Turley Creek and Long Meadow Run
TMDL Implementation Plan
Rockingham County, Virginia

Submitted by:

Virginia Department of Environmental Quality

Prepared by:

Virginia Tech Department of Biological Systems Engineering

Revised: September 9, 2015

VT-BSE Document No. 2015-0004

Project Personnel

Virginia Tech, Department of Biological Systems Engineering (BSE)

Gene Yagow, Sr. Research Scientist
Karen Kline, Research Scientist
Brian Benham, Associate Professor and Extension Specialist

Virginia Department of Environmental Quality (DEQ)

Tara Sieber, Regional TMDL Coordinator, VRO
Don Kain, Water Quality Monitoring and Assessments Manager VRO
Nesha McRae, Non Point Source TMDL Coordinator, VRO
Mark Richards, Central Office

For additional information, please contact:

Virginia Department of Environmental Quality

Water Quality Assessment Office, Richmond: Mark Richards (804) 698-4392
Valley Regional Office, Harrisonburg: Tara Sieber (540) 574-7800

Table of Contents

List of Tables

List of Figures

List of Abbreviations

The following abbreviations are used throughout this document. To better aid the reader in comprehension of the document, each abbreviation is defined here.

BMP – Best Management Practice
BSE – Biological Systems Engineering Department (Virginia Tech)
CBWM -- Chesapeake Bay Watershed Model
CPP -- continuing planning process
CREP -- Conservation Reserve Enhancement Program
CWA – Clean Water Act, the origin of the Total Maximum Daily Load Program
E&S – erosion and sediment
EDAS – Ecological Data Application System
EPA – United States Environmental Protection Agency
EQIP -- Environmental Quality Incentive Program
FG -- future growth
IP – Implementation Plan
LA – Load Allocation, the load allocated to nonpoint and background sources
MOS – Margin of Safety, a load reflecting uncertainty in the modeling process
MS4 – Municipal Separate Storm Sewer Systems, Phase II Stormwater Management Program
NASS -- National Agricultural Statistics Service
NPS – nonpoint source, referring to diffuse sources of pollution, such as from runoff
NRCS – Natural Resources Conservation Service
SWCB – State Water Control Board
SWCD –Soil and Water Conservation District
SWM – storm water management
TMDL – Total Maximum Daily Load (Study)
UALs – Unit Area Loads, e.g., tons/acre.
USDA -- United States Department of Agriculture
VAC – Virginia Administrative Code
VSCI – Virginia Stream Condition Index, an index developed for use in assessing stream health in Virginia
VCC -- Valley Conservation Council
VCE – Virginia Cooperative Extension
VADCR – Virginia Department of Conservation and Recreation
VADEQ – Virginia Department of Environmental Quality
VDOF – Virginia Department of Forestry
VPDES – Virginia Pollutant Detection and Elimination System
VT – Virginia Tech
WHIP -- Wildlife Habitat Incentive Program
WLA – Waste Load Allocation, the load allocated to point sources
WQIF – Water Quality Improvement Fund
WQMIRA – Water Quality Monitoring, Information and Restoration Act
WRP -- Wetland Reserve Program

Long Meadow Run and Turley Creek IP

Executive Summary

Background

Two tributaries of the North Fork of the Shenandoah River in Rockingham County were initally listed as impaired on Virginia's 2002 Section 303(d) Report on Impaired Waters due to water quality violations of the general aquatic life (benthic) standard. These impaired stream segments are 8.53 miles of Long Meadow Run (VAV-B45R_LOM01A00) and 4.01 miles of Turley Creek (VAV-B45R_TRL01A00 and VAV-B45R_TRL02A00).

Total Maximum Daily Loads (TMDLs) were developed for these streams in accordance with Section 303(d) of the Clean Water Act (CWA) and the United States Environmental Protection Agency's Water Quality Planning and Management Regulations. The original TMDL study, submitted in 2012, was not approved and the TMDL was re-opened in June 2014. The process of reopening included a reconvening of the Local Steering Committee, updating the TMDL and IP to address EPA comments and reflect current conditions, and then the re-submitting of the updated TMDL document and model to EPA in August 2015. These TMDLs specify maximum sediment loads for both watersheds, as well as a maximum nitrogen load for Long Meadow Run, that are presumed to be protective of the benthic macroinvertebrate community in order for these stream segments to once again meet the state Aquatic Life Use water quality standard.

This document serves as the Total Maximum Daily Load (TMDL) implementation plan (IP) for Turley Creek and Long Meadow Run.

Pollutant Sources

TMDLs must be developed for a specific pollutant. Since a benthic impairment is based on a biological inventory, rather than on a physical or chemical water quality parameter, the pollutant is not explicitly identified in the assessment, as it is with physical and chemical parameters. The process outlined in USEPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical stressors for each of the impaired watersheds in this study. As a result of the stressor analysis, the most probable stressor contributing to the impairment of the benthic community in Turley Creek was identified as <u>sediment</u> due to the lack of vegetative cover and buffers along the stream in its headwaters, and cattle access through the watershed. In Long Meadow Run, the most probable stressors were identified as <u>nutrients</u>, <u>organic matter</u>, and <u>sediment</u>. Nutrients were identified due to low vegetation scores, high levels of nitrogen in groundwater and the dominance of benthic macroinvertebrates in the biological communities. Phosphorus was determined to be limiting but loads are also minimal, so nitrogen specifically was determined to be the stressor. Nutrients and organic matter are related to each other as stressors, and organic matter was found to be a most probable stressor based on the benthic community metrics. The habitat metrics that were collected as part of the benthic stressor analysis also pointed to sediment as a stressor; especially the embeddedness and bank instability. On an anecdotal note, the diurnal dissolved oxygen sensor was clogged with sediment when deployed by DEQ in Long Meadow Run.

This TMDL was written for the common stressor in both streams, sediment, and will also address nitrogen in Long Meadow Run. Table ES-1 summarizes the pollutant sources and reductions called for in the TMDLs.

Table ES-1. Summary of Turley Creek and Long Meadow Run TMDL Reductions.

Land Use / Source Categories	Area (acres)	Sediment		Nitrogen	
		Load (tons/yr)	% Reduction	Load (lbs/yr)	% Reduction
Turley Creek					
Row Crops, Pasture, and Riparian Pasture	1,940.1	1,031.6	34.0%		
Hay and Residential (incl. Septics)	594.7	100.0	9.2%		
Forest	3,443.8	68.6	0.0%		
Harvested Forest and Transitional	37.7	10.5	42.1%		
Channel Erosion		2.8	9.2%		
Turley Creek Totals	**6,016.3**	**1,213.6**	**30.1%**		
Long Meadow Run					
Row Crops, Pasture, and Riparian Pasture	6,407.7	2,890.5	58.0%	32,323.2	75.0%
Hay and Residential (incl. Septics)	1,792.9	350.2	15.5%	14,568.7	46.2%
Forest	1,663.7	15.8	0.0%	1,080.9	0.0%
Harvested Forest and Transitional	23.1	17.7	39.9%	59.1	21.4%
Channel Erosion		1.8	15.5%	3.9	46.2%
Long Meadow RunTotals	**9,887.5**	**3,276.1**	**53.1%**	**48,035.7**	**64.2%**

Implementation Actions

Potential control measures, their costs, and pollutant removal effectiveness estimates were identified through a review of the Turley Creek and Long Meadow Run TMDLs, through input from the IP Working Groups, from literature review, from modeling, and from review and adjustments suggested by local health department and soil and water conservation personnel. Because Turley Creek and Long Meadow Run each contain a combination of agricultural and developed land uses, implementation actions to address the required pollutant reductions will consist of a variety of control measures to address each pollutant source. Control measure selection was based on their ability to control specific pollutant sources, the required pollutant load reductions, the potential for cost-sharing of the control measure, the likelihood of implementation by landowners, and the input of watershed stakeholders.

Load reductions were based on source loads simulated for the TMDL study, changes in land use, filtering effects of applicable control measures, and the application of effectiveness estimates. Tables ES-2 and ES-3 summarize the necessary pollution control measures organized by land use applied to sediment only in Turley Creek and sediment and nitrogen in Long Meadow Run.

Table ES-2. Turley Creek Control Measures and Sediment Reductions.

Landuse Type	BMP ID	Control Measure Name	Needed BMP Extents	Extent Units	Sediment Load Reduction (tons/yr)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	5.00	acres	7.99
	FR-3, CRFR-3	Woodland buffer filter area	5.00	systems	16.38
	SL-1	Permanent Vegetative Cover on Cropland	4.00	acres	5.76
	SL-15A	Continuous No-Till System	40.00	acres	41.41
	SL-8B	Small Grain cover crop for Nutrient Management	45.00	acres	9.71
	SL-8H	Harvestable Cover Crop	120.00	acres	---
	WP-1	Sediment retention, erosion, or water control structures	1	systems	9.71
AFO/CAFO	WP-4	AWMS (Winter feeding facility)	3	systems	---
		AWMS (Poultry dry-stack facility)	2	systems	---
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	2.00	acres	1.58
	FR-3, CRFR-3	Woodland buffer filter area	5.00	acres	8.21
	SL-7	Extension of CREP Watering Systems	60.00	acres	14.59
	SL-11	Permanent Vegetative Cover on Critical Areas	4.00	systems	10.09
	SL-6, CRSL-6, SL-6T, LE-1T	SL-6 (fencing portion)	5	systems	119.06
	WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	3	systems	13.01
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	3	systems	18.41
		LE + 10-foot setback + Limited Access + PrecRotGraz	2	systems	12.27
	Not cost-shared	LE + 10-foot setback using Polywire	2	systems	12.27
	SL-10T	Grazing Land Protection	40.00	acres	9.73
Harvested forest		Forest harvesting BMP			1.83
Transitional		Erosion and sediment control BMPs			2.61
Channel Erosion	WP-2A	Streambank Stabilization	300.00	linear feet	6.51
Springs	WP-1	Sediment retention, erosion, or water control structures	1	systems	25.99
Total Reduction					**347.13**
Target Reduction					364.68
Target Reduction after 2010-2014 BMPs					346.40

Table ES-3. Long Meadow Run Control Measures and Sediment and Nitrogen Reductions.

Landuse Type	BMP ID	Control Measure Name	Needed BMP Extents	Extent Units	Nitrogen Load Reduction (lbs/yr)	Sediment Load Reduction (tons/yr)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	20	acres	127.33	31.73
	FR-3, CRFR-3	Woodland buffer filter area	5	acres	99.82	7.93
	NM-1A	Nutrient Management Plan Writing and Revisions	100	acres	43.59	---
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	500	acres	198.58	---
	SL-1	Permanent Vegetative Cover on Cropland	50	acres	332.59	71.66
	SL-15A	Continuous No-Till System	185	acres	39.58	188.97
	SL-8B	Small Grain cover crop for Nutrient Management	200	acres	336.27	42.56
	SL-8H	Harvestable Cover Crop	120	acres	111.70	---
	WP-1	Sediment retention, erosion, or water control structures	2	systems	28.06	19.15
	WQ-4	Legume Cover Crop	50	acres	18.03	2.13
AFO/CAFO		Barnyard runoff controls	4	systems	28.74	0.99
	WP-4	AWMS (Winter feeding facility)	6	systems	---	---
	WP-4	AWMS (Poultry dry-stack facility)	4	systems	---	---
	WP-4B	Loafing Lot Management System	1	systems	3.59	0.25
	WP-4C	Composter Facilities	6	systems	---	---
		Manure Transport*	695	tons	18,348.00	---
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	20	acres	94.75	14.70
	FR-3, CRFR-3	Woodland buffer filter area	5	acres	29.22	3.68
	SL-7	Extension of CREP Watering Systems	100	acres	54.66	22.34
	SL-11	Permanent Vegetative Cover on Critical Areas	15	acres	135.66	34.80
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	40	systems	2,581.04	825.03
	WP-2, CRWP-2, WP-2T	LE + Limited Access	14	systems	294.13	55.85
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	22	systems	352.50	106.79
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	13	systems	352.50	63.10
	Not cost-shared	LE + 10-foot setback using Polywire	15	systems	176.25	72.81
	SL-10T	Grazing Land Protection	120	acres	65.60	26.81
	WP-1	Sediment retention, erosion, or water control structures	0	systems	0.00	0.00
	WQ-1	Grass filter strips (Hayland conversion)	10	acres	80.26	2.83
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	10	number	9.04	4.64
		Brush Management	300	acres	0.00	0.00
Harvested forest		Forest harvesting BMP			12.63	0.43
Transitional		Erosion and sediment control BMPs			0.00	6.64
Channel Erosion	WP-2A	Streambank Stabilization	500	linear feet	37.50	10.85
Septics	RB-1	Septic Tank Pumpout	111	systems	114.72	---
	RB-2	Septic Connections	9	systems	186.03	---
	RB-3	Septic tank system repair	40	systems	223.24	---
	RB-4	Septic tank system installment/replacement	15	systems	83.71	---
	RB-4P	Septic tank system installment/replacement with pump	10	systems	55.81	---
	RB-5	Alternative on-site waste treatment systems	15	systems	155.02	---
Springs	IA-747	Denitrifying Bioreactor	1	systems	5,174.74	---
Total Reduction					**29,984.88**	**1,616.68**
Target Reduction					30,843.68	1,738.15
Target Reduction after 2010-2014 BMPs					29,951.73	1,612.70

Costs and Benefits

The costs of implementation were calculated as the extent of BMPs needed throughout the respective implementation period in each watershed, their related unit costs, and estimates of technical assistance needed. Unit costs were estimated from the DCR state agricultural cost-share database for Rockingham County and from the 2015 USDA-NRCS cost list for Virginia, from literature values, and from discussions with local technical personnel.

The primary benefit of implementation is cleaner waters in Virginia, the Shenandoah River Watershed, and Rockingham County. During implementation planning, it is important to recognize that healthy waters improve economic opportunities for Virginians and a healthy economic base provides the resources and funding necessary to pursue restoration and enhancement activities. The agricultural and residential practices recommended in this document will provide economic benefits to the community, as well as the expected environmental benefits.

Pollution Control measures were broken into two stages for Long Meadow Run and combined into one stage for Turley Creek. Tables ES-4 and ES-5 summarize the Implementation costs for Turley Creek and Long Meadow Run. Stage I costs for both watersheds consists of $3,910,331 in agricultural and residential implementation practices and $500,000 in technical assistance, for a total of $4,410,331; while Stage II costs for the Long Meadow Run watershed consists of $2,430,365 in implementation practices and $250,000 in technical assistance, for a total of $2,680,365. The combined cost for both stages in both watersheds is $7,090,696. Additional information about the stages for each stream can be found in the *Implementation Timeline* section below.

Table ES-4. Implementation Costs for Turley Creek.

Landuse Type	BMP ID	Control Measure Name	Stage I (5 years)	Extent Units	Stage I Implementation Cost ($)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	5	acres	$5,000
	FR-3, CRFR-3	Woodland buffer filter area	2	systems	$2,250
	SL-1	Permanent Vegetative Cover on Cropland	4	acres	$620
	SL-15A	Continuous No-Till System	40	acres	$2,200
	SL-8B	Small Grain cover crop for Nutrient Management	225	acres	$22,500
	SL-8H	Harvestable Cover Crop	600	acres	$60,000
	WP-1	Sediment retention, erosion, or water control structures	1	systems	$4,600
AFO/CAFO	WP-4	AWMS (Winter feeding facility)	3	systems	$150,000
		AWMS (Poultry dry-stack facility)	2	systems	$76,000
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	2	acres	$2,000
	FR-3, CRFR-3	Woodland buffer filter area	5	acres	$5,625
	SL-7	Extension of CREP Watering Systems	60	acres	$15,000
	SL-11	Permanent Vegetative Cover on Critical Areas	2	systems	$1,850
	SL-6, CRSL-6, SL-6T, LE-1T	SL-6 (fencing portion)	2	systems	$88,040
	WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	2	systems	$22,840
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	2	systems	$84,740
		LE + 10-foot setback + Limited Access + PrecRotGraz	2	systems	$25,400
	Not cost-shared	LE + 10-foot setback using Polywire	2	systems	$13,400
	SL-10T	Grazing Land Protection	40	acres	$3,080
Harvested forest		Forest harvesting BMP			
Transitional		Erosion and sediment control BMPs			
Channel Erosion	WP-2A	Streambank Stabilization	300	linear feet	$30,000
Springs	WP-1	Sediment retention, erosion, or water control structures	1	systems	$25,000
		Technical Assistance		person-yrs	$125,000
		Total Costs			**$765,145**

Table ES-5. Implementation Costs for Long Meadow Run.

Landuse Type	BMP ID	Control Measure Name	Implementation Extent		Extent Units	Implementation Costs	
			Stage I (5 years)	Stage II (5 years)		Stage I ($)	Stage II ($)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	12	8	acres	$12,000	$8,000
	FR-3, CRFR-3	Woodland buffer filter area	3	2	acres	$3,375	$2,250
	NM-1A	Nutrient Management Plan Writing and Revisions	120	100	acres	$4,200	$3,500
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	1500	2500	acres	$7,500	$12,500
	SL-1	Permanent Vegetative Cover on Cropland	30	50	acres	$4,650	$7,750
	SL-15A	Continuous No-Till System	108	180	acres	$5,940	$9,900
	SL-8B	Small Grain cover crop for Nutrient Management	600	1000	acres	$60,000	$100,000
	SL-8H	Harvestable Cover Crop	360	600	acres	$36,000	$60,000
	WP-1	Sediment retention, erosion, or water control structures	1	0	systems	$4,600	$0
	WQ-4	Legume Cover Crop	150	250	acres	$13,500	$22,500
AFO/CAFO		Barnyard runoff controls	3	1	systems	$20,205	$6,735
	WP-4	AWMS (Winter feeding facility)	3	2	systems	$150,000	$100,000
	WP-4	AWMS (Poultry dry-stack facility)	3	1	systems	$114,000	$38,000
	WP-4B	Loafing Lot Management System	1		systems	$80,000	$0
	WP-4C	Composter Facilities	4	2	systems	$89,200	$44,600
		Manure Transport*	2085	3475	tons	$0	$0
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	12	8	acres	$12,000	$8,000
	FR-3, CRFR-3	Woodland buffer filter area	3	2	acres	$3,375	$2,250
	SL-7	Extension of CREP Watering Systems	60	40	acres	$15,000	$10,000
	SL-11	Permanent Vegetative Cover on Critical Areas	10	5	acres	$9,250	$4,625
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	22	16	systems	$968,440	$704,320
	WP-2, CRWP-2, WP-2T	LE + Limited Access	8	5	systems	$91,360	$57,100
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	14	8	systems	$593,180	$338,960
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	8	5	systems	$101,600	$63,500
	Not cost-shared	LE + 10-foot setback using Polywire	9	15	systems	$60,300	$100,500
	SL-10T	Grazing Land Protection	72	48	acres	$5,544	$3,696
	WP-1	Sediment retention, erosion, or water control structures	0	0	systems	$0	$0
	WQ-1	Grass filter strips (Hayland conversion)	6	10	acres	$1,560	$2,600
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	6	4	number	$16,882	$11,254
		Brush Management	450	750	acres	$157,500	$262,500
Harvested forest		Forest harvesting BMP					
Transitional		Erosion and sediment control BMPs					
Channel Erosion	WP-2A	Streambank Stabilization	300	200	linear feet	$30,000	$20,000
Septics	RB-1	Septic Tank Pumpout	67	111	systems	$18,425	$30,525
	RB-2	Septic Connections	6	3	systems	$33,600	$16,800
	RB-3	Septic tank system repair	24	16	systems	$144,000	$96,000
	RB-4	Septic tank system installment/replacement	9	6	systems	$72,000	$48,000
	RB-4P	Septic tank system installment/replacement with pump	6	4	systems	$66,000	$44,000
	RB-5	Alternative on-site waste treatment systems	9	6	systems	$225,000	$150,000
Springs	IA-747	Denitrifying Bioreactor	1	1	systems	$40,000	$40,000
		Technical Assistance	7.5	5.0	person-yrs	$375,000	$250,000
		Total Costs				**$3,645,186**	**$2,680,365**

* Manure Transport provides a net benefit to the farmer when sold as fertilizer.

