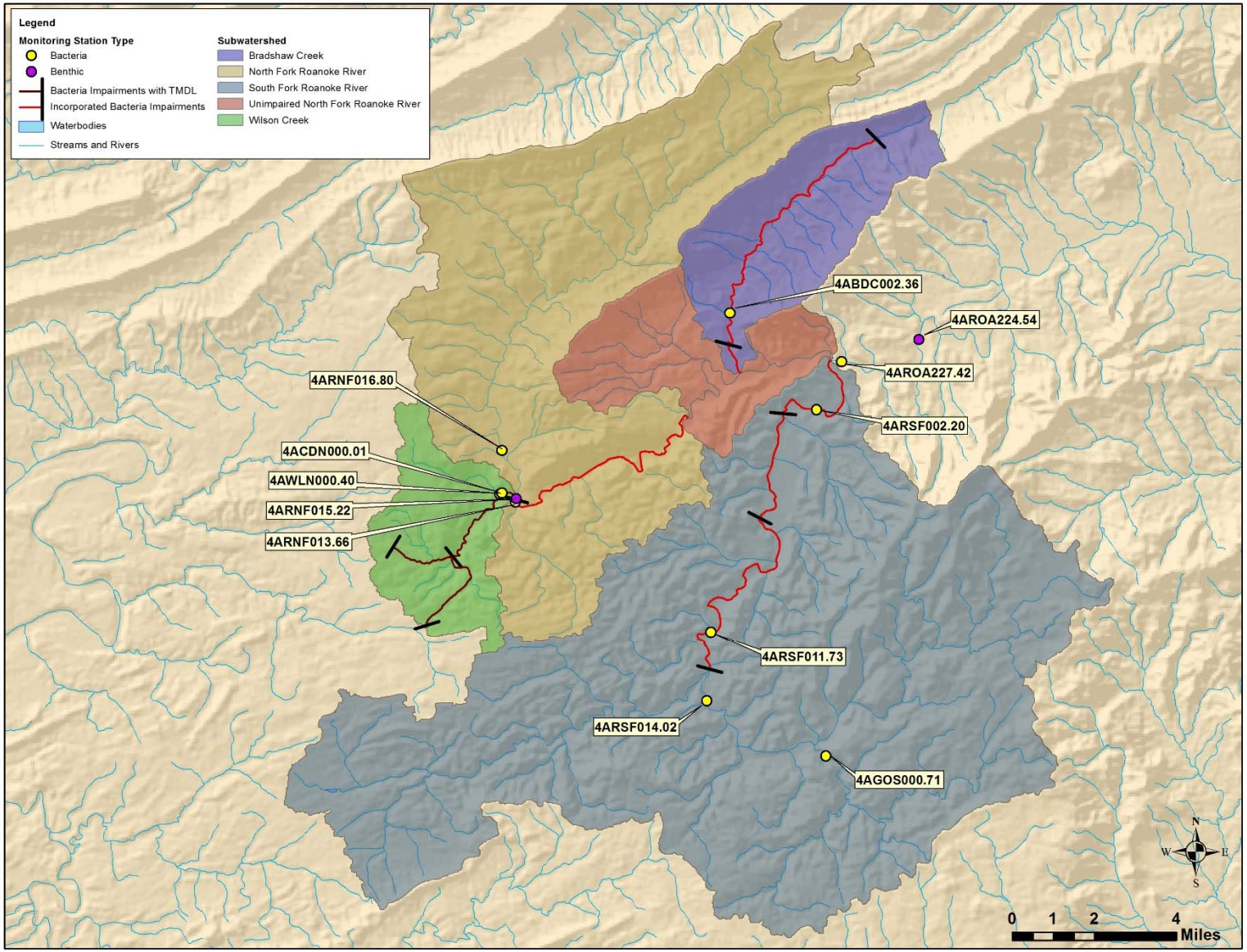

Figure 4. Water Quality Monitoring Stations for Part II

ROLES AND RESPONSIBILITIES OF PARTNERS

Individuals or groups who live or have land management responsibilities in the watershed include federal, state and local government agencies, businesses, special interest groups, and citizens. Participation, support, and cooperation among these partners is essential for improving water quality and removing streams from the impaired waters list.