Implementation Timeline

Implementation milestones establish the fraction of implementation actions to be taken within certain timeframes, and these implementation actions are tracked as the number/type of control measures that are installed and programs or policies developed and executed. The milestones described here are intended to achieve 100% implementation in Turley Creek within 5 years, and in Long Meadow Run, approximately 60% implementation within the first 5 years and the final 40% implementation in the second 5 years. Gradual water quality improvement is expected during the stage following full implementation in each watershed, after which the water quality goals are expected to be met. Tables ES-6 and ES-7 summarize the implementation goals through the staged timelines.

Table ES-6. Staged Implementation Goals for Turley Creek.

Landuse Type	BMP ID	Control Measure Name	Practice Life (yrs)	Needed BMP Extents	2010-2014 BMPs	Stage I (5 years)	Extent Units
Row Crops	FR-1	Aforestation of erodible crop and pastureland	10	5.00		5	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5.00	4.7	2	systems
	SL-1	Permanent Vegetative Cover on Cropland	5	4.00		4	acres
	SL-15A	Continuous No-Till System	5	40.00		40	acres
	SL-8B	Small Grain cover crop for Nutrient Management	1	45.00		225	acres
	SL-8H	Harvestable Cover Crop	1	120.00		600	acres
	WP-1	Sediment retention, erosion, or water control structures	10	1		1	systems
AFO/CAFO	WP-4	AWMS (Winter feeding facility)	10	3		3	systems
		AWMS (Poultry dry-stack facility)	15	2		2	systems
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	10	2.00		2	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5.00		5	acres
	SL-7	Extension of CREP Watering Systems	10	60.00		60	acres
	SL-11	Permanent Vegetative Cover on Critical Areas	10	4.00		2	systems
	SL-6, CRSL-6, SL-6T, LE-1T	SL-6 (fencing portion)	10	5	3 (8,860 ft.)	2	systems
	WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	10	3	1 (3,455 ft.)	2	systems
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	10	3	1 (3,990 ft.)	2	systems
		LE + 10-foot setback + Limited Access + PrecRotGraz	10	2		2	systems
	Not cost-shared	LE + 10-foot setback using Polywire	5	2		2	systems
	SL-10T	Grazing Land Protection	10	40.00		40	acres
Harvested forest		Forest harvesting BMP					
Transitional		Erosion and sediment control BMPs					
Channel Erosion	WP-2A	Streambank Stabilization	20	300.00		300	linear feet
Springs	WP-1	Sediment retention, erosion, or water control structures	10	1		1	systems
		Cumulative Sediment Reduction			**5.0%**	**100%**	

Table ES 7. Staged Implementation Goals for Long Meadow Run.

Landuse Type	BMP ID	Control Measure Name	Practice Life (yrs)	Needed BMP Extents	2010-2014 BMPs	Implementation Extent		Extent Units
						Stage I (5 years)	Stage II (5 years)	
Row Crops	FR-1	Aforestation of erodible crop and pastureland	10	20	3	12	8	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5		3	2	acres
	NM-1A	Nutrient Management Plan Writing and Revisions	3	100		120	100	acres
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	1	500	102	1500	2500	acres
	SL-1	Permanent Vegetative Cover on Cropland	5	50	96.2	30	50	acres
	SL-15A	Continuous No-Till System	5	185	0	108	180	acres
	SL-8B	Small Grain cover crop for Nutrient Management	1	200	1209	600	1000	acres
	SL-8H	Harvestable Cover Crop	1	120	193	360	600	acres
	WP-1	Sediment retention, erosion, or water control structures	10	2		1	0	systems
	WQ-4	Legume Cover Crop	1	50		150	250	acres
AFO/CAFO		Barnyard runoff controls	10	4		3	1	systems
	WP-4	AWMS (Winter feeding facility)	10	6		3	2	systems
	WP-4	AWMS (Poultry dry-stack facility)	15	4		3	1	systems
	WP-4B	Loafing Lot Management System	10	1		1		systems
	WP-4C	Composter Facilities	10	6	7	4	2	systems
		Manure Transport*	1	695		2085	3475	tons
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	10	20		12	8	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5		3	2	acres
	SL-7	Extension of CREP Watering Systems	10	100		60	40	acres
	SL-11	Permanent Vegetative Cover on Critical Areas	10	15		10	5	acres
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	10	40	2 (2,690 ft.)	22	16	systems
	WP-2, CRWP-2, WP-2T	LE + Limited Access	10	14	1 (700 ft.)	8	5	systems
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	10	22		14	8	systems
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	10	13		8	5	systems
	Not cost-shared	LE + 10-foot setback using Polywire	5	15		9	15	systems
	SL-10T	Grazing Land Protection	10	120		72	48	acres
	WP-1	Sediment retention, erosion, or water control structures	10	0		0	0	systems
	WQ-1	Grass filter strips (Hayland conversion)	5	10		6	10	acres
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	10	10		6	4	number
		Brush Management	2	300		450	750	acres
Harvested forest		Forest harvesting BMP						
Transitional		Erosion and sediment control BMPs						
Channel Erosion	WP-2A	Streambank Stabilization	20	500		300	200	linear feet
Septics	RB-1	Septic Tank Pumpout	5	111		67	111	systems
	RB-2	Septic Connections	25	9		6	3	systems
	RB-3	Septic tank system repair	10	40		24	16	systems
	RB-4	Septic tank system installment/replacement	10	15		9	6	systems
	RB-4P	Septic tank system installment/replacement with pump	10	10		6	4	systems
	RB-5	Alternative on-site waste treatment systems	10	15		9	6	systems
Springs	IA-747	Denitrifying Bioreactor	5	1		1	1	systems
		Cumulative Sediment Reduction			**3.8%**	**57.3%**	**100%**	
		Cumulative Nitrogen Reduction			**1.9%**	**66.9%**	**100%**	

Stakeholders

The stakeholders involved in developing the Turley Creek and Long Meadow Run TMDL IP included a Steering Committee, Working Groups, and the general public. The Steering Committee and two Working Groups (one focused on agricultural issues and another on residential issues) were comprised of representatives from VADEQ, VADCR, the Shenandoah Valley Soil and Water Conservation District (SWCD), Natural Resources Conservation Service (NRCS), Virginia Cooperative Extension, and local watershed stakeholders. Public participation occurred via a series of Steering Committee and Working Group meetings, summarized in Table ES-8.

Table ES-8. Summary of TMDL Implementation Planning Meetings.

Meeting Date	Meeting Type
March 21, 2012	Final TMDL Public Meeting and IP Informational Meeting
April 25, 2012	Agricultural Working Group Meeting
May 2, 2012	Steering Committee/Residential Working Group
June 6, 2012	Final IP Public Meeting
July 24, 2014	Local Steering Committee (LSC) Meeting – TMDL Re-opener
March 25, 2015	LSC Meeting – TMDL Remodeling
July 20, 2015	LSC Meeting – TMDL and IP Updates
August 12, 2015	LSC Meeting - IP Update and Planning for the Public Meeting
September 2015	Final IP Update Public Meeting

1.0 INTRODUCTION

A Total Maximum Daily Load (TMDL) study for Turley Creek and Long Meadow Run was prepared and submitted to DEQ in April 2012. This study was not approved by EPA and the current revision phase to re-open the TMDL began in June 2014 in order to address EPA comments, re-evaluate current conditions with the Local Steering Committee (LSC), and then re-submit the revised and updated TMDL. Submission of the TMDLs in these watersheds for EPA approval will be timed to coincide with the completion of this Implementation Plan. The final TMDL allocation scenario was revised to incorporate full input from the LSC so that reductions reflect the acceptable suite and extent of pollutant control measures, also known as best management practices (BMPs), as determined through the implementation planning process. These TMDLs specify maximum sediment loads for both watersheds, as well as total nitrogen loads for Long Meadow Run, that are presumed to be protective of the benthic macroinvertebrate community in order for these stream segments to once again meet the state Aquatic Life Use water quality standard. This document serves as the Total Maximum Daily Load (TMDL) implementation plan (IP) for Turley Creek and Long Meadow Run located in Rockingham County, Virginia.

1.1. *Regulatory Background of the TMDL Study*

In 1972, the US Congress enacted the Federal Water Pollution Control Act known as the "Clean Water Act" (CWA). The founding objective of that legislation was well defined in its opening paragraph,

> *"to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."*

The legislation covers a range of water quality efforts aimed at reaching this objective. Immediately relevant to this project are the requirements that states develop and promulgate water quality standards for waters within their jurisdictions. In §303(d) of the Act, the federal government requires states to identify those water bodies not meeting the published water quality standards for any given pollutant. This list is often called the "303(d) list" or the "impaired waters list." Virginia's first impaired waters list was published and reported to EPA in 1994. Recently, the 303(d) list has been combined with the 305(b) water quality assessment report which describes the overall quality of a state's waters. This "305(b)/303(d) Integrated Report" is published and submitted to EPA every two years.

An additional §303(d) condition requires that, if a particular water body is listed as "impaired," the state must develop a "total maximum daily load" for the exceeded standard for the water body. The "total maximum daily load" or TMDL is essentially a "water pollution budget." A TMDL study defines the amount of pollutant each source in the watershed can contribute to the water body while still allowing the water body to comply with applicable water quality standards.

The "Designation of Uses" of all waters in Virginia is defined in the Code of Virginia (9 VAC 25-260-10) as follows:

> All state waters, including wetlands, are designated for the following uses: recreational uses, e.g. swimming and boating; the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish. (SWCB, 2011)

The water quality standard supported through biological monitoring is Virginia's narrative General Standard (9 VAC 25-260-20, also known as the Aquatic Life Use standard) which states in part:

> State waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are … harmful to human, animal, plant, or aquatic life.
>
> Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled. (SWCB, 2011)

The biological monitoring program in Virginia used to evaluate compliance with the above standard is run by the Virginia Department of Environmental Quality

(VADEQ). Evaluations of monitoring data from this program focus on the benthic (bottom-dwelling) macro (large enough to see) invertebrates (insects, mollusks, crustaceans, and annelid worms) and are used to determine whether or not a stream segment has a benthic impairment. Changes in water quality generally result in alterations to the quantity and diversity of the benthic organisms that live in streams and other water bodies. In addition to being the major intermediate constituent of the aquatic food chain, benthic macroinvertebrates are "living recorders" of past and present water quality conditions. This is due to their relative immobility and their variable resistance to the diverse contaminants that are introduced into streams. The community structure of these organisms provides the basis for the biological evaluation of water quality.

2.0 STATE AND FEDERAL REQUIREMENTS FOR TMDL IMPLEMENTATION PLANS

2.1. *Background*

Once a water body is listed as impaired and a subsequent TMDL study has been conducted, the watershed stakeholders must develop and implement a strategy that will limit the pollutant loadings to those levels allocated in the TMDL study. Such a strategy, also known as an Implementation Plan (IP), must contain actions that will work to achieve the reduced pollutant loadings needed to bring the water body into compliance with the standard. Although such Implementation Plans are alluded to in the federal CWA legislation, they are not a requirement of that act. Such Implementation Plans are, however, a state requirement.

2.2. *State Requirements*

The TMDL Implementation Plan (IP) is a requirement of Virginia's 1997 Water Quality Monitoring, Information, and Restoration Act (§62.1-44.19:4 through 19:8 of the Code of Virginia), or WQMIRA. WQMIRA directs the Virginia Department of Environmental Quality (VADEQ) to "develop and implement a plan to achieve fully supporting status for impaired waters." For an IP to be approved by the State Water Control Board, the IP **must** include the following required components, as outlined in the WQMIRA:

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

2.3. *Federal Recommendations*

Section 303(d) of the CWA and current EPA regulations do not require the development of implementation strategies, though their guidance clearly describes this as the next step leading to the attainment of water quality objectives. In the 1999

"Guidance for Water Quality-Based Decisions: The TMDL Process", EPA recommends the following minimum elements for an approvable IP:

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

These recommendations closely track the State's WQMIRA requirements.

2.4. *Requirements for Section 319 Fund Eligibility*

Beyond the regulatory requirements listed above, the CWA was amended in 1987 to establish the Nonpoint Source Management Program in §319 of that act. Through that program, States, Territories, and Native American Tribes can receive grant monies for a variety of activities, including the restoration of impaired stream segments. Although there are various alternative sources of money to assist with the TMDL implementation process, §319 funds are substantial and most relevant to TMDL implementation. Therefore, the requirements to obtain these funds are discussed in this chapter. The Virginia Department of Conservation and Recreation strongly suggests that the requirements for §319 funds be addressed in the IP (in addition to the required components as described by the WQMIRA).

The EPA develops guidelines that describe the process and criteria to be used to award CWA §319 nonpoint source grants to States. The guidance is subject to revision and the most recent version should be considered for IP development. The "Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories in FY 2003" identifies the following nine elements that must be included in the IP to meet the 319 requirements:

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

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

2.5. *Staged Implementation*

In general, the Commonwealth of Virginia intends for nonpoint source pollutant TMDL reductions to be implemented in a staged fashion. Staged implementation is an iterative process that incrementally implements management measures, initially targeting those sources and/or practices with the largest impact on water quality, coupled with a monitoring plan to continuously assess progress toward full attainment of designated uses.

There are many benefits of staged implementation, including:

1. Through stream monitoring, water quality improvements are recorded as they are accomplished;
2. Quality control is achieved to offset the uncertainties that exist in any watershed simulation model;
3. A mechanism for developing public support is developed;
4. The most cost effective practices are implemented initially; and
5. The adequacy of the TMDL to achieve the water quality standard is ensured.

With successful development and implementation of IPs, Virginia will be well on the way to restoring impaired waters and enhancing the value of the Commonwealth's aquatic resources. Additionally, development of an approved IP will increase the opportunities for a locality to obtain monetary assistance during implementation.

3.0 REVIEW OF THE TURLEY CREEK AND LONG MEADOW RUN TMDL STUDY

The following summary of the Turley Creek and Long Meadow Run TMDLs was excerpted from the final report submitted to the Virginia Department of Environmental Quality in August 2015 entitled "TMDLs for Turley Creek (sediment) and Long Meadow Run (sediment and nitrogen); Rockingham County, Virginia" as prepared by a team from the Virginia Tech Biological Systems Engineering Department.

3.1. *Impairment Listing*

These two neighboring impaired segments in these TMDLs are located within the North Fork Shenandoah River Basin within Rockingham County in the Commonwealth of Virginia (Figure 3-1).

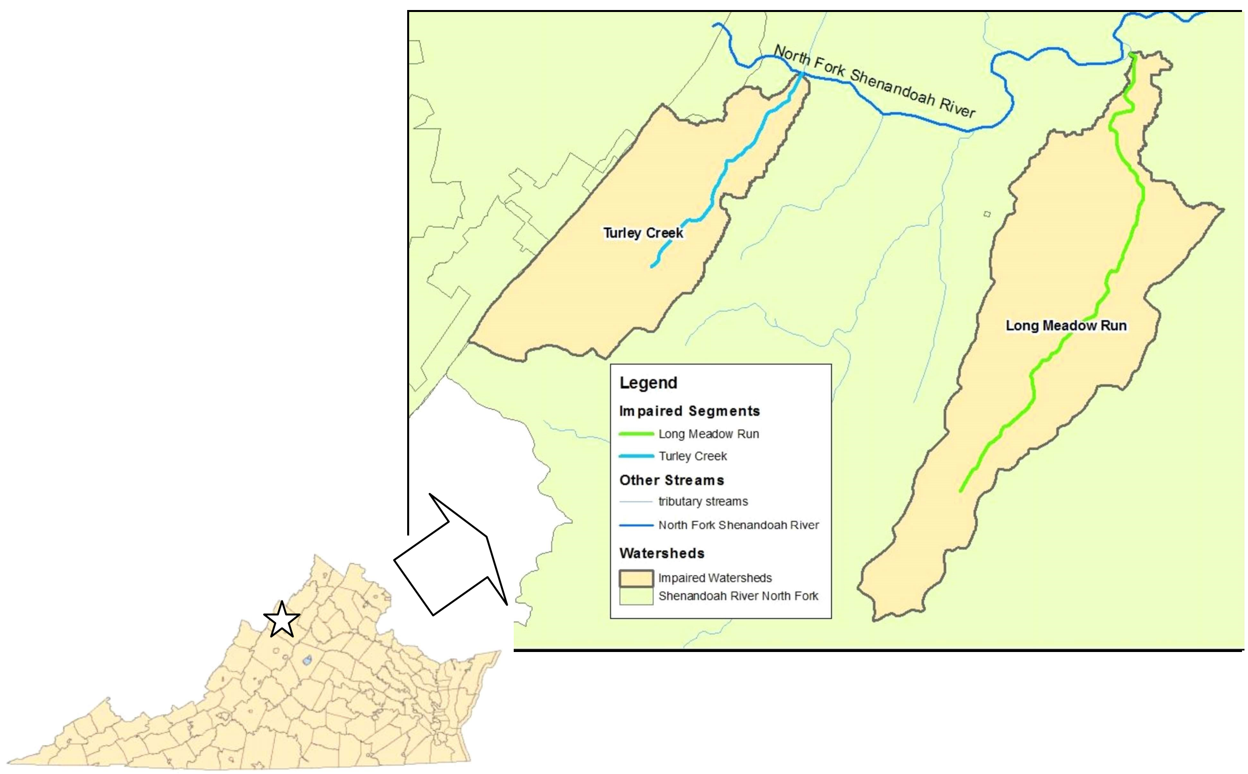


Figure 3-1. Location of Impaired Segments and Watersheds

Turley Creek and Long Meadow Run were originally listed as impaired on Virginia's 2002 Section 305(b) Total Maximum Daily Load Priority Report, due to water quality violations of the general aquatic life (benthic) standard (VADEQ, 2002). As a result, Virginia entered into an agreement with the Environmental Protection Agency (EPA) to write a TMDL by 2014. The original TMDL study, submitted in 2012, was not approved and the TMDL was re-opened in June 2014 in order to address EPA comments and re-submitted to EPA in July 2015.

The Virginia Department of Environmental Quality (DEQ) has delineated the benthic impairment as 4.01 miles on Turley Creek (stream segment VAV-B45R_TRL01A00) and 8.53 miles on Long Meadow Run (stream segment VAV-B45R_LOM01A00). The Turley Creek impaired segment begins just above its confluence with an unknown tributary (originating near Turley Town) and extends downstream to its confluence with the North Fork Shenandoah River. The Long Meadow Run impaired segment begins in the headwaters and extends downstream to its confluence with the North Fork Shenandoah River.