Citizens, Community Groups, and Businesses

Successful cleanup of a watershed depends on local partners taking responsibility for their role in the process. The primary role falls on the local groups that are most affected, that is, citizens, community watershed groups, and businesses.

Citizens: The main role of citizens within the TMDL and implementation process is **involvement and input**. Local residents, farmers, and other members of the public assist in the process through attendance and participation at public meetings, provision of local watershed information, support of public outreach and education, and/or implementing best management practices on their property to help restore water quality.

Community Watershed and Conservation Groups: Local watershed and conservation groups offer a meeting place and events for river and land conservation groups to share ideas and coordinate preservation efforts and are also a showcase site for citizen action. These groups also have a valuable knowledge of the local watershed and river habitat that is important to the implementation process.

Community Civic Groups: Community civic groups take on a wide range of community service including environmental projects. Such groups include Ruritan, Farm Clubs, Homeowner Associations and youth organizations such as 4-H and Future Farmers of America. These groups offer a resource to assist in the public participation process, educational outreach, and assisting with implementation activities in local watersheds.

Animal Clubs/Associations: Clubs and associations for various animal groups (e.g., beef, equine, poultry, swine, and canine) provide a resource to assist and promote conservation practices among farmers and other land owners, not only in rural areas, but in urban areas as well where pet waste has been identified as a source of bacteria in water bodies.

Businesses: Local businesses can also play a role in the implementation process by participating in public meetings, assisting with public outreach and education, providing input about the local watershed history, and/or implementing best management practices on their property to help restore water quality.

Several local partners involved in the cleanup plan include:

- Blue Ridge Land Conservancy
- Clean Valley Council
- Friends of the Rivers of Virginia
- Glade Creek Restoration Committee
- Impact+Amplify
- Mill Mountain Garden Club
- Orvis
- Roanoke Region Chamber of Commerce
- Roanoke River Blueway
- Roanoke Valley Greenways
- Smith Mountain Lake Association
- Southeast Rural Community Assistance Project, Inc.
- Trout Unlimited
- Upper Roanoke River Roundtable
- Western Virginia Water Authority
- Williamson Road Area Business Association, Inc.

Local Government

Members of local governments have knowledge about a community's priorities, how decisions are made locally, and how the watershed's residents interact. These insights may help to ensure the success of the cleanup plan. Local government groups work closely with state and federal agencies throughout the cleanup process.

Soil and Water Conservation Districts (SWCDs): SWCDs are local units of government responsible for the soil and water conservation work within their boundaries. The districts' role is to increase voluntary conservation practices among farmers, ranchers and other land users. The Roanoke River TMDL IP watershed includes Mountain Castles (covering Botetourt County), Blue Ridge (covering Roanoke County), and Skyline (covering Floyd and Montgomery Counties) SWCDs.

Planning District Commissions (PDCs): PDCs were organized to promote the efficient development of the physical, social, and economic resources of the regional district including the environment by assisting and encouraging local governmental agencies to plan for the future. PDCs focus much of their efforts on water quality planning, which is complementary to the TMDL process. TMDL development and implementation projects are often contracted through PDCs. The Roanoke Valley-Alleghany Regional Commission contracted the Roanoke River TMDLs IP project.

County, City, and Town Government Departments: City and county government staff work closely with PDCs and state agencies to develop and implement TMDLs. They may also help to promote education and outreach to citizens, businesses and developers to introduce the importance of the TMDL process. Local governments have the ability to enact ordinances that aid in the reduction of water pollutants and support BMP implementation such as requirements for pet waste pickup and septic system maintenance and pump out. They operate the locality Virginia Stormwater Management Program in accordance to the Stormwater Management Act. Representatives from **Botetourt, Floyd, Montgomery, and Roanoke Counties; the Cities of Roanoke and Salem; and the Towns of Blacksburg, Christiansburg, and Vinton** participated in the IP development process through meeting attendance, comments and suggestions on various aspects of the plan, and/or provision of watershed, BMP, and water quality data.

State Government

Virginia Department of Environmental Quality (VADEQ): VADEQ administers the TMDL process, including the public participation component, and formally submits the TMDLs and IPs to EPA and the State Water Control Board for approval. VADEQ has a role in working with local agency partners to track implementation progress for control measures identified in the IP. In addition, VADEQ provides available grant funding and technical support for TMDL implementation. Regional staff will work with interested partners on grant proposals for BMP implementation funding. VADEQ is also responsible for assessing water quality to determine compliance with water quality standards both before and after TMDL development and BMP implementation to determine when water quality standards are attained and the streams can be removed from Virginia's impaired water list.

Virginia Department of Conservation and Recreation (VADCR): VADCR works with soil and water conservation districts to provide cost share and operating grants for BMP implementation and tracking. In addition, VADCR manages the state's Nutrient Management Program, which provides technical assistance to producers in appropriate manure storage and fertilizer applications.

Virginia Department of Agriculture and Consumer Services (VDACS): VDACS administers the Agricultural Stewardship Act with the local soil and water district investigates and reviews water quality problems caused by agricultural producers.

Virginia Department of Health (VDH): VDH is responsible for adopting and implementing regulations for onsite wastewater treatment and disposal including correction of failed septic systems and/or elimination of straight pipes. VDH staff also provide technical assistance to homeowners with septic system maintenance, design and installation, and respond to complaints regarding failing septic systems and straight pipes.

Virginia Department of Forestry (VDOF): VDOF has a major role in protecting watersheds through riparian forest buffers and encourages the use of best management practices to keep streams free of silvicultural sediments. VDOF administers several cost-share which provides financial assistance to private landowners and the forest industry for pine reforestation.

Virginia Cooperative Extension (VCE): VCE is a product of cooperation among local, state, and federal governments in partnership with citizens. VCE offers educational programs and technical resources for topics such as crops, grains, livestock, poultry, dairy, natural resources, and environmental management.

Virginia Department of Transportation (VDOT): VDOT provides guidance in the design of BMPs for water quality control and stormwater management related to VDOT projects and facilities. In addition, VDOT participates in educating the public on the protection of state waters, stormwater pollution prevention, and their MS4 program.

Federal Government

The **U.S. Environmental Protection Agency (EPA)** oversees the various programs necessary for the success of the Clean Water Act. Additionally, the EPA has outlined the minimum elements necessary for an IP to be approved which would allow States to receive Clean Water Act Section 319 funding for use in impaired water restoration and implementation of an IP.

The **Natural Resources Conservation Service (NRCS)**, as part of the U.S. Department of Agriculture, works closely with private landowners as well as local, state and federal agencies and policymakers to conserve soil, water, and other natural resources. NRCS is a major funding partner for impaired water bodies through the Environmental Quality Incentive Program (EQIP).

INTEGRATION WITH OTHER WATERSHED PLANS

Like most watersheds in Virginia, clean water in the Roanoke River watershed involves many different organizations, programs and activities. Such efforts include both voluntary and regulatory action and plans that may compliment the goals outlined in this plan. Often these efforts are related or collaborative. Frequently, coordination of local programs can increase participation and prevent redundancy.

Watershed-wide Plans

Livable Roanoke Valley: The Roanoke Valley Alleghany Regional Council and the Council of Community Services created the Partnership for a Livable Roanoke Valley (Livable Roanoke Valley) to address regional challenges such as the economy, employment, population growth, retention of the workforce, health care, and poverty and to plan for a better future. One goal within the first integrated regional plan for the Roanoke Valley is to work collaboratively to preserve the historic, cultural, and natural assets of the region including the improvement of air and water quality, which 85% of respondents indicated was a top priority for the valley. Actions to support this strategy include the development of stormwater banking systems and the restoration and maintenance of stream buffers along critical waterways. More information on this plan is available at http://livableroanoke.org/.