The DEQ 2010 Fact Sheets for Category 5 Waters (VADEQ, 2010) state that Turley Creek and Long Meadow Run are impaired based on assessments at biological stations 1BTRL000.02 and 1BLOM000.24, respectively. The source of impairment in both Turley Creek and Long Meadow Run was considered “Unknown.”

Additional bacteria impairments in Turley Creek and Long Meadow Run were already addressed by the TMDL developed for the North Fork of the Shenandoah River (Brannan et al., 2006). Any reductions required by the TMDL developed for the benthic impairment will be coordinated with those called for by the bacteria TMDL; primarily these consist of 85% reduction in bacteria (manure) applied to cropland and pasture, and 30% reduction from livestock in streams. An implementation plan to address the bacteria impairments has not yet been developed for this watershed.

3.2. *Watershed Characteristics*

The Turley Creek watershed and the Long Meadow Run watershed are part of the Potomac and Shenandoah River basin, and parts of state hydrologic unit B45 (National Watershed Boundary Dataset PS55). Turley Creek and Long Meadow Run are located north of Harrisonburg on US Route 613 and US Route 259 respectively, in Rockingham County, Virginia. Turley Creek and Long Meadow Run both flow northeast and discharge into the North Fork Shenandoah River. The North Fork Shenandoah River is a tributary of the Potomac River Basin, which flows into the Chesapeake Bay.

Long Meadow Run and Turley Creek watersheds lie in an area of karst topography. Karst watersheds often contain stream segments that lose water as they flow downstream. The water infiltrates into the ground recharging the local groundwater, because the water table is below the bottom of the stream channel. Flow from losing streams may disappear from the surface channel at some times and in some reaches during the year, only to re-emerge as surface flow further downstream.

The Turley Creek watershed is located entirely within the Northern Sandstone Ridges sub-division, of the Ridge and Valley ecoregion while the Long Meadow Run watershed is located entirely within the Northern Limestone/Dolomite Valleys sub-division, of the Ridge and Valley ecoregion. The Ridge and Valley ecoregion is primarily ridges and lowland valleys and is composed of sandstone, shale, conglomerate and coal (USEPA, 2002).

The Turley Creek watershed is comprised of soils primarily in the Frederick (59%) and Weikert (15%) series, while the Long Meadow Run watershed contains predominantly soils in the Frederick series (92%). These series form various complexes, many with rock outcrops (USDA-NRCS, 2010).

Land use categories for the Turley Creek and Long Meadow Run watersheds were derived from the 2009 cropland data layer developed by the USDA National Agricultural Statistics Service. The NASS data are available online and were developed from USDA National Resources Inventory data in agricultural areas and supplemented with 2006 National Land Classification Data (NLCD) in non-agricultural areas. The distribution of land use acreages in the watershed is given in Table 3-1, and shown in

Figure 3-2. The Long Meadow Run watershed is 9,889.1 acres in size. The main land use category in the watershed is pasture (53% of the watershed), followed by forest (17%), hay (13%), and the remainder in cropland, residential or developed land uses. The Turley Creek watershed is 6,029.0 acres in size. The main land use categories in the watershed are forest (58% of the watershed) and pasture (27%). The remainder is in hay, cropland, residential or developed land uses. The pasture/hay categories were combined and assigned as 85% pasture and 15% hay, based on professional judgment by local NRCS personnel.

Table 3-1. NASS Land Use Summary in Turley Creek and Long Meadow Run (acres)

NASS Landuse Categories	Lower Long Meadow Run	Upper Long Meadow Run	Unnamed Tributary	Long Meadow Run Total	Lower Turley Creek	Upper Turley Creek	Brock Creek	Turley Creek Total
	Area in acres				Area in acres			
Corn	60.7	602.0	216.9	879.6	81.7	101.5	20.5	203.8
Soybeans	6.2	44.0	37.0	87.2	5.4	10.8	0.8	17.0
Barley	-	7.0	2.3	9.3	3.9	-	-	3.9
Winter Wheat	-	14.7	-	14.7				-
Rye	-	11.6	-	11.6				-
Alfalfa	13.2	27.8	5.4	46.5	4.9	-	0.8	5.7
Other Pasture/Hays	362.2	4,595.7	1,498.9	6,456.8	485.6	805.2	628.3	1,919.1
Pasture/Grass	1.0	37.3	12.0	50.2	16.3	13.6	68.6	98.5
NLCD - Open Water	1.6	-	-	1.6	1.9	-	10.8	12.7
NLCD - Developed/Open Space	18.4	336.7	125.7	480.8	35.3	87.1	110.9	233.3
NLCD - Developed/Low Intensity	6.1	106.0	34.2	146.4	9.9	8.1	22.9	40.9
NLCD - Developed/Medium Intensit	1.0	12.2	2.6	15.8	-	0.8	3.1	3.9
NLCD - Developed/High Intensity	-	0.8	-	0.8	-	-	1.5	1.5
NLCD - Barren	0.6	-	-	0.6	-	-	8.5	8.5
NLCD - Deciduous Forest	4.7	1,214.7	272.6	1,491.9	340.8	343.3	2,517.4	3,201.4
NLCD - Evergreen Forest	1.2	116.4	30.4	148.0	44.2	67.4	128.6	240.3
NLCD - Mixed Forest	-	24.3	3.1	27.4	6.0	12.6	18.3	36.9
Dbl. Crop Barley/Corn	-	16.7	-	16.7	0.8	0.8	-	1.5
Dbl. Crop Barley/Soybeans	-	3.1	-	3.1				-
Total	477.0	7,170.9	2,241.2	**9,889.1**	1,036.6	1,451.3	3,541.1	**6,029.0**

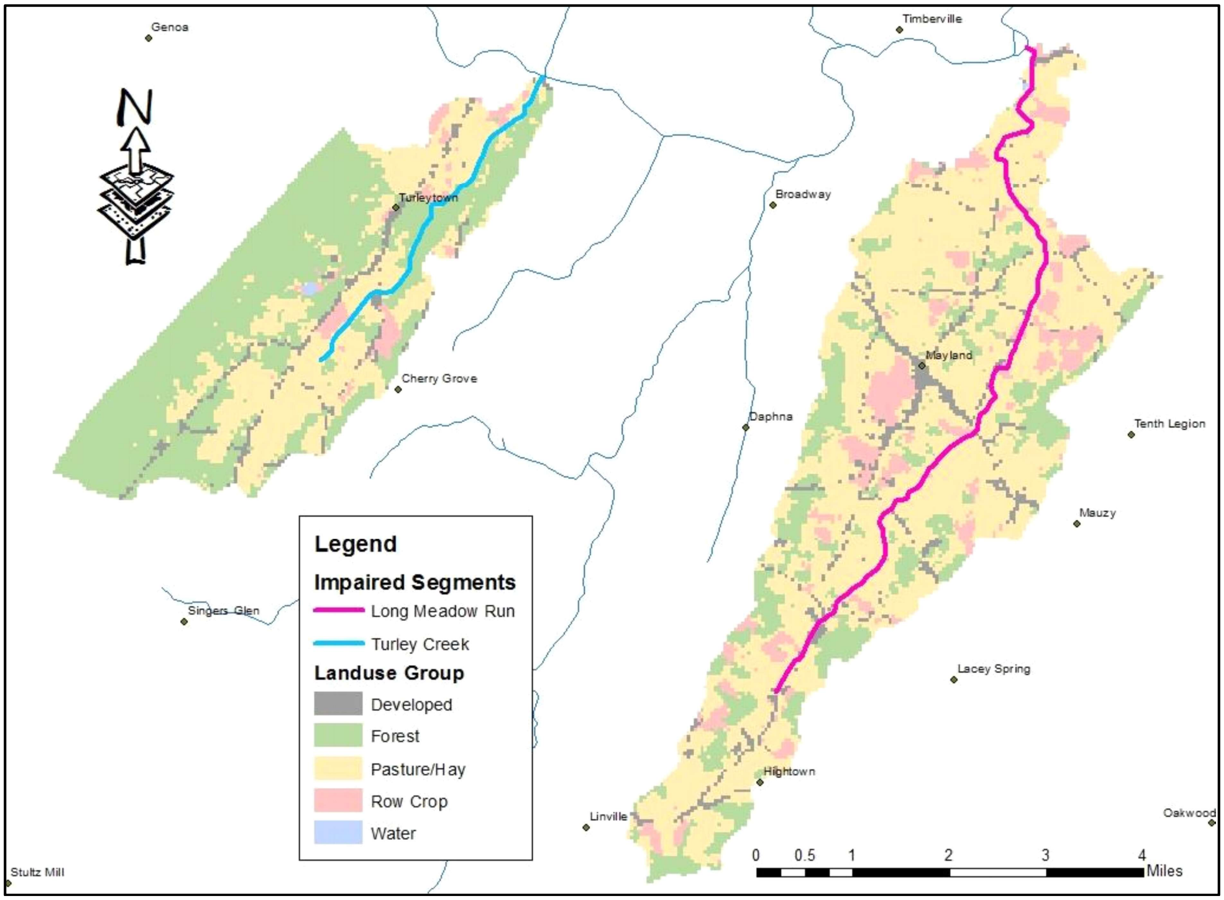


Figure 3-2. **NASS Generalized Land Use in Turley Creek and Long Meadow Run Watersheds**

3.3. *Biological Monitoring*

Biological monitoring consisted of sampling the benthic macro-invertebrate community along with corresponding habitat assessments. The data for the bioassessments in Turley Creek and Long Meadow Run were based on DEQ biological monitoring at one DEQ monitoring site in each watershed. The biological monitoring station on Turley Creek (1BTRL000.02) was monitored 23 times between 1996 and 2014. The biological monitoring station on Long Meadow Run (1BLOM000.24) was monitored 22 times between 1996 and 2014. In addition, after the beginning of the TMDL study, 5 benthic macro-invertebrate samples were taken on the main tributary to Turley Creek, Brock Creek (1BBRO000.34), which remains healthy. The locations of the DEQ biological and ambient monitoring stations in the Turley Creek and Long Meadow Run watersheds are shown in Figure 3-3.

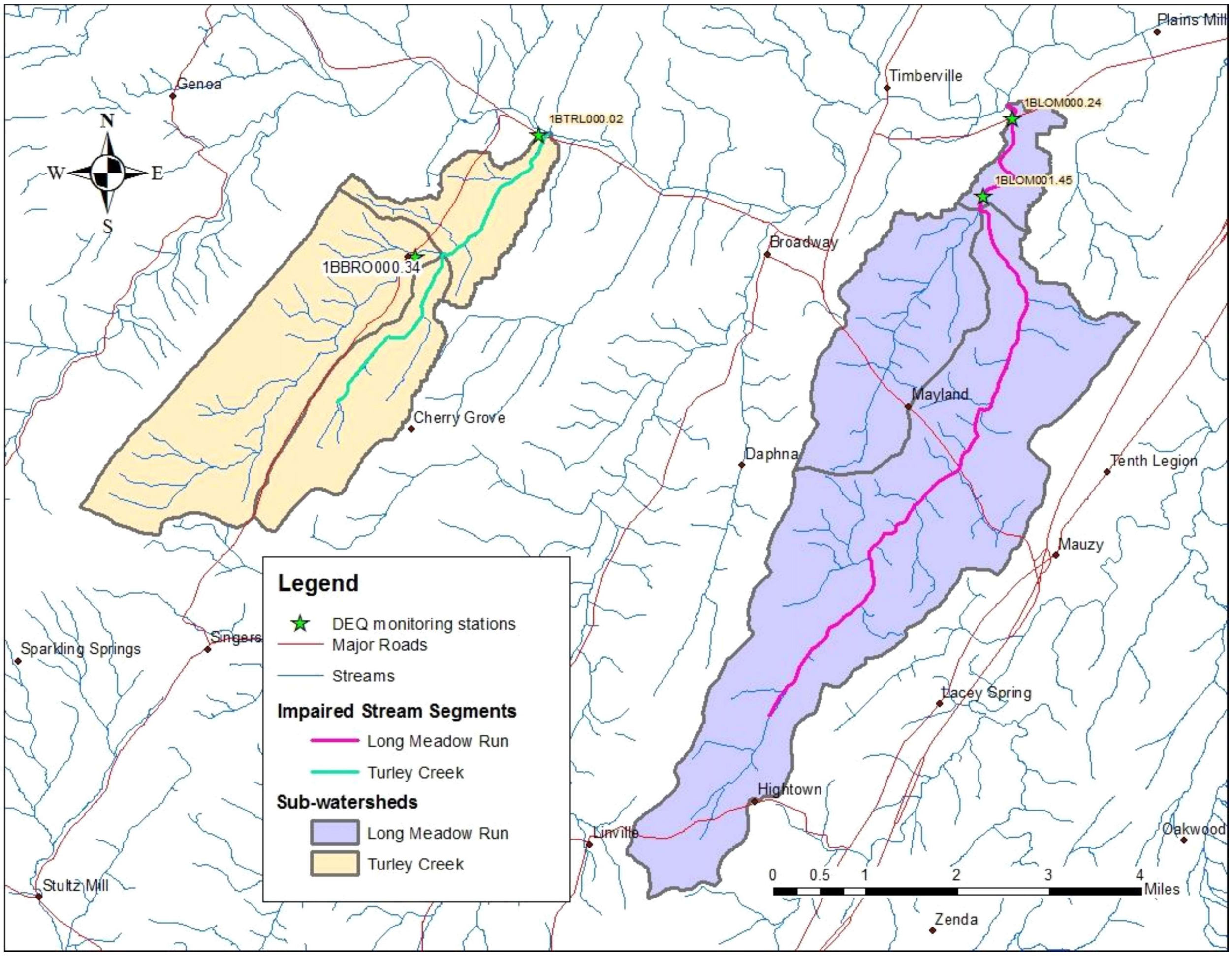


Figure 3-3. Locations of DEQ Monitoring Stations in the Turley Creek and Long Meadow Run Watersheds

DEQ's biological assessment method is based on the Virginia Stream Condition Index (VSCI) for Virginia's non-coastal areas (Tetra Tech, 2003). This multi-metric index is based on eight biomonitoring metrics that are measures of the diversity, pollution tolerance, and abundance of organisms identified during a taxa inventory of each sample. VSCI has a scoring range of 0-100, where a maximum score of 100 represents the best benthic community sites. The current proposed threshold criteria defines "non-impaired" sites as those with a VSCI of 60 or above, and "impaired" sites as those with a score below 60 (VADEQ, 2011). The VSCI scores for Turley Creek are shown in Figure 3-4 and indicate a minor impairment, with most scores ±10 points of the impairment threshold score. The VSCI scores for Long Meadow Run are shown in

Figure 3-5 and indicate a consistently impaired stream, with all samples well below the impairment threshold.

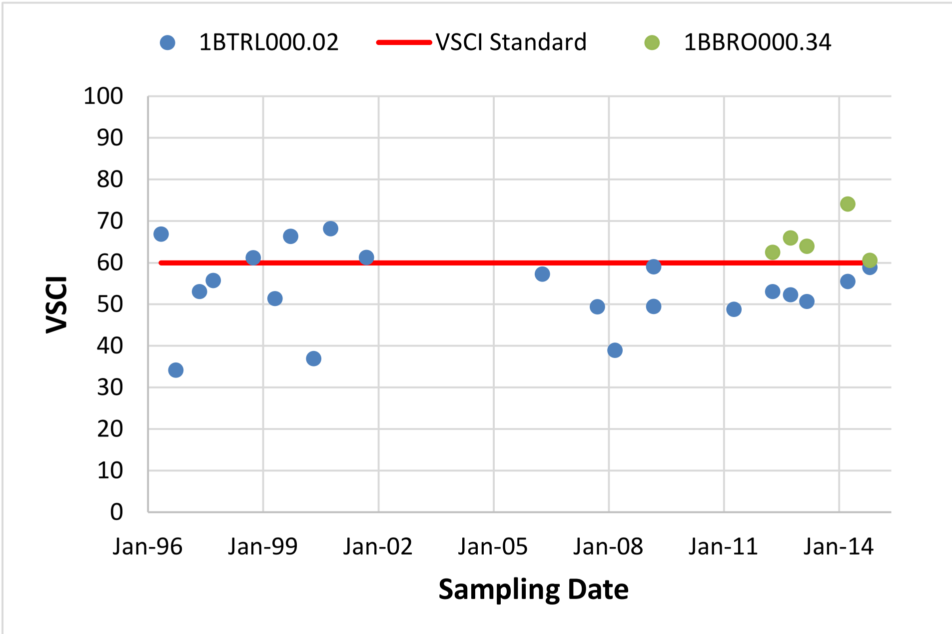


Figure 3-4. VSCI Scores for Turley Creek (TRL)

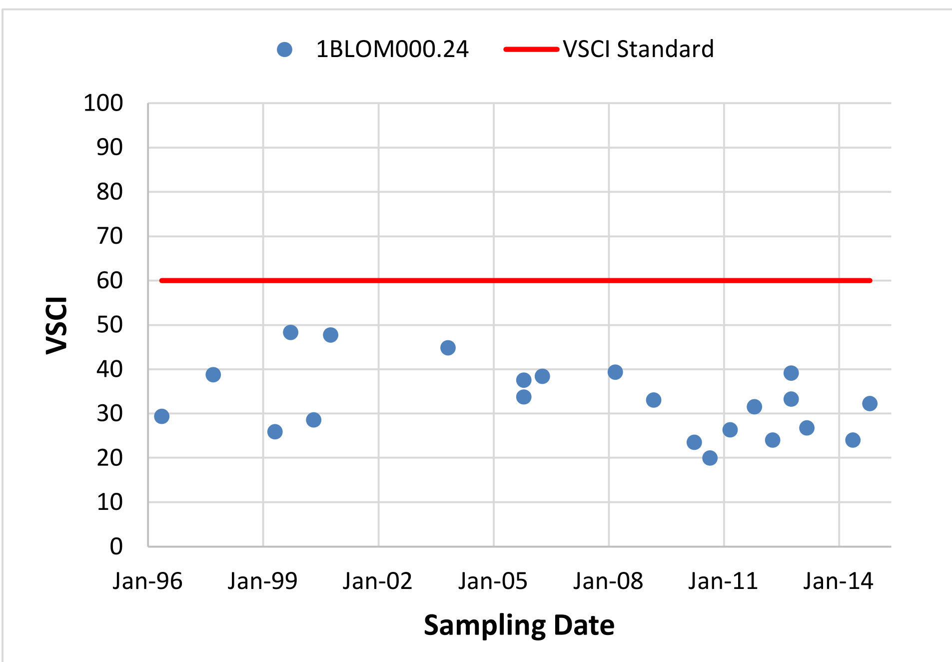


Figure 3-5. VSCI Scores for Long Meadow Run (LOM)

A qualitative analysis of various habitat parameters was conducted in conjunction with each biological sampling event. Habitat data collected as part of the biological monitoring were obtained from DEQ through the EDAS database. Each of the 10 parameters included in the habitat assessment was rated on a scale of 0-20, with a maximum score of 20 indicating the most desirable condition, and a score of 0 indicating the poorest habitat conditions. The best possible overall score for a single evaluation is 200. The habitat assessment data for Turley Creek are shown in Table 3-2, and for Long Meadow Run in Table 3-3. Many of the “poor” to “marginal” habitat scores shown in these two tables relate fairly closely with the sediment stressor.