New River Valley Livability Initiative: The Livability Initiative began as a regional planning process to develop a vision for the future and develop strategies that businesses, community organizations, local governments, and individuals can use to make the vision a reality. Goals included in the plan are protection and improvement of natural landscapes and ecosystems including water resources. Strategies focus on waste, water and stormwater systems; land conservation; protection and restoration of wetlands, forests, riparian areas; outreach and education; development of watershed management and stream restoration plans; agricultural and stormwater BMPs; and expansion of water quality monitoring. A partnership between the Community Foundation of the New River Valley and the New River Valley Regional Commission support implementation of the Initiative's goals and strategies, track progress on key indicators, and identify needed resources. More information on this plan is available at http://nrvlivability.org/.

Upper Roanoke River Roundtable (URRR): The URRR supports numerous projects including education and outreach activities, riparian plantings, cleanup activities, citizen stream monitoring, and pet waste stations. These efforts intend to identify, prevent, and resolve water resources issues, reduce nonpoint source pollution, and improve the health of streams in the watershed. The URRR partners with other stakeholders for restoration projects including work on pet waste issues involving education, installation of pet waste collection stations on greenways and trails within the Roanoke River watershed, and the provision of station supplies.

Roanoke River Blueway: The Roanoke River Blueway is a 45-mile water trail running from the South Fork Roanoke River in Montgomery County, along the mainstem of the Roanoke River within Franklin and Roanoke Counties, to Smith Mountain Lake in Bedford County. In addition to providing river access for recreational opportunities such as canoeing, kayaking, fishing, and wildlife viewing, the Blueway holds a goal of educating the public about the importance of watersheds and water resources. See http://www.roanokeriverblueway.org/ for more information.

Roanoke Valley Greenways: The Roanoke Valley, Virginia greenway program arose in 1995 as a citizen initiative to improve quality of life in the region. The City of Roanoke, Roanoke County, Salem and the Town of Vinton established the Roanoke Valley Greenway Commission in 1997 with the signing of an Intergovernmental Agreement. Greenway founders set up Pathfinders for Greenways, Inc. to be a non-profit organization that could involve volunteers in greenway development. To date, 26 miles of greenways with bicycle/pedestrian trails have been built in the Roanoke Valley, with additional hubs of natural surface trails at Mill Mountain, Carvins Cove, and Read Mountain. The 2007 update to the Roanoke Valley Greenway Plan provides for 35 routes throughout the Roanoke Valley.

Western Virginia Water Authority: The Western Virginia Water Authority is committed to helping the public learn about protecting and preserving natural resources through free outreach classroom presentations and facility tours to customers and school, civic, neighborhood and community groups. Classroom presentations on a wide range of topics, including water supply, watersheds, water conservation and properties of water are available for students in the City of Roanoke, Roanoke County, and Franklin County. In the past, the Authority has also offered free water conservation kits for its water and sewer customers to help save on water bills and to raise the profile of water resource issues in the community.

Trout Unlimited (TU): The Roanoke Valley Chapter of TU focuses on implementing local projects which support the TU mission to "conserve, protect and restore North America's trout and salmon fisheries and their watersheds." Some projects that the Roanoke Valley Chapter has been involved in are Trout in the Classroom, Help Glade Creek, and Project Healing Waters.

The Cities of Roanoke and Salem, the Town of Vinton, and Roanoke County all support **urban tree canopy projects**. The addition of trees to a landscape benefits both residents and the environment by providing improved water quality; reducing temperatures, air pollution, stormwater runoff, and carbon dioxide; saving energy; and providing habitat for wildlife and educational opportunities.

Local Comprehensive Plans

The Counties of Botetourt, Floyd, Montgomery, and Roanoke, the Cities of Roanoke and Salem, and the Towns of Blacksburg and Christiansburg have all developed a comprehensive plan **to guide local growth, development, and planning while also protecting and enhancing natural and rural resources**. Resources highlighted in the plans include water and land resources such as watersheds, surface water and groundwater, stormwater, open space, agriculture, riparian areas, water quality, soils, aquatic and terrestrial wildlife and vegetation, land uses, utilities, and pollution control. Each plan typically includes goals as well as strategies and policies to help achieve the stated goals. Strategies and policies include education and outreach on water resources issues, septic system maintenance, pet waste, and BMPs; encouragement of the use of agricultural, sewage disposal, and stormwater BMPs; protection of streambanks and planting of riparian buffers; ordinances to protect water quality, and incentives for low-impact development (LID) techniques. Other approaches encourage connection to public water and sewer, enforce site development/construction standards and erosion and sedimentation control laws, support efforts to investigate pollution and maintain and improve water quality standards, and discourage land uses that have a detrimental effect on the environment. In particular, stormwater management strategies focus on stormwater runoff and soil erosion for the protection of surface water quality, aquatic habitat, and human health and safety including the development of management and control plans, improvement of the stormwater management system, implementation of BMPs and LID techniques that reduce runoff, and reduction of impervious surfaces.

MS4 TMDL Action Plans

The following entities within the Roanoke River watershed have an MS4 permit:

- Botetourt County
- City of Roanoke
- City of Salem
- Montgomery County
- Roanoke County
- Town of Blacksburg
- Town of Christiansburg
- Town of Vinton
- Veterans Administration Medical Center
- Virginia Department of Transportation
- Virginia Western Community College

MS4 permittees are required to limit and prevent, to the extent possible, pollutants from entering the stormwater system in order to protect the water quality of surrounding surface waters. To achieve the required TMDL wasteload allocations (or pollutant loads from point sources), MS4 operators must develop and implement a TMDL action plan that includes the minimum elements of public education and outreach on stormwater impacts, public involvement and participation, illicit discharge detection and elimination, construction site stormwater runoff control, post-construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. These include measures such as BMPs, stormwater management strategies, maintenance of stormwater infrastructure and discharge data, public involvement, education, and outreach. Most of the MS4 permittees have an illicit discharge detection and elimination system in place. In preparing local TMDL action plans, Municipal Separate Storm Sewer System permittees can use the Roanoke River IP Parts I and II as a resource for to

develop their MS4 TMDL action plans. However, the IP does not provide prescriptive actions for the localities to employ in order to meet their MS4 requirements.

Legal Authority

In accordance with the Virginia Stormwater Management Law and the Virginia Erosion, Sediment Control Law, ordinances regulating stormwater management and erosion and sediment control are mandatory within the Roanoke River TMDL implementation study area. These regulations address land disturbing activities to prevent an increase in stormwater quality and quantity issues such as erosion, sedimentation, flooding, and polluted stormwater runoff and surface waters. Although every local program varies, each contains a stormwater pollution prevention plan that must include a stormwater management plan, erosion and sediment control plan, and pollution prevention plan outlining techniques and best management practices to prevent and reduce stormwater related issues. The Virginia Stormwater BMP Clearinghouse describes available BMPs and is available at http://www.vwrrc.vt.edu/swc/.

Recently, both the City of Roanoke and the Towns of Blacksburg Christiansburg adopted a Stormwater Utility Ordinance. All developed properties, with some exceptions, are subject to the fee (Stormwater Utility Fee) based on the impervious area of the parcel. BMPs and on-site stormwater management activities can reduce the impact to the public stormwater system by treating or reducing the stormwater runoff from a developed property. In order to recognize the positive impact these BMPs can have, properties that install and maintain stormwater management and control BMPs that reduce stormwater quantity and improve the quality of the runoff from their property can qualify to receive a reduction in their stormwater fee. Additional information is available at http://www.roanokeva.gov/, http://www.blacksburg.gov/index.aspx?page=1864, and http://www.christiansburg.org/index.aspx?nid=921.