Table 3-2. Habitat Evaluation Scores for Turley Creek (TRL)

StationID	1BTRL000.02																					
Collection Date	05/29/07	05/30/96	10/16/96	10/08/97	10/23/98	05/19/99	10/14/99	05/19/00	10/27/00	10/02/01	05/03/06	10/09/07	03/24/08	03/27/09	10/13/09	10/12/10	04/27/11	11/08/11	04/30/12	10/18/12	03/20/13	Average
Channel Alteration	12	16	10	12	12	11	14	13	16	16	17	15	16	14	16	17	17	15	17	17	16	14.7
Bank Stability	8	6	12	12	9	14	16	14	15	14	11	13	15	10	14	12	14	13	14	12	14	12.5
Vegetative Protection	6	8	10	10	10	7	14	17	6	12	9	14	14	7	14	14	15	16	11	10	13	11.3
Embeddedness	12	8	10	12	15	17	11	11	15	10	11	14		13	17	12	16	11	14	12	17	12.9
Channel Flow Status	20	20	20	16	16	20	18	14	18	15	15	13	16	13	14	12	19	17	17	16	20	16.6
Frequency of riffles (or bends)	16	16	12	14	19	14	18	17	17	19	17	16	17	18	13	17	15	11	16	16	16	15.9
Riparian Vegetative Zone Width	0	0	0	0	0	1	9	5	2	3	4	5	2	3	7	8	10	4	7	9	8	4.1
Sediment Deposition	14	10	8	14	18	16	17	14	19	15	11	14	14	14	12	10	13	12	10	13	12	13.3
Epifaunal Substrate / Available Cover	10	10	10	12	17	17	18	13	16	17	15	18	17	17	16	14	17	17	15	17	16	15.2
Velocity / Depth Regime	16	16	10	12	15	15	18	18	14	16	18	17	16	16	15	14	18	15	16	16	16	15.6
10-metric Total Habitat Score	**114**	**110**	**102**	**114**	**131**	**132**	**153**	**136**	**138**	**137**	**128**	**139**	**127**	**125**	**138**	**130**	**154**	**131**	**137**	**138**	**148**	**131.5**

- Marginal or Poor habitat metric rating.

Table 3-3. Habitat Evaluation Scores for Long Meadow Run (LOM)

StationID	1BLOM000.24																			
Collection Date	06/05/96	10/16/96	05/29/97	10/08/97	10/23/98	05/19/99	10/14/99	05/19/00	10/27/00	11/17/03	11/07/05	05/03/06	03/26/08	03/27/09	04/15/10	09/13/10	03/22/11	11/08/11	04/30/12	03/20/13	Average
Channel Alteration	16	14	10	10	13	10	16	13	13	10	8	10	8	11	12	13	13	9	13	13	11.8
Bank Stability	16	14	14	16	9	12	17	14	14	8	10	8	2	16	10	8	4	16	14	12	11.7
Vegetative Protection	16	14	14	14	16	20	18	18	20	16	18	18	2	12	18	16	16	14	16	13	15.5
Embeddedness	12	12	12	8	16	18	9	16	10	13	16	15	10	11	13	15	15	12	13	14	13.0
Channel Flow Status	20	20	20	20	17	20	18	15	15	19	17	12	15	14	16	14	17	17	17	19	17.1
Frequency of riffles (or bends)	8	8	8	8	11	10	14	10	7	13	5	6	10	11	11	12	8	13	11	13	9.9
Riparian Vegetative Zone Width	6	6	6	4	4	6	10	5	3	4	4	4	4	2	6	8	4	4	8	5	5.2
Sediment Deposition	10	14	10	8	18	15	16	10	14	11	11	1	3	3	4	5	6	3	1	3	8.3
Epifaunal Substrate / Available Cover	12	14	10	8	17	16	17	17	16	17	17	7	9	16	16	5	15	16	17	17	14.0
Velocity / Depth Regime	14	10	10	10	15	14	14	8	10	14	13	12	12	13	14	13	10	14	15	14	12.5
10-metric Total Habitat Score	**130**	**126**	**114**	**106**	**136**	**141**	**149**	**126**	**122**	**125**	**119**	**93**	**75**	**109**	**120**	**109**	**108**	**118**	**125**	**123**	**118.7**

- Marginal or Poor habitat metric rating.

3.4. *Ambient and Stream Sediment Monitoring*

Ambient water quality sampling has been conducted at one primary station each on Turley Creek (1BTRL000.02) and on Long Meadow Run (1BLOM001.45). An additional sample was taken at a headwater spring in Long Meadow Run (1BLOM007.36) to assess the nutrient concentrations in groundwater. Turley Creek and Long Meadow Run are both designated as Class IV Mountainous Zones Waters (SWCB, 2011).

In Turley Creek, field physical parameters include temperature, pH, dissolved oxygen (DO), and conductivity. Chemical parameters include various forms of nitrogen and phosphorus – nitrite and nitrate N, total N, ortho-P and total P; various forms of solids – total solids, volatile solids, and suspended solids; ammonia; chemical oxygen demand (COD); alkalinity; chlorides; sulfates; total dissolved solids (TDS); total organic carbon (TOC); biochemical oxygen demand (BOD); turbidity; and bacteria (fecal coliform and Escherichia coli). Monitoring data for the suite of solids and field parameters date back to September 1991, while the majority of sampling for nutrients and bacteria began in early 2008.

In Long Meadow Run, field physical parameters include temperature, pH, DO, and conductivity. Chemical parameters include non-filterable residue; various forms of nitrogen- nitrite and nitrate N, ammonia, and total N; various forms of phosphorus – ortho-P and total P; turbidity; and bacteria (fecal coliform and Escherichia coli). Monitoring in this watershed only began in Spring 2005. Relevant results from the ambient monitoring for both watersheds are discussed under the stressor analysis in the next section.

Additionally, two sediment samples were collected for Turley Creek watershed and analyzed by DEQ for a standard suite of metals, while a third was collected on Long Meadow Run. An additional sediment sample was analyzed in 2008-2009 as part of a study by Serena Ciparis, Fish and Wildlife Conservation Department at Virginia Tech. None of the tested substances exceeded any established consensus-based probable effects concentration (PEC), and most of the metals were not detected above their respective minimum detection limit (MDL).

3.5. *Other Assessment Data*

Diurnal dissolved oxygen (DO) tests: No exceedences of either the minimum dissolved oxygen standard of 4.0 mg/L, or the daily average standard of 5.0 mg/L for Class IV waters were observed on Turley Creek, as shown in Figure 3-6. The diurnal DO test on Long Meadow failed due to excessive sediment.

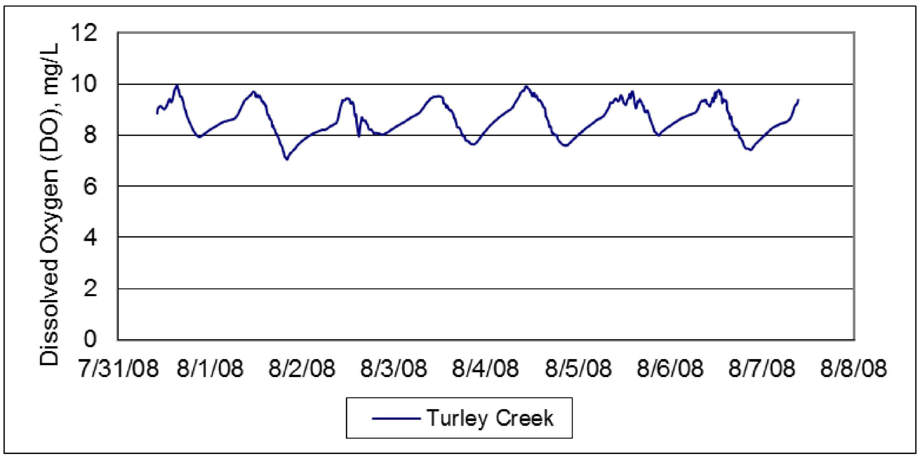


Figure 3-6. 8-Day Diurnal DO Results for Turley Creek

Relative Bed Stability (RBS) Analysis: Turley Creek shows a very low percentage of fine sediment in the stream, as shown in Table 3-4. A high percentage of fine sediment in streams would directly contribute to embeddedness, the filling of the interstitial spaces in the channel bottom. The Log Relative Bed Stability (LRBS) score of negative one (-1) indicates that sediments ten times larger than the median are moving at bankfull, with a medium probability of impairment from sediment. DEQ biologists indicated that Long Meadow Run was one of the most unstable streams sampled in Virginia, as shown by the high percentage of fines, the high degree of embeddedness, and the low LRBS score, indicative of highly modified channels.

Table 3-4. RBS Analysis Results for Turley Creek (TRL) and Long Meadow Run (LOM)

Station	Sample Date	Mean Substrate Size (mm)	LRBS	Mean Embeddedness (channel + margin) (%)	% fines
1BTRL000.02	07/27/10	0.162	-0.857	39.5	13.3
1BLOM000.24	09/13/10	0.095	-2.167	80.4	67.0

Permitted Sources: As of November 2014, there were five (5) general discharge permits for single-family homes in the watersheds, two in Turley Creek and three in Long Meadow Run.

As of November 2014, there were currently no active DEQ VPDES permits for construction stormwater, but there is one industrial stormwater discharge permit for the Neff Lumber Mills, Inc. in the Brock Creek tributary to Turley Creek.

There were 23 poultry animal feeding operations (AFOs) active in Long Meadow Run watershed, and nine (9) poultry AFOs in Turley Creek, as of January 2015.

As of November 2014, there was one mining permit with five outfalls in the Turley Creek watershed, belonging to the Rockdale Quarries, formerly the C.S. Mundy – Broadway Quarry. The mining permit carries various requirements for monitoring their operations. Stormwater runoff from the permitted area is directed through an NPDES sediment pond. In-stream monitoring and groundwater monitoring are less permit-specific, so that each monitoring location may serve as compliance for the upstream permitted area.

Additional Information:

Monitoring data were also available from a 2008-2009 research study in Long Meadow Run conducted by Serena Ciparis, Fish and Wildlife Conservation Department at Virginia Tech, collected near the Rt. 211 bridge crossing which showed high levels of both nitrate-nitrogen and suspended sediment.

The Virginia Cooperative Extension conducted Household Drinking Water clinics in Rockingham County in 1999 and 2009, where homeowners submitted water samples from their private water supply system for analysis. While the samples may not be directly representative of the groundwater quality in the area, they do provide some information on general levels of physical and chemical parameters that may be impacted by groundwater. The VAHWQP uses the EPA primary and secondary standards of the Safe Drinking Water Act, which are enforced for public systems as guidelines for private water supplies. Some interesting trends between 1999 and 2009 were observed. Increasing percentages of samples were noted above the recommended level of total dissolved solids (TDS), below the minimum pH drinking water standard (6.5), and above the drinking water nitrate-N standard (10 mg/L). During the same period however, the percentage of samples indicating the presence of both total coliform and *E. coli* bacteria decreased.

A groundwater protection plan was developed for the C.S. Mundy – Broadway Quarry by the consultant, Continental Placer Inc. (CPI), in December 2004. The report found that:

- The average quarry dewatering rate of 0.22-0.30 MGD was rated as minimal to moderate.
- No complaints regarding water quantity or quality issues had been reported since installation of the dewatering system in 2003. Two springs on the property continue to flow uninterrupted.
- No other major groundwater users and very few private water supply wells are within a 1,000-foot radius of the Broadway Quarry.
- There have been no significant releases of petroleum products.
- Reclamation plan calls for re-grading the surface and allowing the quarry to fill with water, which should have no impacts on local groundwater.

Field observations, stakeholder re-collections, and map analyses indicated that much of Long Meadow Run has been channelized in the distant past, as shown by the lack of sinuosity along its length, which can lead to significant bank erosion according to DEQ biologists. Also, many in-stream ponds were built in the 1980's as landowners tried to store water, leading to law suits that ruled that the in-stream ponds were permissible, as long as they did not impede flow.

The Virginia Water Protection (VWP) permit program generally exempts small-scale ponds for agricultural use. One of the exclusions of the 9VAC25-210-60 regulation is for the construction and maintenance of farm or stock ponds and farm or stock impoundments that are less than 25 feet in height or create a maximum impoundment capacity smaller than 100 acre-feet. This exclusion however, does not apply to irrigation withdrawals from these ponds or impoundments which do require permitting.

Aerial imagery of the Long Meadow Run watershed reveals a high density of such impoundments in this watershed, which have modified the hydrology in this watershed and could impact both water quality and aquatic life diversity.

Baseflow in Long Meadow Run comes predominantly from two springs – Big Spring, upstream near Lacey Springs Stables, and Holsinger Spring, downstream on Holsinger Road. During periods of low or no rainfall, portions of the main channel (approximately a 4-mile stretch above the downstream spring) become dry and/or intermittent. This watershed is in a karst-dominated region and Long Meadow Run is considered to be a losing stream, with a portion of its normal flow diverted to subterranean flow. Unpermitted withdrawals, averaging 6-8 truckloads (3,400-3,600 gallons) per day, are made from the Holsinger Spring by a water hauler for use by other farmers and some households.

3.6. *Benthic Stressor Analysis Summary*

TMDLs must be developed for a specific pollutant. Since a benthic impairment is based on a biological inventory, rather than on a physical or chemical water quality parameter, the pollutant is not identified in the assessment, as it is with physical and chemical parameters. The process outlined in EPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical stressor for each of the impaired watersheds in this study. Watershed and water quality data from these streams, permit data, local data, and field observations were used to help identify candidate causes.

The Turley Creek (VAV-B45R_TRL01A00) stream segment is only slightly impaired for its aquatic life use, with recent individual VSCI sample scores ranging between 34 and 69, where a score of 60 or above represents a non-impaired condition (scale: 0 – 100). Turley Creek is impacted primarily by agricultural land uses. Sediment was selected as the most probable stressor based on the poor habitat scores given for the lack of riparian vegetation and livestock access to streams.

The Long Meadow Run (VAV-B45R_LOM01A00) stream segment is moderately to severely impaired for its aquatic life use, with recent individual VSCI sample scores ranging between 25 and 48, where a score of 60 or above represents a non-impaired condition (scale: 0 – 100). Long Meadow Run is impacted by agricultural land uses. Nitrogen, organic matter and sediment were selected as the most probable stressors based on the predominance of organic matter and nutrient-loving organisms, repeated poor scores for riparian vegetation, high nitrate concentrations, and livestock access to streams. The high density of in-stream farm impoundments that affect baseflow in this watershed may also contribute to the impairment within Long Meadow Run.

In addition to the benthic impairments, both Turley Creek and Long Meadow Run also have bacteria impairments which were addressed during a previously developed TMDL (Brannan et al., 2006). Pollutant sources which were identified to affect the bacteria load reductions in the bacteria TMDL will also affect loads from stressors identified for the biological impairment. In particular, the bacteria TMDL calls for reductions of 85% from bacteria loads on cropland and pasture and 30% reduction from livestock with direct stream access. Since the loads relate primarily to livestock manure, the bacteria reductions from cropland and pasture will also reduce loads of nutrients and organic matter from these sources. The livestock exclusion BMPs will further reduce loads of nutrients, organic matter, and sediment.

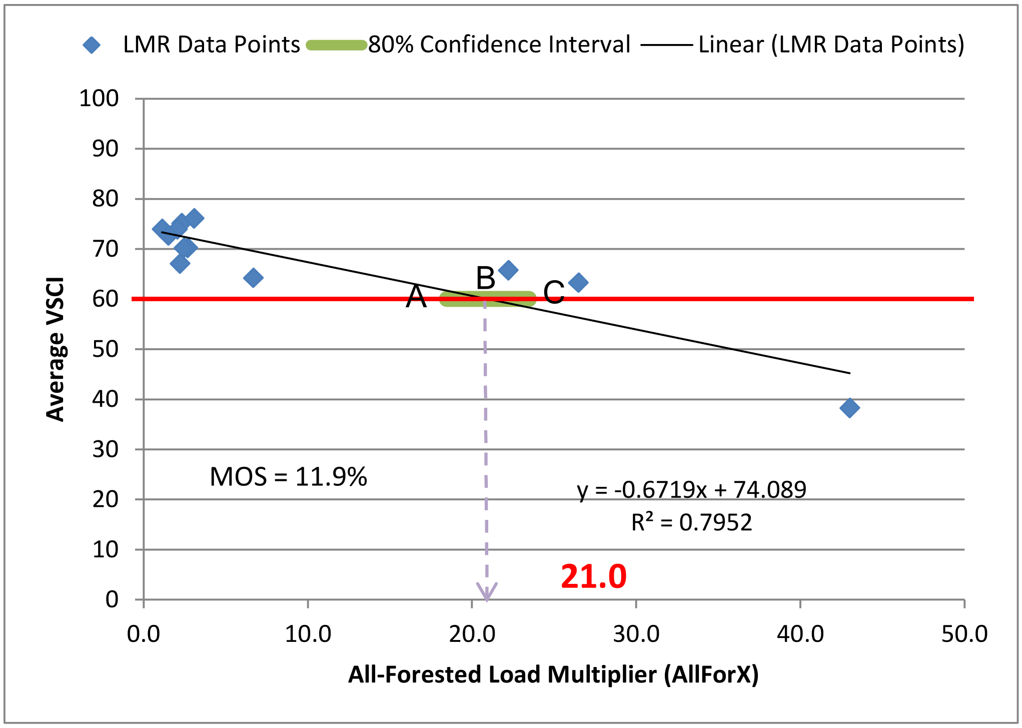
Since livestock manure is the primary source of organic matter in this watershed, the organic matter stressor should be sufficiently addressed with BMPs called for in the bacteria TMDL and, therefore, organic matter does not require a separate TMDL for the biological impairment. Although some reductions in the nitrogen and sediment biological stressors will accrue from the bacteria TMDL, there are additional sources of sediment in both watersheds and additional sources of nitrogen in Long Meadow Run that merit separate TMDLs for these stressors.

Therefore, a sediment TMDL will be developed to address the biological impairment in Turley Creek, and nitrogen and sediment TMDLs will be developed to address the biological impairment in Long Meadow Run.

3.7. *Modeling for Nitrogen and Sediment Impairments*

Since there are no in-stream water quality standards for either nitrogen or sediment in Virginia, an alternate method was needed for establishing a reference endpoint that would represent the “non-impaired” condition.

For the Turley Creek and Long Meadow Run impairments, the procedure used to set TMDL endpoint loads is a modification of the methodology used to address sediment impairments in Maryland’s non-tidal watersheds (MDE, 2006, 2009), hereafter referred to as the “all-forest load multiplier” (AllForX) approach. AllForX is the ratio of the simulated pollutant load for existing conditions to the pollutant load from an all-forest condition for the same watershed. The AllForX approach was applied locally for Turley Creek and Long Meadow Run, using a selection of watersheds with monitoring stations that have healthy biological scores. When AllForX is regressed against VSCI for a number of healthy watersheds surrounding a particular TMDL watershed or set of TMDL watersheds, the developed relationship can be used to quantify the value of the AllForX threshold that corresponds to the biological health threshold (VSCI < 60) used to assess aquatic life use impairments in Virginia. The pollutant TMDL load is then calculated as the value of the AllForX threshold times the all-forest pollutant load of the TMDL watershed. Since a number of watersheds are used to quantify the regression, a confidence interval around the threshold was used to quantify the margin of safety in the Total Maximum Daily Load equation. AllForX regressions were created to identify sediment AllForX threshold values for both Turley Creek and Long Meadow Run (shown in Figure 3-7) and a nitrogen AllForX threshold value for Long Meadow Run. Modeling was performed with the GWLF2010 model, based on previous versions of GWLF by Haith et al. (1992), Evans et al. (2001), and Yagow and Hession (2007).