Citizen Monitoring

VADEQ supports a program for the voluntary monitoring of state waters by citizen groups. This monitoring can assist in the listing or delisting of impaired waters, TMDL development through source identification, tracking progress of waters with approved TMDLs or TMDL implementation plans, and identifying waters for potential future VADEQ monitoring. Citizen monitoring also helps to educate the public about water quality in the region and the effect of anthropogenic land uses and activities on water quality. A quality assurance project plan is required before citizens can receive funding for water quality monitoring. State funding allows for development and support of monitoring programs, purchase of equipment, and educational materials. For additional information, see http://www.deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/CitizenMonitoring.aspx.

FUNDING SOURCES FOR IMPLEMENTATION

Potential funding sources available to help implement the proposed BMPs were identified during development of the implementation plan. Funding options vary in applicability according to specific watershed conditions, pollutant sources, land uses, and project sponsors.

Federal

USEPA Federal Clean Water Act Section 319 Incremental Funds
Virginia is awarded grant funds through the U.S. Environmental Protection Agency to implement TMDLs through Section 319 of the Federal Clean Water Act. Stakeholder organizations can apply to VADEQ on a competitive basis for 319 grants to implement the BMPs and educational components included in a TMDL IP.

United States Department of Agriculture (USDA) – Farm Service Agency (FSA)

- **Conservation Reserve Program (CRP)** – This program offers cost-share assistance to establish tree or herbaceous vegetation cover on cropland. Offers for the program are ranked, accepted and processed during fixed signup periods that are announced by FSA. Applicants must have owned or operated the land for at least 12 months prior to the close of the signup period. Contracts are developed for 10 to 15 years. The payment to the participant is up to 50% of the cost for establishing ground cover. Incentive payments for wetlands hydrology restoration equal 25% of the cost of restoration.
- **Conservation Reserve Enhancement Program (CREP)** – This program "enhances" the existing USDA CRP Continuous Sign-up by increasing the cost-share rates from 50% to 75% and 100%, increasing the rental rates, and offering a flat rate incentive payment to place a permanent "riparian easement" on the enrolled area. Pasture and cropland adjacent to streams, intermittent streams, seeps, springs, ponds and sinkholes are eligible to be enrolled. Buffers consisting of native, warm-season grasses on cropland, to mixed hardwood trees on pasture, must be established in widths ranging from the minimum of 30% of the floodplain or 35 feet, whichever is greater, to a maximum average of 300 feet. Cost-sharing of 75% to 100% is available to help pay for livestock fencing, watering facilities, hardwood tree planting, filter strip establishment, and wetland restoration. In addition, a 40% incentive payment upon completion is offered and an average rental rate of $70/acre on stream buffer area for 10 to 15 years. The Commonwealth of Virginia will make an additional payment to landowners who place a perpetual conservation easement on the enrolled area.

USDA – Natural Resources Conservation Service (NRCS)

- **Conservation Stewardship Program (CSP)** – The CSP is a voluntary program that encourages agricultural and forestry producers to address resource concerns by (1) undertaking additional conservation activities, and (2) improving and maintaining existing conservation systems. CSP provides financial and technical assistance to help landowners conserve and enhance soil, water, air, and related natural resources on their land. CSP is available to all producers, regardless of

operation size or crops produced. Eligible lands include cropland, grassland, prairie land, improved pastureland, rangeland, nonindustrial private forest land, and agricultural land under the jurisdiction of an Indian tribe.

- **Environmental Quality Incentives Program (EQIP)** – This program funds voluntary conservation actions to address significant natural resource needs and objectives. Approximately 65% of the EQIP funding for Virginia is directed toward "Priority Areas" selected by a local conservation group with the remaining 35% of the funds are directed toward statewide priority concerns of environmental needs. EQIP offers 5-year to 10-year contracts to landowners and farmers to provide 75% cost-share assistance, 25% tax credit, and/or incentive payments to implement conservation practices and address the priority concerns.
- **Agricultural Lands Easement Program** – This program provides grants to purchase conservation easements that permanently restrict development on important farmland and reward landowners who participate in the program with permanent tax breaks. The program consolidates the former Farm and Ranch Lands Protection Program (FRPP), Grassland Reserve Program (GRP) and Wetlands Reserve Program (WRP) into a single program.

United States Fish and Wildlife Service (USFWS) – The Fish and Wildlife Service administers a variety of natural resource assistance grants to governmental, public and private organizations, groups and individuals.

- **Roanoke Logperch Annual Grant** – The grant program is administered jointly by Appalachian Power, USFWS, and the Virginia Department of Game and Inland Fisheries (VDGIF). The grant covers the Roanoke River watershed including the North and South Forks of the Roanoke River. The funds can be used to match Federal grants.

State

Virginia Agricultural Best Management Practices (BMPs) Cost-Share Program – The cost-share program is administered by local SWCDs through VADCR to encourage farmers and landowners to use BMPs on their land to better control transport of pollutants into waters due to excessive surface flow, erosion, leaching, and inadequate animal waste management.

Virginia Agricultural Best Management Practices Loan Program – The principal focus and utilization of the program, administered by VADEQ, is to improve water quality. The program provides low interest financing to encourage the use of BMPs which reduce or eliminate non-point source pollution to Virginia waters, to protect open space or natural values, and to ensure the availability of the land for agricultural, forest, recreation, or open space use.

Virginia Agricultural Best Management Practices Tax Credit Program – The program can be used by any individual or corporation engaged in agricultural production for market and who has a SWCD-approved soil conservation plan. The program provides a tax credit of an amount equaling 25% of the first $70,000 expended for agricultural best management practices not to exceed $17,500 or the total amount of the tax imposed by this program (whichever is less) in the year the project was completed. It is approved for use in supplementing the cost of repairs to streamside fencing.

Virginia Clean Water Revolving Loan Fund – EPA awards grants to states to capitalize their Clean Water State Revolving Funds (CWSRFs). The states, through the CWSRF, make loans for high-priority water quality activities. Eligible projects include point source, nonpoint source and estuary protection projects. Point source projects 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; and leaking underground storage tank remediation.

Virginia Department of Environmental Quality Citizen Water Monitoring Grant Program – The primary purpose of this program is to provide funding for water quality monitoring groups and individuals to monitor the quality of Virginia's waters. The grant can be used to purchase water quality monitoring equipment, train volunteers, fund lab analysis, and promote stream monitoring efforts.

Virginia Department of Forestry

- **Urban and Community Forestry Assistance Program (U&CF)** –The U&CF Program is designed to encourage projects that promote tree planting, the care of trees, the protection and enhancement of urban and community forest ecosystems, and education on tree issues in urban areas. Grants may be awarded to state agencies, local and regional governments, non-profit organizations, neighborhood associations, civic groups, public educational institutions (college level), or community groups. The typical proposal is in the $5,000 to $10,000 range.
- **Virginia Forest Stewardship Program** – The purpose of this program is to encourage the long-term stewardship of nonindustrial private forest lands, by assisting landowners to more actively manage their forest and related resources according to an approved Forest Stewardship Management Plan. The Forest Stewardship Program provides assistance to owners of forest land and other lands where good stewardship will enhance and sustain the long term productivity of multiple forest resources. The program provides landowners with the professional planning and technical assistance they need to keep their land in a productive and healthy condition.

Virginia Outdoors Foundation (VOF) –The primary way VOF protects land is by holding voluntary conservation agreements (easements) with landowners that restrict certain types of development on land in perpetuity. VOF also administers the Open Space Lands Preservation Trust Fund, which assists landowners with the costs of conveying open-space easements and purchases all or part of the value of easements.

Virginia Small Business Environmental Compliance Assistance Loan Fund – The Fund, administered through VADEQ, is used to make loans or to guarantee loans to small businesses for the purchase and installation of equipment and structures for environmental pollution control or agricultural BMPs. The equipment must be needed by the small business to comply with the federal Clean Air Act, or it will allow the small business to implement voluntary pollution prevention measures. The loans are available in amounts up to $100,000 and will carry an interest rate of 3%.