B = AllForX endpoint value used for the TMDL; AC = the 80% Confidence Interval (shown in green); (B - A)/B = The MOS fraction; A = AllForX value used for the target allocation load.

Figure 3-7. Regression and AllForX Threshold for Sediment in Long Meadow Run

The value of AllForX used to set the sediment TMDL load (the AllForX threshold) was the value where the regression line crossed the biological impairment threshold of VSCI = 60 (AllForX = 21.0), indicated by point B. The TMDL load for each watershed was then calculated as its All-Forest sediment load times the AllForX threshold (21.0). An 80% confidence interval was then calculated around the point where the regression line intersects the biological impairment threshold (VSCI = 60). The margin of safety (MOS) was calculated as the All-Forest sediment load times the difference in AllForX between the point where the regression crosses VSCI = 60 (AllForX = 21.0) and the lower bound of the 80% confidence interval (AllForX = 18.46), amounting to 11.9%. Note that the MOS is equal to this difference expressed as a percentage of the AllForX threshold, and therefore is the same for all watersheds using this regression.

In a similar fashion, the sediment regression developed for Turley Creek resulted in an AllForX threshold of 9.72 and an MOS of 7.4%. The nitrogen regression for Long Meadow Run resulted in an AllForX threshold value of 4.10 and an MOS of 11%.

Although these TMDLs are developed for sediment (as well as nitrogen for Long Meadow Run), attainment of a healthy benthic community will ultimately be based on biological monitoring of the benthic macro-invertebrate community, in accordance with established DEQ protocols. If a future review should find that the reductions called for in these TMDLs based on current modeling are found to be insufficiently protective of local water quality, then revision(s) will be made as necessary to provide reasonable assurance that water quality goals will be achieved.

3.8. *Sources of Sediment*

Sediment sources can be divided into point and nonpoint sources. Sediment loads are primarily contributed by nonpoint sources in both the Turley Creek and Long Meadow Run watersheds. The major sources of sediment are agricultural land and urban land. Agricultural lands, such as cropland and pasture/hay areas, can contribute excessive sediment loads through erosion and build-up/washoff processes. Agricultural lands are particularly susceptible to erosion due to less vegetative coverage. Stormwater runoff from urban areas and construction sites also contribute sediment to the stream. Along stream corridors, livestock with stream access also contribute to in-stream sediment loads by trampling streambanks and disturbing channel sediment.

3.9. *Sources of Nitrogen*

In-stream nitrogen arises primarily from an imbalance of nitrogen imports to the watershed in the form of livestock feed and fertilizer. Concentrations of manure found in and around animal feeding operations contribute to the nitrogen available for transport to streams during rainfall events. Poorly-timed applications of manure and other fertilizers are also subject to transport through rainfall-runoff. Excess nutrient fertilization on cropland also eventually makes its way to groundwater and resurfaces as baseflow. This has been exhibited in Long Meadow Run, where nitrate concentrations in several springs, during baseflow, have been measured at elevated levels around 8 mg/L, and are similar to concentrations measured at the watershed outlet downstream. Improper or failing septic systems also contribute to nitrogen pollution, as does fertilizer wash-off from residential lawns.

3.10. *TMDL Allocations and Load Reductions*

The objective of a TMDL is to allocate allowable loads among different pollutant sources so that appropriate actions can be taken to achieve water quality standards (USEPA, 1991). The stressor analysis in Turley Creek indicated that sediment was the "most probable stressor" in the watershed, and therefore, sediment will serve as the basis for development of the TMDL. In the Long Meadow Run watershed, the stressor analysis indicated nutrients, organic matter, and sediment as stressors. However, since bacteria reductions called for in the bacteria TMDL for the North Fork Shenandoah River will already reduce particulate nutrients and organic matter and encompass the Long Meadow Run watershed, the TMDLs in the Long Meadow Run watershed will be developed only for nitrogen and sediment.

The AllForX approach was used to set appropriate sediment and nitrogen TMDL endpoints and to quantify the margin of safety (MOS) for each TMDL watershed. Separate AllForX sediment regressions were developed for each of the watersheds, and an AllForX nitrogen regression was developed for Long Meadow Run, along with the selected comparison watersheds, as detailed in the TMDL report (Yagow et al., 2015).

3.8.1. TMDLs

The TMDL calculated for each watershed consisted of a permitted waste load allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS), using the following equation:

$$TMDL = WLA + LA + MOS$$

The TMDL load was calculated as the product of the corresponding threshold AllForX values and the all-forest load of either sediment or nitrogen for each impaired watershed.

The waste load allocation (WLA) was calculated using the 80% confidence interval and the AllForX threshold value for each regression. WLA consisted of loads from aggregated construction permits and loads from permitted facilities for both stormwater and effluent.

The LA was calculated as the TMDL minus the sum of MOS and WLA. The TMDL load, components, and aggregated WLAs are shown for the Long Meadow Run and Turley Creek sediment TMDLs in Table 3-5, and for the Long Meadow Run nitrogen TMDL in Table 3-6.

Table 3-5. Long Meadow Run and Turley Creek Sediment TMDLs (tons/yr)

Impairment	TMDL	WLA		LA	MOS
	(tons/yr)				
Cause Code Group B45R-01-BEN					
Long Meadow Run	1,766.4	27.92		1,527.7	210.8
VAV-B45R_LOM01A00		aggregate construction =	10.05 tons/yr		
		aggregate SFH permits =	0.21 tons/yr		
		Future Growth WLA =	17.66 tons/yr		
Cause Code Group B45R-02-BEN					
Turley Creek	926.8	19.87		838.2	68.7
VAV-B45R_TRL01A00		aggregate construction =	3.65 tons/yr		
VAV-B45R_TRL02A00		aggregate ISWGP Permits (VAG840133, VAR050808) =	6.86 tons/yr		
		aggregate SFH permits =	0.08 tons/yr		
		Future Growth WLA =	9.27 tons/yr		

Table 3-6. Long Meadow Run Nitrogen TMDL (lbs/yr)

Impairment	TMDL	WLA		LA	MOS
	(lbs/yr)				
Cause Code Group B45R-01-BEN					
Long Meadow Run	19,532.1	520.6		16,866.7	2,144.8
VAV-B45R_LOM01A00		aggregate construction =	20.7 lbs/yr		
		aggregated SFH WLA =	304.6 lbs/yr		
		Future Growth WLA =	195.3 lbs/yr		

3.8.2. Load Allocation Scenarios

The target load for the allocation scenario in each watershed is the TMDL minus the MOS, where both the TMDL and MOS were quantified using the AllForX methodology.

Sediment loads were simulated with GWLF using a 2007 BMP scenario. These Existing Loads were then adjusted based on load reductions from BMPs that have been installed in the watersheds through 12/31/09 as the baseline Existing Loads that correspond with the weather and landuse inputs. Reductions due to BMP installation from 2010 through 2014 were also accounted for as credits against the needed reductions.

Although groundwater was initially simulated as a separate source to emphasize its important contribution to stream nitrogen loads, in reality the nitrogen in groundwater arises from management practices associated with individual landuses, and can best be reduced through improved management practices on those landuses. In order to make this link more explicit, the groundwater nitrogen load was distributed among the pervious landuses in each watershed based on the simulated ratio of groundwater N to runoff N and the relative area of each landuse. For this purpose, simulated output from the A51165PS2_5560_5100 land-river segment in the Chesapeake Bay Watershed Model Phase 5.3.2 was used with average annual NO23 used to represent groundwater N and average annual OrgN used to represent surface runoff N. Although this is only an approximation of the groundwater and runoff loads, it appeared to be a reasonable means of distributing groundwater N among the landuses.

Two allocation scenarios were created for each watershed. In each scenario, Forest and Permitted WLAs were not subjected to reductions. Areas of harvested forest and construction are transient sources of sediment subject to existing regulations. Their reduction efficiencies were currently estimated as only half of those possible. Both allocation scenarios assume that these practices will meet their potential reduction efficiencies with better enforcement of existing regulations. In addition, the first allocation scenario assumed equal percent reductions from all other sources, while in the second scenario, higher percent reductions were required from the largest sources (Row Crops and Pasture) with lower percent reductions from the other sources. Sediment allocation scenarios are detailed in Table 3-7 and Table 3-8 for Long Meadow Run and Turley Creek watersheds, respectively, while the nitrogen allocation scenarios for Long Meadow Run are in Table 3-9.

The 2007 BMP Scenario Load is shown at the top of each table for comparison with the 2009 baseline Existing Sediment Load, as shown within the table. Beneath each table is shown the Target Allocation Load (TMDL – MOS – future growth (FG)), and the Needed Load Reduction, both as an amount and as a % of the Existing Load. The load reduction from BMPs installed from 2010-2014 are in the far right column.

The Local Steering Committee preferred Scenario 2 as being the more appropriate starting point around which to build an Implementation Plan for achieving sediment and nitrogen reductions from both the Long Meadow Run and Turley Creek watersheds.

Table 3-7. Sediment TMDL Load Allocation Scenario for Long Meadow Run

2007 BMP Load = (tons/yr) 3,624.1

Land Use/ Source Group	Area (acres)	2009 Sediment Load (tons/yr)	Scenario 1		Scenario 2		2009-2014 BMP Load Reductions (tons/yr)
			% Reduction	Allocated Load (tons/yr)	% Reduction	Allocated Load (tons/yr)	
Row Crops	848.6	481.6	53.4%	224.5	58.0%	202.3	122.2
Pasture	5,419.4	2,104.5	53.4%	981.0	58.0%	883.9	20.4
Riparian Pasture	139.7	304.4	53.4%	141.9	58.0%	127.9	35.3
Hay	1,154.9	299.6	53.4%	139.7	15.5%	253.2	-52.3
Forest	1,663.7	15.8	0.0%	15.8	0.0%	15.8	-0.1
Harvested Forest	16.7	1.0	41.3%	0.6	41.3%	0.6	0.0
Developed, impervious	37.8	7.8	53.4%	3.6	15.5%	6.6	0.0
Developed, pervious	600.2	42.8	53.4%	19.7	15.5%	35.9	0.0
Transitional	6.4	16.7	39.8%	10.0	39.8%	10.0	0.0
Channel Erosion		1.8	53.4%	0.8	15.5%	1.5	0.0
Permitted WLA				0.21		0.21	
Total Load		**3,276.06**		**1,537.91**		**1,537.91**	**125.5**

TMDL - MOS - FG = (tons/yr) **1,537.91**

Needed Reduction = (tons/yr) 1,738.15 [shaded] = WLA components

% Reduction Needed = (%) 53.1%

Permitted VPDES loads were subtracted from "Developed, pervious" loads.

Channel erosion reduction credits are distributed proportionately from all land-based sources.

Table 3-8. Sediment TMDL Load Allocation Scenario for Turley Creek

2007 BMP Load = (tons/yr) 1,225.1

Land Use/ Source Group	Area (acres)	2009 Sediment Load (tons/yr)	Scenario 1		Scenario 2		2009-2014 BMP Load Reductions (tons/yr)
			% Reduction	Allocated Load (tons/yr)	% Reduction	Allocated Load (tons/yr)	
Row Crops	220.3	154.2	31.8%	105.2	34.0%	101.76	14.6
Pasture	1,673.2	751.6	31.8%	512.9	34.0%	496.02	4.0
Riparian Pasture	46.6	125.9	31.8%	85.9	34.0%	83.08	0.6
Hay	309.5	76.5	31.8%	52.2	9.2%	69.40	-1.0
Forest	3,443.8	68.6	0.0%	68.6	0.0%	68.61	0.0
Harvested Forest	34.8	4.3	42.9%	2.4	42.9%	2.45	0.0
Developed, impervious	11.3	3.0	31.8%	-0.1	9.2%	0.58	0.0
Developed, pervious	273.9	20.54	31.8%	9.2	9.2%	13.82	0.0
Transitional	2.9	6.3	41.7%	3.7	41.7%	3.65	0.0
Channel Erosion		2.8	31.8%	1.9	9.2%	2.55	0.0
Permitted WLA				6.9		6.94	
Total Load		**1,213.6**		**848.88**		**848.88**	**18.3**

TMDL - MOS - FG = (tons/yr) **848.88**

Needed Reduction = (tons/yr) 364.68   [shaded] = WLA components

% Reduction Needed = (%) 30.1%

Permitted ISWGP impervious loads were subtracted from "Developed, impervious" loads.

Permitted VPDES and ISWGP pervious were subtracted from "Developed, pervious" loads.

Table 3-9. Nitrogen TMDL Load Allocation Scenario for Long Meadow Run

2007 BMP Load = (lbs/yr) 49,112.9

Land Use/ Source Group	Area (acres)	2009 Nitrogen Load (lbs/yr)	Scenario 1		Scenario 2		2009-2014 BMP Load Reductions (lbs/yr)
			% Reduction	Allocated Load (lbs/yr)	% Reduction	Allocated Load (lbs/yr)	
Row Crops	848.6	3,795.9	66.2%	1,284.0	75.0%	949.0	978.0
Pasture	5,419.4	27,355.0	66.2%	9,253.2	75.0%	6,838.8	15.3
Riparian Pasture	139.7	1,172.2	66.2%	396.5	75.0%	293.1	4.3
Hay	1,154.9	5,444.0	66.2%	1,841.5	46.2%	2,930.1	-78.4
Forest	1,663.7	1,080.9	0.0%	1,080.9	0.0%	1,080.9	-27.3
Harvested Forest	16.7	38.4	32.9%	25.8	32.9%	25.8	0.0
Developed, impervious	37.8	1,014.9	66.2%	343.3	46.2%	546.2	0.0
Developed, pervious	600.2	813.2	66.2%	275.1	46.2%	437.7	0.0
Transitional	6.4	20.7	0.0%	20.7	0.0%	20.7	0.0
Septic Systems							0.0
non-discharging		7,296.5	66.2%	2,365.1	46.2%	3,763.1	0.0
permitted				304.6		304.6	0.0
Channel Erosion		3.9	66.2%	1.3	46.2%	2.1	0.0
Total Load		**48,035.7**		**17,192.0**		**17,192.0**	**892.0**

TMDL - MOS - FG = (lbs/yr) **17,192.0**

Needed Reduction = (lbs/yr) 30,843.7 (shaded) = WLA components

% Reduction Needed = (%) 64.2%

Permitted discharging septic system loads were subtracted from "Septic System, non-discharging" loads.

Pre-2009 channel erosion reduction credits were distributed proportionately from all land-based sources.

4.0 PUBLIC PARTICIPATION

4.1. *Introduction*

An essential step in crafting a TMDL implementation plan and then implementing that plan is input from, and engagement of, a broad range of stakeholders (individuals, agencies, organizations, and businesses who have an interest in improving water quality and a familiarity with local conditions). Public participation involves a dialogue between local stakeholders and government agencies and a discussion of available resources that can be devoted to TMDL implementation, such as funding and technical support.

The stakeholders involved in developing the Turley Creek and Long Meadow Run TMDL IP included a Steering Committee, Working Groups, and the general public. The Steering Committee and two Working Groups (one focused on agricultural issues and another on residential issues) were comprised of representatives from VADEQ, VADCR, the Shenandoah Valley Soil and Water Conservation District (SWCD), Natural Resources Conservation Service (NRCS), Virginia Cooperative Extension, and local watershed stakeholders. Public participation occurred via a series of Steering Committee and Working Group meetings, Table 4-1. These meetings, as well as additional public participation activities, are described in the following sections.

Table 4-1. Summary of TMDL Implementation Planning Meetings

Meeting Date	Meeting Type
March 21, 2012	Final TMDL Public Meeting and IP Informational Meeting
April 25, 2012	Agricultural Working Group Meeting
May 2, 2012	Steering Committee/Residential Working Group
June 6, 2012	Final IP Public Meeting
July 24, 2014	Local Steering Committee (LSC) Meeting – TMDL Re-opener
March 25, 2015	LSC Meeting – TMDL Remodeling
July 20, 2015	LSC Meeting – TMDL and IP Updates
August 12, 2015	LSC Meeting - IP Update and Planning for the Public Meeting
September 2015	Final IP Update Public Meeting

4.2. *Synopsis of TMDL Implementation Planning Meetings*

The first of two public-noticed public meetings for implementation planning occurred on March 21, 2012 at the J. Frank Hillyard Middle School in Broadway, Virginia. This public meeting served as both the final TMDL meeting and the kick-off meeting for implementation planning and had an attendance of 21. The goals of the public meeting were:

- to present the benthic TMDLs for Turley Creek and Long Meadow Run;
- to provide a basic introduction to the process of implementing TMDLs;
- to engage the community through the Steering Committee and the Working Groups; and
- to explain the roles and responsibilities of each Working Group and the commitment needed for a successful process.

At this meeting we had intended to form and outline the implementation planning process for both Working Groups, but since all attendees opted to sit in on a discussion for the Agricultural Working Group, we discussed both agricultural and residential issues within a single group. The Working Group was charged with discussing, analyzing, and prioritizing potential nitrogen and sediment pollutant source reduction corrective measures.

A second Agriculture Working Group meeting was held on April 25, 2012 at the Linville-Edom Ruritan Hall in Linville, Virginia, with 10 people in attendance. The Working Group provided an opportunity for participants to give direct feedback about potential sources of problems and appropriate solutions to impairments. The goals of these meetings were:

- to review the IP purpose and development process;
- to update existing maps with respect to land use and bacteria sources;
- to identify locations of known or suspected water quality problems due to nitrogen and sediment; and

- to identify corrective measures (BMPs and other approaches) for reducing nitrogen and sediment loads.

The Residential Working Group meeting was held in conjunction with the Steering Committee whose job it was to balance the interests and desires voiced in the Working Groups. One Steering Committee meeting was held on May 2, 2012 at the DEQ Valley Regional Office in Harrisonburg, Virginia, and was attended by 6 people. The goal of the Steering Committee meeting was:

- to present the Steering Committee with a summary of the Working Group meetings;
- to refine input on the suite of corrective measures recommended by the Working Groups; and
- to present and solicit feedback on the draft TMDL IP and plan the final public meeting.

The second and final public meeting for Implementation Plan development occurred at 7:00 pm on June 6, 2012 at the J. Frank Hillyard Middle School in Broadway, Virginia (13 stakeholders attended the meeting). The goals of the meeting were:

- to review the TMDL implementation planning process and the implementation chronology laid out in the TMDL IP;
- to review the analysis and techniques used to determine the final suite of corrective measures included in the TMDL IP; and
- to solicit stakeholder feedback (a formal 30-day public comment period following the final public meeting).

Since the original TMDL was rejected by EPA, another series of meetings was held during the current revision phase to re-open the TMDL starting in June 2014 in order to address EPA comments and to re-submit the TMDL. The first Local Steering Committee meeting during this revision phase was held on July 24, 2014 at the Shenandoah Valley Soil and Water Conservation District office in Harrisonburg, Virginia, where an update was presented on the status of the previous Long Meadow Run

TMDLs for sediment and nitrogen and the Turley Creek TMDL for sediment, some planned sediment and nitrogen TMDL endpoint and modeling revisions, followed by discussion on how best to elicit public participation during the revision phase. A total of 17 people were in attendance at this LSC meeting.

The next LSC meeting was held March 25, 2015 at the Massanutten Regional Library. The Local Steering Committee discussed the draft TMDL report, including the TMDLs, existing sediment and nitrogen loads, and allocation scenarios to meet the individual TMDLs. The stakeholders agreed that a public meeting to mark the completion of the TMDL and Implementation Plan could feature food in some way, possibly an ice cream social or barbeque contest in late June. The group agreed to meet one additional time to review the TMDL and IP documents and review BMP and cost estimates and strategies.

Another LSC committee meeting was held on July 20, 2015 to review the draft implementation plan and to comment of BMP extents, efficiencies, and unit costs.

A final LSC committee meeting was held on August 12, 2015 to review the updated implementation plan and to plan for a public meeting sometime in September.

5.0 IMPLEMENTATION ACTIONS

An important element of the TMDL implementation plan is to encourage voluntary compliance with implementation of control measures by local, state, and federal government agencies, business owners, and private citizens. In order to encourage voluntary implementation, information must be obtained on the types of control measures that can achieve the pollutant reduction goals specified in the TMDL as practically and cost-effectively as possible.

5.1. *TMDL Reduction Goals*

The Turley Creek TMDL identified sediment and the Long Meadow Run TMDL identified nitrogen and sediment as the pollutants responsible for the impairment in their respective watersheds. Table 5-1 summarizes the pollutant sources and reductions called for in the TMDLs.

Table 5-1. Summary of Turley Creek and Long Meadow Run TMDL Reductions

Land Use / Source Categories	Area (acres)	Sediment		Nitrogen	
		Load (tons/yr)	% Reduction	Load (lbs/yr)	% Reduction
Turley Creek					
Row Crops, Pasture, and Riparian Pasture	1,940.1	1,031.6	34.0%		
Hay and Residential (incl. Septics)	594.7	100.0	9.2%		
Forest	3,443.8	68.6	0.0%		
Harvested Forest and Transitional	37.7	10.5	42.1%		
Channel Erosion		2.8	9.2%		
Turley Creek Totals	**6,016.3**	**1,213.6**	**30.1%**		
Long Meadow Run					
Row Crops, Pasture, and Riparian Pasture	6,407.7	2,890.5	58.0%	32,323.2	75.0%
Hay and Residential (incl. Septics)	1,792.9	350.2	15.5%	14,568.7	46.2%
Forest	1,663.7	15.8	0.0%	1,080.9	0.0%
Harvested Forest and Transitional	23.1	17.7	39.9%	59.1	21.4%
Channel Erosion		1.8	15.5%	3.9	46.2%
Long Meadow RunTotals	**9,887.5**	**3,276.1**	**53.1%**	**48,035.7**	**64.2%**

5.2. *Selection of Appropriate Control Measures*

Potential control measures, their costs, and pollutant removal effectiveness estimates were identified through a review of the Turley Creek and Long Meadow Run TMDLs, through input from the IP Working Groups, from literature review, from modeling, and from review and adjustments suggested by local health department and soil and water conservation personnel. Because Turley Creek and Long Meadow Run each contain a combination of agricultural and developed land uses, implementation actions to address the required pollutant reductions will consist of a variety of control measures to address each pollutant source. Control measure selection was based on their ability to control specific pollutant sources, the required pollutant load reductions, the potential for cost-sharing of the control measure, the likelihood of implementation by landowners, and the input of watershed stakeholders. A list of potential control measures required to reduce these pollutant sources and their effectiveness values are listed in Table 5-2. BMPs that result in a landuse change have a variable efficiency depending on a variety of site-specific conditions.

Table 5-2. Potential control measure efficiencies for nitrogen and sediment

BMP ID	BMP Name	Reduction Type	Nitrogen Removal Efficiency (%)	Sediment Removal Efficiency (%)
FR-1	Aforestation of erodible crop and pastureland	Landuse change		
FR-3, CRFR-3	Woodland buffer filter area (cropland filter)	Efficiency	48.46	52.57
IA-747	Denitrifying Bioreactor	Efficiency	60	0
LE-1T	Livestock Exclusion with Riparian Buffers (fencing)	Landuse change		
LE-1T	Livestock Exclusion with Riparian Buffers (PrecRotGraz)	Efficiency	10.15	30
LE-1T	Livestock Exclusion with Riparian Buffers (upland filter)	Efficiency	33.88	52.57
LE-2, LE-2T	Livestock Exclusion with Reduced Setback (fencing)	Landuse change		
LE-2, LE-2T	Livestock Exclusion with Riparian Buffers (PrecRotGraz)	Efficiency	10.15	30
LE-2, LE-2T	Livestock Exclusion with Riparian Buffers (upland filter)	Efficiency	33.88	52.57
NM-1A	Nutrient Management Plan Writing and Revisions	Efficiency	6.21	0
NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	Efficiency	7	0
RB-1	Septic Tank Pumpout	Efficiency	5	0
RB-2	Septic Connections	Efficiency	100	0
RB-3	Septic tank system repair	Efficiency	27	0
RB-4	Septic tank system installment/replacement	Efficiency	27	0
RB-4P	Septic tank system installment/replacement with pump	Efficiency	27	0
RB-5	Alternative on-site waste treatment systems	Efficiency	50	0
SL-1	Permanent Vegetative Cover on Cropland	Landuse change		
SL-10T	Pasture Management	Efficiency	10.15	30
SL-11	Permanent Vegetative Cover on Critical Areas	Landuse change		
SL-15A	Continuous No-Till System	Efficiency	3.05	64
SL-6, CRSL-6, SL-6T	SL-6 (fencing portion)	Landuse change		
SL-6, CRSL-6, SL-6T	SL-6 (upland filter)	Efficiency	33.88	52.57
SL-6, CRSL-6, SL-6T	SL-6 (upland portion)	Efficiency	10.15	30
SL-6B	Alternative Water System	Efficiency	5	10
SL-8B	Small Grain cover crop for Nutrient Management	Efficiency	23.97	13.33
SL-8H	Harvestable Cover Crop	Efficiency	13.27	0
SL-9	Grazing Land Protection	Efficiency	10.15	30
WP-1	Sediment retention, erosion, or water control structures	Efficiency	20	60
WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	Landuse change		
WP-2, CRWP-2, WP-2T	Streambank protection (upland filter)	Efficiency	33.88	52.57
WP-2A	Streambank Stabilization	Load reduction		
WP-4	AWMS (winter feeding facility/dry stack)			
WP-4	AWMS (poultry dry-stack facility)			
	Barnyard runoff controls	Efficiency	20	40
WP-4B	Loafing Lot Management System	Efficiency	20	40
WP-4C	Composter Facilities			
WP-7	Surface Water Runoff Impoundment for Water Quality	Efficiency	20	60
WQ-1	Grass filter strips (Hayland conversion)	Landuse change		
WQ-1	Grass filter strips (Hayland filter)	Efficiency	33.88	52.57
WQ-11, CRWQ-11	Agricultural Sinkhole Protection	Efficiency	20	40
WQ-4	Legume Cover Crop	Efficiency	5.14	2.67
WQ-6B, CRWQ-6B	Wetland Restoration	Efficiency	16.64	9.75
	Brush Management			
	Manure Transport	Load reduction		

Livestock exclusion includes additional reductions from filtering of upstream runoff loads: 4x area for nitrogen, 2x area for sediment and, where noted, reductions for associated Rotation Grazing (PrecRotGraz).

Nitrogen and sediment removal efficiencies are primarily from the Chesapeake Bay Watershed Implementation Plans, except for the denitrifying bioreactor, whose nitrogen efficiency is from preliminary research results by Easton.

Appendix A provides a glossary of BMP and other control measure definitions, while Appendix B contains a list of BMP codes and practice names.

5.3. *Quantification of Control Measures by Pollutant Source*

The extent of existing control measures previously implemented in the Turley Creek and Long Meadow Run watersheds were quantified using the Virginia DCR Agricultural BMP Tracking Program database and data provided by USDA's local NRCS office. The initial list of control measures considered for inclusion in the implementation plan consisted of those practices already installed in the Turley Creek and Long Meadow Run watersheds, given that there is already some degree of acceptability for these types of control measures. These were supplemented with additional BMPs recommended as being needed by local soil and water conservation personnel.

For the AllForX and the Existing conditions modeling, BMPs were simulated as passthru factors by state 6-digit HUC watersheds for both the impaired and comparison watersheds. These passthru factors accounted for BMPs installed from 2002 through 2007, and were the same ones used by Virginia DCR for the 2014 Statewide Watershed Nonpoint Source Pollutant Load Assessment.

For the 2009 baseline Existing Conditions modeling, active BMP extents were assessed and summarized from local SWCD and NRCS data that corresponded with additional BMPs installed between 2008 and 2009 to correspond with the simulated land use and weather. GIS spatial analyses were used to extract BMPs that fell within the Long Meadow Run and Turley Creek portions of state HUs PS57 and PS55, respectively. These were then spatially joined with appropriate sub-watersheds within Long Meadow Run and Turley Creek watersheds. Pivot tables were then created in an EXCEL spreadsheet to summarize BMP extents for each sub-watershed by practice and year installed. BMPs active in 2009 and in 2014 were assessed as those within their respective design practice life, and in certain instances, using best professional judgment.

SWCD and NRCS data were summarized individually for each sub-watershed. These BMPs were then cross-walked with the Chesapeake Bay Program's BMP Short Names to enable assignment of appropriate load reductions or reduction efficiencies.

NRCS data only included those BMPs not receiving SWCD cost-sharing, in order to avoid double-counting practices. A summary of implementation extents available under both programs summed for each watershed are included in Table 5-3 and Table 5-4 for SWCD and NRCS, respectively.

Table 5-3. Implementation under SWCD Cost-Share Program, 2010-2014

DCR Practice Code	Practice Name	Long Meadow Run	Turley Creek	Units
CP-22	Riparian Buffer Rent	8.3	4	Acres
CRFR-3	CREP Riparian Forest Buffer Planting	8.3	1.1	Acres
CRSL-6	CREP Grazing land protection	2,020	1,275	Lin. Feet
FR-1	Aforestation of erodible crop and pastureland	3	4.7	Acres
FR-3	Woodland buffer filter area	0.4	0.7	Acres
LE-2	Livestock Exclusion with Reduced Setback	0	3,990	Lin. Feet
NM-1A	Nutrient Management Plan Writing and Revisions	2,128.62	0	Acres
NM-3B	Manure Application to Corn Using Pre-app. Nitrate Test	101.72	0	Acres
SL-1	Permanent Vegetative Cover on Cropland	96.2	8.5	Acres
SL-11B	Farm Road or Heavy animal Travel lane Stabilization	0.19	0.22	Acres
SL-6	Stream Exclusion With Grazing Land Management	670	6,620	Lin. Feet
SL-6B	Alternative Water System	127.4	31.7	Acres
SL-8B	Small Grain cover crop for Nutrient Management	1,203.06	0	Acres
SL-8H	Harvestable Cover Crop	193.2	0	Acres
WP-2	Streambank protection (fencing)	700	3,455	Lin. Feet
WP-2B	Stream Crossing & Hardened Access	0	1	Count
WP-4	Animal waste control facilities	2	0	Count
WP-4C	Composter Facilities	6	0	Count
Total Cost of DCR Cost-Shared BMPs between 2010 and 2014		**$250,548**	**$96,556**	

Table 5-4. Implementation under USDA-NRCS Cost-share Program, 2010-2011

NRCS Practice Code	NRCS Practice Name	Long Meadow Run	Turley Creek	Units
100	Comprehensive Nutrient Management Plan	1	0	number
102	Comprehensive Nutrient Management Plan - Written	1	0	number
103	Comprehensive Nutrient Management Plan - Applied	3	0	number
313	Waste Storage Facility	3	0	number
316	Animal Mortality Facility	1	0	number
328	Conservation Crop Rotation	269.1	90.2	acres
340	Cover Crop	5.9	0	acres
382	Fence	3385	1617	lin. ft.
512	Forage and Biomass Planting	28.8	0	acres
516	Pipeline	1635	785	lin. ft.
528	Prescribed Grazing	61.4	0	acres
561	Heavy Use Area Protection	2	0	acres
578	Stream Crossing	0	1	number
595	Integrated Pest Management (IPM)	4.5	0	acres
612	Tree/Shrub Establishment	2.6	0	acres
614	Watering Facility	1	2	number
633	Waste Recycling	628.2	0	acres

BMPs involving land use changes were simulated as acreages and load reductions from the former land use and as acreage and load increases in the new land use. Load reductions by land use were summarized as passthru factors. State SL-6 and CRSL-6 practices were simulated as having land use change, filtering effect, and rotational grazing components; state LE-2 and WP-2 practices had both a land use change and a filtering component. Rotational grazing acres were calculated as the Area Benefitted minus (fencing length x buffer width) / 43,560. Efficiencies for filtering practices were applied to 2x the buffer acreage for sediment and 4x the buffer acreage for nitrogen.

An analysis was then performed to identify the maximum extent of each measure needed to meet reduction goals. The initial list of control measures was supplemented with additional measures identified through discussions with stakeholders at the public and working group meetings. This section provides a summary of the final set of control measures and extents needed to achieve the load reductions specified in each TMDL for the identified pollutants in each watershed. Summaries of control measures for Long Meadow Run and Turley Creek are given in Table 5-5 and Table 5-6, respectively. Note that reduction targets have been discounted by reductions due to implementation efforts between 2010 and 2014 at the bottom of each table.

Load reductions were based on source loads simulated for the TMDL study, changes in land use, filtering effects of applicable control measures, and the application of effectiveness estimates. Additional details on the control measures applicable to each landuse are described in the appropriate following sub-section, while details on the load reduction calculations for each control measure are provided in Appendix C.

Table 5-5. Turley Creek Control Measures and Sediment Reductions

Landuse Type	BMP ID	Control Measure Name	Needed BMP Extents	Extent Units	Sediment Load Reduction (tons/yr)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	5.00	acres	7.99
	FR-3, CRFR-3	Woodland buffer filter area	5.00	systems	16.38
	SL-1	Permanent Vegetative Cover on Cropland	4.00	acres	5.76
	SL-15A	Continuous No-Till System	40.00	acres	41.41
	SL-8B	Small Grain cover crop for Nutrient Management	45.00	acres	9.71
	SL-8H	Harvestable Cover Crop	120.00	acres	---
	WP-1	Sediment retention, erosion, or water control structures	1	systems	9.71
AFO/CAFO	WP-4	AWMS (Winter feeding facility)	3	systems	---
		AWMS (Poultry dry-stack facility)	2	systems	---
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	2.00	acres	1.58
	FR-3, CRFR-3	Woodland buffer filter area	5.00	acres	8.21
	SL-7	Extension of CREP Watering Systems	60.00	acres	14.59
	SL-11	Permanent Vegetative Cover on Critical Areas	4.00	systems	10.09
	SL-6, CRSL-6, SL-6T, LE-1T	SL-6 (fencing portion)	5	systems	119.06
	WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	3	systems	13.01
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	3	systems	18.41
		LE + 10-foot setback + Limited Access + PrecRotGraz	2	systems	12.27
	Not cost-shared	LE + 10-foot setback using Polywire	2	systems	12.27
	SL-10T	Grazing Land Protection	40.00	acres	9.73
Harvested forest		Forest harvesting BMP			1.83
Transitional		Erosion and sediment control BMPs			2.61
Channel Erosion	WP-2A	Streambank Stabilization	300.00	linear feet	6.51
Springs	WP-1	Sediment retention, erosion, or water control structures	1	systems	25.99
Total Reduction					**347.13**
Target Reduction					364.68
Target Reduction after 2010-2014 BMPs					346.40

**The SL-8H practice is not eligible for cost-share under current DCR Guidelines.

Table 5-6. Long Meadow Run Control Measures and Nitrogen and Sediment Reductions

Landuse Type	BMP ID	Control Measure Name	Needed BMP Extents	Extent Units	Nitrogen Load Reduction (lbs/yr)	Sediment Load Reduction (tons/yr)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	20	acres	127.33	31.73
	FR-3, CRFR-3	Woodland buffer filter area	5	acres	99.82	7.93
	NM-1A	Nutrient Management Plan Writing and Revisions	100	acres	43.59	---
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	500	acres	198.58	---
	SL-1	Permanent Vegetative Cover on Cropland	50	acres	332.59	71.66
	SL-15A	Continuous No-Till System	185	acres	39.58	188.97
	SL-8B	Small Grain cover crop for Nutrient Management	200	acres	336.27	42.56
	SL-8H	Harvestable Cover Crop	120	acres	111.70	---
	WP-1	Sediment retention, erosion, or water control structures	2	systems	28.06	19.15
	WQ-4	Legume Cover Crop	50	acres	18.03	2.13
AFO/CAFO		Barnyard runoff controls	4	systems	28.74	0.99
	WP-4	AWMS (Winter feeding facility)	6	systems	---	---
	WP-4	AWMS (Poultry dry-stack facility)	4	systems	---	---
	WP-4B	Loafing Lot Management System	1	systems	3.59	0.25
	WP-4C	Composter Facilities	6	systems	---	---
		Manure Transport*	695	tons	18,348.00	---
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	20	acres	94.75	14.70
	FR-3, CRFR-3	Woodland buffer filter area	5	acres	29.22	3.68
	SL-7	Extension of CREP Watering Systems	100	acres	54.66	22.34
	SL-11	Permanent Vegetative Cover on Critical Areas	15	acres	135.66	34.80
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	40	systems	2,581.04	825.03
	WP-2, CRWP-2, WP-2T	LE + Limited Access	14	systems	294.13	55.85
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	22	systems	352.50	106.79
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	13	systems	352.50	63.10
	Not cost-shared	LE + 10-foot setback using Polywire	15	systems	176.25	72.81
	SL-10T	Grazing Land Protection	120	acres	65.60	26.81
	WP-1	Sediment retention, erosion, or water control structures	0	systems	0.00	0.00
	WQ-1	Grass filter strips (Hayland conversion)	10	acres	80.26	2.83
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	10	number	9.04	4.64
		Brush Management	300	acres	0.00	0.00
Harvested forest		Forest harvesting BMP			12.63	0.43
Transitional		Erosion and sediment control BMPs			0.00	6.64
Channel Erosion	WP-2A	Streambank Stabilization	500	linear feet	37.50	10.85
Septics	RB-1	Septic Tank Pumpout	111	systems	114.72	---
	RB-2	Septic Connections	9	systems	186.03	---
	RB-3	Septic tank system repair	40	systems	223.24	---
	RB-4	Septic tank system installment/replacement	15	systems	83.71	---
	RB-4P	Septic tank system installment/replacement with pump	10	systems	55.81	---
	RB-5	Alternative on-site waste treatment systems	15	systems	155.02	---
Springs	IA-747	Denitrifying Bioreactor	1	systems	5,174.74	---
Total Reduction					**29,984.88**	**1,616.68**
Target Reduction					30,843.68	1,738.15
Target Reduction after 2010-2014 BMPs					29,951.73	1,612.70

** The SL-8H and Brush management practices are not eligible for cost-share under current DCR Guidelines.

5.3.1. Cropland

Runoff from cropland is a source of both nitrogen and sediment loads. Nitrogen loads are delivered to the land from the spreading of stored manure and from applied commercial fertilizer, while sediment loads result from combinations of slope, soil conditions, vegetative cover, and rainfall intensity. Nitrogen from manure and fertilizer can be reduced either by source reduction or filtering measures (buffers), while sediment can be reduced by measures that increase vegetative cover, reduce effective slope lengths, or provide filtering. The selected cropland control measures include the Continuous No-till (SL-15A) practice, the use of Cover Crops (SL-8B, SL-8H, and WQ-4), permanent vegetative cover (SL-1), afforestation of erodible cropland (FR-1), woodland buffers (FR-3), grass filters (WQ-1), sediment and erosion retention structures (WP-1), and Nutrient Management practices (NM-1A and NM-3C).