Virginia Stormwater Local Assistance Fund (SLAF) – SLAF funds stormwater projects including new stormwater best management practices, stormwater BMP retrofits, stream restoration, low impact

development projects, buffer restoration, pond retrofits, and wetland restoration. Eligible recipients are local governments such as any county, city, town, municipal corporation, authority, district, commission, or political subdivision. The fund is administered by VADEQ.

Virginia Water Quality Improvement Fund – This is a permanent, non-reverting fund established by the Commonwealth of Virginia 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 sources and nonpoint sources are administered through VADEQ. Most WQIF grants provide matching funds on a 50/50 cost-share basis.

Regional and Private

Community Development Block Grant (CDBG) – The CDBG program provides annual grants on a formula basis to 1209 general units of local government and States to address a wide range of unique community development needs. Each activity must benefit low- and moderate-income persons, prevent or eliminate slums or blight, or address community development needs having a particular urgency because existing conditions pose a serious and immediate threat to the health or welfare of the community for which other funding is not available.

Foundation for Roanoke Valley – The Foundation for Roanoke Valley supports qualified nonprofit organizations primarily in the Cities of Roanoke and Salem and the Counties of Roanoke, Alleghany, Botetourt, Craig and Franklin. The Foundation looks for projects and programs where a moderate amount of grant money can produce a significant result as well as for innovative but practical approaches to solving community problems.

National Fish and Wildlife Foundation (NFWF) – NFWF awards grants for the purpose of conserving fish, wildlife, plants, and their habitats. Grants generally range between $10,000 and $150,000.

- **Five Star and Urban Waters Restoration Grant Program** – This NFWF program seeks to develop nation-wide-community stewardship of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. The program requires the establishment and/or enhancement of diverse partnerships and an education/outreach component that will help shape and sustain behavior to achieve conservation goals. The Five Star program provides $20,000 to $50,000 grants with an average award size of $25,000.

Southeast Rural Community Assistance Project (SERCAP) – 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, or installation of a septic system, and

$2,000 toward repair, replacement, or installation of an alternative waste treatment system. Funding is only available for families making less than 125% of the federal poverty level.

Virginia Environmental Endowment – The Virginia Environmental Endowment is a nonprofit, independent grant-making foundation whose mission is to improve the quality of the environment by using its capital to encourage all sectors to work together to prevent pollution, conserve natural resources, and promote environmental literacy. Current grant-making priorities in Virginia include improving local rivers and protecting water quality throughout Virginia, Chesapeake Bay restoration, enhancing land conservation and sustainable land use, advancing environmental literacy and public awareness, and supporting emerging issues in environmental protection.

Wetland and Stream Mitigation Banking – Mitigation banks are sites where aquatic resources such as wetlands, streams and streamside buffers are restored, created, enhanced, or preserved for the purpose of providing compensatory mitigation in advance of impacts to similar resources. Mitigation banking is a commercial venture that provides compensation for aquatic resources in financially and environmentally preferable ways. Mitigation banks are required to be protected in perpetuity, to provide financial assurances and long term stewardship. The mitigation banking process is overseen by an Inter-Agency Review Team made up of state and federal agencies and chaired by VADEQ and the U.S. Army Corps of Engineers.

Total Action for Progress (TAP) – The mission of TAP is to help individuals and families achieve economic and personal independence through education, employment, affordable housing, and safe and healthy environments. The Indoor Plumbing Rehabilitation program provides installations and renovations of indoor plumbing to homes that do not have indoor plumbing or have inoperable indoor plumbing. Residents of the counties of Alleghany, Bath, Bedford, Botetourt, Craig, Floyd, Franklin, Giles, Henry, Montgomery, Patrick, Pulaski, and Roanoke are potentially eligible for this service. The Indoor Plumbing Rehabilitation program is a loan-based program, based on a 10-year loan with zero interest.

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