5.3.2. Animal Feeding Operations

Animal feeding operations tend to concentrate manure generation and to produce runoff-driven sediment and nutrients from impervious and bare areas surrounding these operations. Excess nitrogen is targeted primarily through Manure Transport of excess manure out of the watershed, while barnyard runoff controls and loafing lot management are the primary measures used to control sediment in these areas. Animal Waste Management Storage (WP-4) facilities, including poultry litter storage sheds, beef winter feeding facilities, and Mortality Composters (WP-4C) are also included as complimentary BMPs to control nutrients from these operations.

5.3.3. Degraded Riparian Pasture

Unrestricted livestock access to streams allows for direct deposition of manure and associated nutrients into streams, and promotes degradation of streambanks and riparian vegetation through livestock hoof action A GIS analysis was performed to delineate stream lengths adjacent to, or included in, pasture areas in these watersheds. The National Agricultural Statistics Service 2009 cropland data layer was used for this analysis. Since the NASS data were also used for the determination of land use areas for TMDL modeling, these data were used to assess the relative intersection of pasture areas and streams for IP development. Because of the difficulty in differentiating between pasture and hay in aerial imagery, the two NASS landuse categories – “Pasture/Grass” and “Other Pasture/Hay” were combined for this analysis. Local NRCS estimates of the pasture/hay distribution as 85% pasture and 15% hay were then applied to the total riparian stream length. The 2011 National Hydrography Dataset (NHD) streams layer was used to represent streams and to classify them as either perennial or intermittent. Since streams may have access from either 1-side or 2-sides, a visual estimate of 1-sided streams was made in Turley Creek (7.8%) and applied to both watersheds, and the remainder assessed as having 2-sided access. The total stream length requiring fencing was then multiplied by a 35-ft buffer, converted to acres and compared with the area in "degraded riparian pasture" used for modeling in each watershed. The modeled areas were 21-29% smaller than the calculated areas, so the stream length requiring fencing was reduced by those amounts, assuming that the difference was due to intermittent streams that do not require fencing. This produced an estimate of 188,428 feet of fencing needs in Long Meadow Run and 57,873 feet in Turley Creek.

"Livestock exclusion fencing" is defined as fencing that meets VADCR or federal CREP (Conservation Reserve Enhancement Program) cost-share requirements with a minimum of a 10 ft. or 35 ft. buffer, while "voluntary fencing" is defined as poly-wire fencing with a narrower buffer width decided by the landowner (assumed to be 10 feet) that is not eligible for cost-sharing. The agricultural working group requested that a combination of livestock exclusion fencing and voluntary fencing practices be included in the IP for these watersheds.

Some applicable cost-shared BMPs for livestock exclusion in these watersheds are the SL-6/CRSL-6 practice (Livestock Exclusion with Riparian Buffers), the LE-2T (Livestock Exclusion with Reduced Setback for TMDL Implementation), and the WP-2T (Stream Protection for TMDL Implementation) systems of practices. The SL-6/CRSL-6 practice includes streamside fencing, cross fencing, alternative water system(s) and/or hardened stream crossing(s) when needed, and a 35-ft buffer from the stream. While most systems utilize grass buffers in the excluded area, some SL-6/CRSL-6 practices are configured with an add-on forest buffer practice (FR-3/CRFR-3). The LE-2T practice is similar to the SL-6 practice, except that the stream exclusion fencing requires a minimum buffer of only 10 feet from the stream. The WP-2T practice is similar to the SL-6 practice, except it does not include an alternative watering system and the cost-share rate is less. The WP-2T system may be a suitable option where a watering system already exists. The SL-6 and LE-2T practices also include rotational grazing components.

The percentage mix of the various livestock exclusion (LE) alternative practices was based on the distribution needed to achieve the overall watershed sediment reductions. While this IP focuses on fencing along both perennial and intermittent streams, the highest priority should be given to livestock exclusion systems on perennial streams to achieve the most impact on reducing nitrogen and sediment loads.

5.3.4. Pasture

Runoff from pasture is also a source of both nitrogen and sediment loads. Nitrogen loads to pasture areas come from grazing livestock and the spreading of stored manure and commercial fertilizer. While part of the nitrogen and sediment loads from pasture areas will be filtered by buffers inside fencing in the riparian zone, additional reductions in pollutants from pasture areas can be achieved through improved pasture management and rotational grazing included as a component in most livestock exclusion BMPs, along with the state Grazing Land Management (SL-10T) BMP, and the CREP Extension to Watering Systems (WP-7) practice. Some areas may also require critical area stabilization (SL-11), installation of a sediment control structure (WP-1), or conversion to forest (FR-1) practices to reduce excess erosion. Also included in the menu of control measures is the NRCS practice for Brush Management which was added in response to stakeholders concerns about erosion promoted by the spread of shallow-rooted invasive cedar trees in pastures.

5.3.5. Residential

The primary pollutant control measures included in this IP for residential areas relate to septic systems and local springs. Since nitrogen was identified as a pollutant only in Long Meadow Run, this suite of practices only applies in that watershed. In Long Meadow Run watershed, 64% of the population is on sewer systems.

Based on discussions with a representative from the Shenandoah Valley SWCD during the residential working group meeting and follow-up discussions with a representative of the Virginia Department of Health, it was estimated that 50% of failing septic systems could be repaired without installing a new system. Of those failing systems needing to be replaced, it was estimated that 40% would be conventional systems, 35% would need to be replaced with alternative waste treatment systems because of soil and bedrock limitations in the watershed, and 25% would need to include a pump to lift the septic tank effluent to the drain field. Septic tank pump-outs were discussed at the Steering Committee/Residential Working Group meeting. It was estimated that 20% of the 555 non-sewered households in Long Meadow Run would volunteer to schedule pump-outs if they were made aware of the necessity and benefits of septic pump-outs. The RB-1 (Septic Tank Pump-out) practice can also be used as a first step in identifying failing septic systems in the watershed. In addition to these control measures, an educational effort that targets septic system awareness and basic maintenance will be important for successful implementation.

One spring in Turley Creek was noted as a source of underground sediment arising from the karst terrain and other possibly unknown causes. A sediment retention structure (WP-1) was proposed to reduce the impact of this source on Brock Creek, a tributary to Turley Creek. In Long Meadow Run, a major spring was monitored with high nitrate baseflow concentrations, similar to those at the watershed's outlet. A denitrifying bioreactor (DNBR) would be a very cost-effective BMP to reduce the nitrates from this or similar appropriate source areas.

Sediment loads from construction areas in the watersheds arise primarily from stormwater runoff over areas where land has been disturbed and vegetative cover removed. Some of these areas may have had transient erosion and sediment (E&S) permits, may have been disturbed prior to the issuance of a permit, or may represent smaller areas of disturbance that do not require a permit. Areas with E&S permits are already required to control sediment runoff from these sites, but may require increased setback distances, faster establishment of vegetation in setback areas, or for increased plantings in setback areas, as determined by state inspectors.

5.3.6. Forest Harvesting BMPs

The main source of sediment on forested lands comes from commercial forest harvesting operations. In Virginia, loggers are required to protect water quality, and the VDOF developed BMPs as guidelines for proper timber harvesting for Virginia's loggers.

To ensure voluntary compliance with these guidelines, the VDOF began conducting Best Management Practice Field Audits in 1993. Conducted four times a year, the field audits provide a useful tool in gauging the status of Virginia's water quality protection efforts. If loggers do not follow "best management practices" on harvest sites, sediment deposition may occur, and that can cause them to face civil penalties under the Silvicultural Water Quality Law. The forest harvesting BMP is a system of integrated conservation practices that are designed to prevent off-site sediment impact, protect stream crossings, and neutralize storm water runoff.

5.4. *Technical Assistance Needs*

Technical assistance is needed for design and installation of selected control measures, as well as for educational outreach. An implementation period of 5 years is planned for Turley Creek, while a longer 10 year period of implementation is planned for Long Meadow Run. Additional technical assistance needed in the Turley Creek watershed is estimated as one-half (0.5) full-time-equivalent (FTE) employee per year for the 5 years of implementation, while an average of 1.5 FTE is needed for the first 5 years in Long Meadow Run, with 1.0 FTE needed in the second 5 years. These estimates were based on similar projects and experience and knowledge of the Steering Committee. Educational outreach will include strategies identified by stakeholders for facilitating installation and execution of implementation actions.

5.5. *Education and Outreach*

Personnel from the Shenandoah Valley SWCD and NRCS have already been in contact with farmers in the watershed, providing outreach, technical and financial assistance to farmers to encourage the installation of agricultural BMPs. The Agricultural Working Group suggested that an outreach campaign be presented to the numerous local Ruritan Clubs to educate farmers on the availability of opportunities through this implementation plan and to educate homeowners of the possibility of failing septic systems. One idea that was brought forward in the Agriculture Working Group was to investigate the possibility of recruiting Trout Unlimited’s “Trout in the Classroom” program for schools in the Turley Creek area. The school system was also identified as a common channel of communication where many homeowners, renters, and other stakeholders could be reached either through their children's school programs, "back to school" nights, PTA service announcements, or other methods.

Other educational tasks identified in neighboring TMDL watersheds include:

- Promoting benefits of properly installed and maintained septic systems.
- Utilizing the Virginia Cooperative Extension (VCE) Household Water Quality Program to educate homeowners about well and septic system management.
- Coordinating with Friends of the North Fork Shenandoah River, Valley Conservation Council, Pure Water Forum, and other watershed groups when conducting outreach programs with stakeholders.
- Providing materials for conservation and natural resources management to local area schools.
- Providing implementation effort materials to local VCE 4-H and agricultural extension agents for use in their presentations.
- Supporting efforts to strengthen an existing ordinance so that poultry litter sold to other farmers is stored properly prior to land application.

5.6. *Costs of Implementation*

The costs of implementation were calculated as the extent of BMPs needed throughout the respective implementation period in each watershed, their related unit costs, and estimates of technical assistance needed. Unit costs were estimated from the DCR state agricultural cost-share database for Rockingham County and from the 2015 USDA-NRCS cost list for Virginia, from literature values, and from discussions with local technical personnel.

Technical assistance needs were calculated based on an estimate of the additional SWCD personnel required for installation of the pollutant control measures. For planning purposes, one full-time employee (FTE) was budgeted as $50,000/yr, including benefits, training, and related costs. Technical assistance was estimated as 0.5 FTE for Turley Creek over the 5 years of implementation, amounting to $25,000 per year. In Long Meadow Run, the estimated additional personnel amounted to 1.5 FTE during the first 5 years of implementation and 1.0 FTE during the second 5 years.

The extent of sediment control measures was quantified earlier in this chapter for meeting TMDL pollutant reductions in Turley Creek, if all were to be installed in one year. However, since implementation is planned over a 5-year period in this watershed, each BMP whose practice life is less than the implementation period must be implemented more than once on the same acreage. These Needed BMP Extents and the Cumulative Needed BMP Extents are summarized in Table 5-7 together with their practice life, unit costs, and total implementation costs for Turley Creek. The total estimated cost for full implementation of sediment control measures in the Turley Creek watershed is $765,145.

Table 5-7. Turley Creek Control Measures Costs

Landuse Type	BMP ID	Control Measure Name	Unit Cost ($/unit)	Practice Life (yrs)	Needed BMP Extents	Extent Units	5-yr Needed BMP Extent	Stage I Implementation Cost ($)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	$1,000.00	10	5.00	acres	5	$5,000
	FR-3, CRFR-3	Woodland buffer filter area	$1,125.00	10	5.00	systems	2	$2,250
	SL-1	Permanent Vegetative Cover on Cropland	$155.00	5	4.00	acres	4	$620
	SL-15A	Continuous No-Till System	$55.00	5	40.00	acres	40	$2,200
	SL-8B	Small Grain cover crop for Nutrient Management	$100.00	1	45.00	acres	225	$22,500
	SL-8H	Harvestable Cover Crop	$100.00	1	120.00	acres	600	$60,000
	WP-1	Sediment retention, erosion, or water control structures	$4,600.00	10	1	systems	1	$4,600
AFO/CAFO	WP-4	AWMS (Winter feeding facility)	$50,000.00	10	3	systems	3	$150,000
		AWMS (Poultry dry-stack facility)	$38,000.00	15	2	systems	2	$76,000
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	$1,000.00	10	2.00	acres	2	$2,000
	FR-3, CRFR-3	Woodland buffer filter area	$1,125.00	10	5.00	acres	5	$5,625
	SL-7	Extension of CREP Watering Systems	$250.00	10	60.00	acres	60	$15,000
	SL-11	Permanent Vegetative Cover on Critical Areas	$925.00	10	4.00	systems	2	$1,850
	SL-6, CRSL-6, SL-6T, LE-1T	SL-6 (fencing portion)	$44,020.00	10	5	systems	2	$88,040
	WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	$11,420.00	10	3	systems	2	$22,840
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	$42,370.00	10	3	systems	2	$84,740
		LE + 10-foot setback + Limited Access + PrecRotGraz	$12,700.00	10	2	systems	2	$25,400
	Not cost-shared	LE + 10-foot setback using Polywire	$6,700.00	5	2	systems	2	$13,400
	SL-10T	Grazing Land Protection	$77.00	10	40.00	acres	40	$3,080
Harvested forest		Forest harvesting BMP						
Transitional		Erosion and sediment control BMPs						
Channel Erosion	WP-2A	Streambank Stabilization	$100.00	20	300.00	linear feet	300	$30,000
Springs	WP-1	Sediment retention, erosion, or water control structures	$4,600.00	10	1	systems	1	$25,000
		Technical Assistance	$50,000.00		0.5	person-yrs	2.5	$125,000
		Total Costs						**$765,145**

The extents of nitrogen and sediment control measures were quantified earlier in this chapter for meeting TMDL pollutant reductions in Long Meadow Run, if all were to be installed in one year. However, since implementation is planned over a 10-yr period in this watershed, each BMP whose practice life is less than the implementation period must be implemented more than once on the same acreage. These Needed BMP Extents and the Cumulative Needed BMP Extents are summarized in Table 5-8 together with their practice life, unit costs, and total implementation costs for Long Meadow Run.

The total estimated cost for full implementation of sediment control measures in the Long Meadow Run watershed is $6.33 M.

Table 5-8. Long Meadow Run Control Measure Costs

Landuse Type	BMP ID	Control Measure Name	Unit Cost ($/unit)	Practice Life (yrs)	Needed BMP Extents	Implementation Extent		Extent Units	Cumulative 10-yr Needed BMP Extents	Implementation Costs	
						Stage I (5 years)	Stage II (5 years)			Stage I ($)	Stage II ($)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	$1,000	10	20	12	8	acres	20	$12,000	$8,000
	FR-3, CRFR-3	Woodland buffer filter area	$1,125	10	5	3	2	acres	5	$3,375	$2,250
	NM-1A	Nutrient Management Plan Writing and Revisions	$35	3	100	120	100	acres	220	$4,200	$3,500
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	$5	1	500	1500	2500	acres	4000	$7,500	$12,500
	SL-1	Permanent Vegetative Cover on Cropland	$155	5	50	30	50	acres	80	$4,650	$7,750
	SL-15A	Continuous No-Till System	$55	5	185	108	180	acres	288	$5,940	$9,900
	SL-8B	Small Grain cover crop for Nutrient Management	$100	1	200	600	1000	acres	1600	$60,000	$100,000
	SL-8H	Harvestable Cover Crop	$100	1	120	360	600	acres	960	$36,000	$60,000
	WP-1	Sediment retention, erosion, or water control structures	$4,600	10	2	1	0	systems	1	$4,600	$0
	WQ-4	Legume Cover Crop	$90	1	50	150	250	acres	400	$13,500	$22,500
AFO/CAFO		Barnyard runoff controls	$6,735	10	4	3	1	systems	4	$20,205	$6,735
	WP-4	AWMS (Winter feeding facility)	$50,000	10	6	3	2	systems	5	$150,000	$100,000
	WP-4	AWMS (Poultry dry-stack facility)	$38,000	15	4	3	1	systems	4	$114,000	$38,000
	WP-4B	Loafing Lot Management System	$80,000	10	1	1		systems	1	$80,000	$0
	WP-4C	Composter Facilities	$22,300	10	6	4	2	systems	6	$89,200	$44,600
		Manure Transport*	$20	1	695	2085	3475	tons	5560	$0	$0
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	$1,000	10	20	12	8	acres	20	$12,000	$8,000
	FR-3, CRFR-3	Woodland buffer filter area	$1,125	10	5	3	2	acres	5	$3,375	$2,250
	SL-7	Extension of CREP Watering Systems	$250	10	100	60	40	acres	100	$15,000	$10,000
	SL-11	Permanent Vegetative Cover on Critical Areas	$925	10	15	10	5	acres	15	$9,250	$4,625
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	$44,020	10	40	22	16	systems	38	$968,440	$704,320
	WP-2, CRWP-2, WP-2T	LE + Limited Access	$11,420	10	14	8	5	systems	13	$91,360	$57,100
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	$42,370	10	22	14	8	systems	22	$593,180	$338,960
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	$12,700	10	13	8	5	systems	13	$101,600	$63,500
	Not cost-shared	LE + 10-foot setback using Polywire	$6,700	5	15	9	15	systems	24	$60,300	$100,500
	SL-10T	Grazing Land Protection	$77	10	120	72	48	acres	120	$5,544	$3,696
	WP-1	Sediment retention, erosion, or water control structures	$4,600	10	0	0	0	systems	0	$0	$0
	WQ-1	Grass filter strips (Hayland conversion)	$260	5	10	6	10	acres	16	$1,560	$2,600
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	$2,814	10	10	6	4	number	10	$16,882	$11,254
		Brush Management	$350	2	300	450	750	acres	1200	$157,500	$262,500
Harvested forest		Forest harvesting BMP									
Transitional		Erosion and sediment control BMPs									
Channel Erosion	WP-2A	Streambank Stabilization	$100	20	500	300	200	linear feet	500	$30,000	$20,000
Septics	RB-1	Septic Tank Pumpout	$275	5	111	67	111	systems	178	$18,425	$30,525
	RB-2	Septic Connections	$5,600	25	9	6	3	systems	9	$33,600	$16,800
	RB-3	Septic tank system repair	$6,000	10	40	24	16	systems	40	$144,000	$96,000
	RB-4	Septic tank system installment/replacement	$8,000	10	15	9	6	systems	15	$72,000	$48,000
	RB-4P	Septic tank system installment/replacement with pump	$11,000	10	10	6	4	systems	10	$66,000	$44,000
	RB-5	Alternative on-site waste treatment systems	$25,000	10	15	9	6	systems	15	$225,000	$150,000
Springs	IA-747	Denitrifying Bioreactor	$40,000	5	1	1	1	systems	2	$40,000	$40,000
		Total Costs								**$3,645,186**	**$2,680,365**

* Manure Transport provides a net benefit to the farmer when sold as fertilizer.

The number of pollutants reduced with each control measure may vary from a single pollutant to a wide range of pollutants. The cost effectiveness analysis shown in Table 5-9 does not attempt to perform a complete benefit analysis, but is confined to long-term cost/unit pollutant for nitrogen and sediment in the Long Meadow Run watershed, and for sediment in the Turley Creek watershed. These cost effectiveness factors for the various control measures do not attempt to factor in the cost savings from reductions of multiple pollutants, though obviously a greater benefit is received from these control measures. They do, however, consider load reductions over the useful practice life, so that the cost-effectiveness is calculated as practice cost ($) / (practice life (yrs) x load reduction/yr). For several BMPs, appropriate means of calculating pollutant load reduction had not been identified, though the need for them had been discussed at LSC meetings and costs have been ascribed. As these are quantified during implementation, extents of other less cost-effective BMPs can be reduced to arrive at the pollutant reduction endpoints in the most cost-effective fashion.

Table 5-9. Relative cost-effectiveness of control measures for nitrogen and sediment removal

Landuse Type	BMP ID	Control Measure Name	Practice Life (yrs)	Long Meadow Run		Turley Creek
				($ / lb nitrogen)	($ / ton sediment)	($ / ton sediment)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	10	$16	$63	$63
	FR-3, CRFR-3	Woodland buffer filter area	10	$6	$71	$34
	NM-1A	Nutrient Management Plan Writing and Revisions	3	$27		
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	1	$13		
	SL-1	Permanent Vegetative Cover on Cropland	5	$5	$22	$22
	SL-15A	Continuous No-Till System	5	$51	$11	$11
	SL-8B	Small Grain cover crop for Nutrient Management	1	$59	$470	$464
	SL-8H	Harvestable Cover Crop	1	$107		---
	WP-1	Sediment retention, erosion, or water control structures	10	$33	$48	$47
	WQ-4	Legume Cover Crop	1	$250	$2,115	
AFO/CAFO		Barnyard runoff controls	10	$94	$2,724	
	WP-4	AWMS (Winter feeding facility)	10			---
	WP-4	AWMS (Poultry dry-stack facility)	15			---
	WP-4B	Loafing Lot Management System	10	$2,227	$32,353	
	WP-4C	Composter Facilities	10			
		Manure Transport*	1			
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	10	$21	$136	$126
	FR-3, CRFR-3	Woodland buffer filter area	10	$19	$153	$68
	SL-7	Extension of CREP Watering Systems	10	$46	$112	$103
	SL-11	Permanent Vegetative Cover on Critical Areas	10	$10	$40	$37
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	10	$68	$213	$185
	WP-2, CRWP-2, WP-2T	LE + Limited Access	10	$54	$286	$263
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	10	$264	$873	$690
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	10	$47	$262	$207
	Not cost-shared	LE + 10-foot setback using Polywire	5	$114	$276	$218
	SL-10T	Grazing Land Protection	10	$14	$34	$32
	WP-1	Sediment retention, erosion, or water control structures	10			$18
	WQ-1	Grass filter strips (Hayland conversion)	5	$6	$184	
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	10	$311	$606	
		Brush Management	2			
Channel Erosion	WP-2A	Streambank Stabilization	20	$67	$230	$230
Septics	RB-1	Septic Tank Pumpout	5	$53		
	RB-2	Septic Connections	25	$11		
	RB-3	Septic tank system repair	10	$108		
	RB-4	Septic tank system installment/replacement	10	$143		
	RB-4P	Septic tank system installment/replacement with pump	10	$197		
	RB-5	Alternative on-site waste treatment systems	10	$242		
Springs	IA-747	Denitrifying Bioreactor	5	$2		
	WP-1	Sediment retention, erosion, or water control structures	10			$18

Blank cells indicate that practices were either not applied in that watershed or that they are not applicable to one or another of the pollutants. The “---“ symbol indicates that applicable reductions have not yet been quantified.

5.7. *Benefits of Implementation*

The primary benefit of implementation is cleaner waters in Virginia. During implementation planning, it is important to recognize that healthy waters improve economic opportunities for Virginians and a healthy economic base provides the resources and funding necessary to pursue restoration and enhancement activities. The agricultural and residential practices recommended in this document will provide economic benefits to the community, as well as the expected environmental benefits.

Specifically, alternative (clean) water sources, exclusion of cattle from streams, improved pasture management, and private sewage system maintenance will each provide economic benefits to land owners. Money spent by landowners and state agencies in the process of implementing this plan will stimulate the local economy. In addition to allowing the aquatic communities to thrive, the sediment control measures will also reduce delivery of other pollutants to the stream from upland locations. Many of the BMPs intended to reduce soil losses also increase infiltration, which will decrease peak flows downstream.

A clean water source has been shown to improve weight gain and milk production in cattle. Fresh clean water is an essential requirement for healthy livestock, with healthy cattle consuming, on a daily basis, close to 10% of their body weight during winter and 15% of their body weight in summer. Many livestock illnesses can be spread through contaminated water supplies. For instance, coccidia can be delivered through feed, water and haircoat contamination with manure (VCE, 2000). In addition, horses drinking from marshy areas or areas where wildlife or cattle carrying Leptospirosis have access tend to have an increased incidence of moonblindness associated with Leptospirosis infections (VCE, 1998b). Some farmers have also noticed decreased leg injuries in livestock from crossing steep or muddy stream banks (Zeckoski et al., 2007). A clean water source can prevent illnesses that reduce production and incur the added expense of avoidable veterinary bills.

In addition to reducing the likelihood of animals contracting waterborne illnesses by providing a clean water supply, streamside fencing excludes livestock from wet, swampy environments as are often found next to streams where cattle have regular access. Keeping cattle in clean, dry areas has been shown to reduce the occurrence of mastitis and foot rot. The VCE (1998a) reports that mastitis costs producers $100 per cow in reduced quantity and quality of milk produced. On a larger scale, mastitis costs the U.S. dairy industry about $1.7-2 billion annually or 11% of total U.S. milk production. While the spread of mastitis through a dairy herd can be reduced through proper sanitation of milking equipment, mastitis-causing bacteria can be harbored and spread in the environment where cattle have access to wet and dirty areas. Installation of streamside fencing and well managed loafing areas will reduce the amount of time that cattle have access to these areas.

Taking the opportunity to implement an improved pasture management system in conjunction with installing clean water supplies will also provide economic benefits for the producer. Improved pasture management can allow a producer to feed less hay in winter months, consequently, improving the profitability of the operation. With feed costs typically responsible for 70 to 80% of the cost of growing or maintaining an animal, and pastures providing feed at a cost of 0.01 to 0.02 cents/lb of total digestible nutrients (TDN) compared to 0.04 to 0.06 cents/lb TDN for hay, 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. Distributed off-stream waterers and cross-fencing can also improve forage utilization and manure nutrient distribution throughout a pasture (Zeckoski et al., 2007). In addition to reducing costs to producers, intensive pasture management can boost profits, by allowing higher stocking rates and increasing the amount of gain per acre. Another benefit is that cattle are in closer proximity to each other, allowing for quicker examination and handling. In general, many of the agricultural BMPs recommended in this document will provide both environmental benefits and economic benefits to the farmer.

The residential programs will play an important role in improving water quality, since human waste can carry with it human viruses in addition to the nitrogen loads targeted in the Long Meadow Run TMDL. In terms of economic benefits to homeowners, an improved understanding of on-site sewage treatment systems (OSTS), including knowledge of what steps can be taken to keep them functioning properly and the need for regular maintenance, will give homeowners the tools needed for extending the life of their systems and reducing the overall cost of ownership. The average septic system will last 20 to 25 years, if properly maintained. Proper maintenance includes: knowing the location of the system components and protecting them (e.g., not driving or parking on top of them), not planting trees in locations where roots could damage the system, keeping hazardous chemicals out of the system, and pumping out the septic tank every 3 to 5 years. The cost of proper maintenance, as outlined here, is relatively inexpensive in comparison to repairing or replacing an entire system. Additionally, the repair/replacement and pump-out programs will benefit owners of private sewage (e.g., septic) systems, particularly low-income homeowners, by sharing the cost of required maintenance.

In addition to the benefits to individual landowners, the economy of the local community will be stimulated through expenditures made during implementation, and the infusion of dollars from funding sources outside the impaired areas. Building contractors and material suppliers who deal with septic system pump-outs, private sewage system repair and installation, fencing, and other BMP components can expect to see an increase in business during implementation. Additionally, income from maintenance of these systems should continue long after implementation is complete. A portion of the funding for implementation can be expected to come from state and federal sources. This portion of funding represents money that is new to the area and will stimulate the local economy. In general, implementation will provide not only environmental benefits to the community, but economic benefits as well, which, in turn, will allow for individual landowners to participate in implementation.

6.0 MEASURABLE GOALS AND MILESTONES

6.1. *Implementation Goals*

The goals of TMDL implementation are to restore the water quality in the impaired stream segments in the Turley Creek and Long Meadow Run watersheds so that they comply with water quality standards and to de-list these segments from the Commonwealth of Virginia's 303(d) List of Impaired Waters. Progress towards these goals will be measured by improvement in the Virginia Stream Condition Index (VSCI). The VSCI is based on biological metrics calculated from an inventory of the benthic macro-invertebrate community in each stream, and is performed in the spring and the fall each year at biological monitoring stations on each impaired stream segment. As this IP addresses benthic impairments in both Turley Creek and Long Meadow Run, the ultimate water quality goal is the restoration of healthy benthic macro-invertebrate communities, denoted by two consecutive VSCI scores in the non-impaired range (≥ 60). Annual assessments of progress will monitor improvements not only in the VSCI scores, but also in two of the habitat metrics most related to sediment impacts – "sediment deposition" and "embeddedness", and, for Long Meadow Run, also in the nitrogen concentrations monitored at the watershed outlet. Because the relationship between nutrient and sediment "loads" and benthic community health is not fully quantifiable, the additional monitoring of the benthic community under this staged implementation approach is being used in lieu of interim water quality goals.

6.2. *Implementation Milestones*

Implementation milestones establish the fraction of implementation actions to be taken within certain timeframes, and these implementation actions are tracked as the number/type of control measures that are installed and programs or policies developed and executed. The milestones described here are intended to achieve 100% implementation in Turley Creek within 5 years, and in Long Meadow Run, approximately 60% implementation within the first 5 years and the final 40% implementation in the second 5 years. Gradual water quality improvement is expected during the stage following full implementation in each watershed, after which the water quality goals are expected to be met.

Many implementation activities are already underway in both watersheds. The Turley Creek and Long Meadow Run TMDL IP Steering Committee support these ongoing activities. Implementation of livestock exclusion and pasture management control measures that also reduce bacteria loads are encouraged, as these are complementary to practices needed for the North Fork of the Shenandoah River Bacteria TMDL, which encompasses Turley Creek and Long Meadow Run watersheds and calls for an 85% reduction in bacteria (manure) applied to cropland and pasture and a 30% reduction through livestock exclusion from streams.

The implementation of control measures will be accomplished in stages. In general, the Commonwealth intends that the needed control measures be implemented in a progressive process that first addresses the pollutant sources with the largest impact on water quality. This staged approach is based on meeting water quality goals over a ten-year period in Turley Creek and over a fifteen-year period in Long Meadow Run. The differences in the length of the implementation plans for the two watersheds are necessary to accommodate the larger number of practices needed to achieve nitrogen and sediment reductions in Long Meadow Run. Each stage will consist of a 5-year period. In Turley Creek, implementation will be completed during Stage I, with achievement of designated uses by the end of Stage II. In Long Meadow Run, implementation will be completed during the first two stages, followed by a period of gradual recovery to account for expected lag times in the system between implementation and water quality improvement in Stage III. In Long Meadow Run, Stage I will consist of the implementation of all needed pollutant control measures identified for cropland, approximately 60% of those identified for grazing lands and fencing systems, and the denitrifying bioreactor identified for addressing nitrogen from one spring source; Stage II will consist of completing implementation of all other identified pollutant control measures. After installation of all control measures during the first two stages, full maturation of the control measures, full attainment of water quality goals and de-listing from the Section 303(d) list are expected by the end of the last 5-year period (Stage III).

The list and extent of control measures that are currently in place, and those scheduled to be implemented in Stage I and Stage II are shown for Turley Creek and Long Meadow Run in Table 6-1 and Table 6-2, respectively.

Monitoring will continue throughout the process to document progress towards goals and to provide a mechanism for evaluating the effectiveness of the implementation actions for achieving intended water quality goals. The benefits of staged implementation as stream monitoring continues are: 1) it allows for water quality improvements to be recorded as they are being achieved; 2) it provides a measure of quality control, given the uncertainties which exist in any implementation plan; 3) it provides a mechanism for developing public support; 4) it helps to ensure that the most cost-effective practices are implemented initially; and 5) it allows for the evaluation of the adequacy of the TMDL in achieving the water quality standard.

Table 6-1. Staged Implementation Goals for Turley Creek

Landuse Type	BMP ID	Control Measure Name	Practice Life (yrs)	Needed BMP Extents	2010-2014 BMPs	Stage I (5 years)	Extent Units
	FR-1	Aforestation of erodible crop and pastureland	10	5.00		5	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5.00	4.7	2	systems
	SL-1	Permanent Vegetative Cover on Cropland	5	4.00		4	acres
Row Crops	SL-15A	Continuous No-Till System	5	40.00		40	acres
	SL-8B	Small Grain cover crop for Nutrient Management	1	45.00		225	acres
	SL-8H	Harvestable Cover Crop	1	120.00		600	acres
	WP-1	Sediment retention, erosion, or water control structures	10	1		1	systems
AFO/CAFO	WP-4	AWMS (Winter feeding facility)	10	3		3	systems
		AWMS (Poultry dry-stack facility)	15	2		2	systems
	FR-1	Aforestation of erodible crop and pastureland	10	2.00		2	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5.00		5	acres
	SL-7	Extension of CREP Watering Systems	10	60.00		60	acres
	SL-11	Permanent Vegetative Cover on Critical Areas	10	4.00		2	systems
Pasture/Hay	SL-6, CRSL-6, SL-6T, LE-1T	SL-6 (fencing portion)	10	5	3 (8,860 ft.)	2	systems
	WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	10	3	1 (3,455 ft.)	2	systems
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	10	3	1 (3,990 ft.)	2	systems
		LE + 10-foot setback + Limited Access + PrecRotGraz	10	2		2	systems
	Not cost-shared	LE + 10-foot setback using Polywire	5	2		2	systems
	SL-10T	Grazing Land Protection	10	40.00		40	acres
Harvested forest		Forest harvesting BMP					
Transitional		Erosion and sediment control BMPs					
Channel Erosion	WP-2A	Streambank Stabilization	20	300.00		300	linear feet
Springs	WP-1	Sediment retention, erosion, or water control structures	10	1		1	systems
		Cumulative Sediment Reduction			**5.0%**	**100%**	

Table 6-2. Staged Implementation Goals for Long Meadow Run

Landuse Type	BMP ID	Control Measure Name	Practice Life (yrs)	Needed BMP Extents	2010-2014 BMPs	Implementation Extent		Extent Units
						Stage I (5 years)	Stage II (5 years)	
Row Crops	FR-1	Aforestation of erodible crop and pastureland	10	20	3	12	8	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5		3	2	acres
	NM-1A	Nutrient Management Plan Writing and Revisions	3	100		120	100	acres
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	1	500	102	1500	2500	acres
	SL-1	Permanent Vegetative Cover on Cropland	5	50	96.2	30	50	acres
	SL-15A	Continuous No-Till System	5	185	0	108	180	acres
	SL-8B	Small Grain cover crop for Nutrient Management	1	200	1209	600	1000	acres
	SL-8H	Harvestable Cover Crop	1	120	193	360	600	acres
	WP-1	Sediment retention, erosion, or water control structures	10	2		1	0	systems
	WQ-4	Legume Cover Crop	1	50		150	250	acres
AFO/CAFO		Barnyard runoff controls	10	4		3	1	systems
	WP-4	AWMS (Winter feeding facility)	10	6		3	2	systems
	WP-4	AWMS (Poultry dry-stack facility)	15	4		3	1	systems
	WP-4B	Loafing Lot Management System	10	1		1		systems
	WP-4C	Composter Facilities	10	6	7	4	2	systems
		Manure Transport*	1	695		2085	3475	tons
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	10	20		12	8	acres
	FR-3, CRFR-3	Woodland buffer filter area	10	5		3	2	acres
	SL-7	Extension of CREP Watering Systems	10	100		60	40	acres
	SL-11	Permanent Vegetative Cover on Critical Areas	10	15		10	5	acres
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	10	40	2 (2,690 ft.)	22	16	systems
	WP-2, CRWP-2, WP-2T	LE + Limited Access	10	14	1 (700 ft.)	8	5	systems
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	10	22		14	8	systems
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	10	13		8	5	systems
	Not cost-shared	LE + 10-foot setback using Polywire	5	15		9	15	systems
	SL-10T	Grazing Land Protection	10	120		72	48	acres
	WP-1	Sediment retention, erosion, or water control structures	10	0		0	0	systems
	WQ-1	Grass filter strips (Hayland conversion)	5	10		6	10	acres
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	10	10		6	4	number
		Brush Management	2	300		450	750	acres
Harvested forest		Forest harvesting BMP						
Transitional		Erosion and sediment control BMPs						
Channel Erosion	WP-2A	Streambank Stabilization	20	500		300	200	linear feet
Septics	RB-1	Septic Tank Pumpout	5	111		67	111	systems
	RB-2	Septic Connections	25	9		6	3	systems
	RB-3	Septic tank system repair	10	40		24	16	systems
	RB-4	Septic tank system installment/replacement	10	15		9	6	systems
	RB-4P	Septic tank system installment/replacement with pump	10	10		6	4	systems
	RB-5	Alternative on-site waste treatment systems	10	15		9	6	systems
Springs	IA-747	Denitrifying Bioreactor	5	1		1	1	systems
		Cumulative Sediment Reduction			**3.8%**	**57.3%**	**100%**	
		Cumulative Nitrogen Reduction			**1.9%**	**66.9%**	**100%**	

The costs associated with Stage I and Stage II implementation efforts are summarized in Table 6-3 and Table 6-4 for Turley Creek and Long Meadow Run, respectively.

Table 6-3. Staged Implementation Costs for Turley Creek

Landuse Type	BMP ID	Control Measure Name	Stage I (5 years)	Extent Units	Stage I Implementation Cost ($)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	5	acres	$5,000
	FR-3, CRFR-3	Woodland buffer filter area	2	systems	$2,250
	SL-1	Permanent Vegetative Cover on Cropland	4	acres	$620
	SL-15A	Continuous No-Till System	40	acres	$2,200
	SL-8B	Small Grain cover crop for Nutrient Management	225	acres	$22,500
	SL-8H	Harvestable Cover Crop	600	acres	$60,000
	WP-1	Sediment retention, erosion, or water control structures	1	systems	$4,600
AFO/CAFO	WP-4	AWMS (Winter feeding facility)	3	systems	$150,000
		AWMS (Poultry dry-stack facility)	2	systems	$76,000
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	2	acres	$2,000
	FR-3, CRFR-3	Woodland buffer filter area	5	acres	$5,625
	SL-7	Extension of CREP Watering Systems	60	acres	$15,000
	SL-11	Permanent Vegetative Cover on Critical Areas	2	systems	$1,850
	SL-6, CRSL-6, SL-6T, LE-1T	SL-6 (fencing portion)	2	systems	$88,040
	WP-2, CRWP-2, WP-2T	Streambank protection (fencing)	2	systems	$22,840
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	2	systems	$84,740
		LE + 10-foot setback + Limited Access + PrecRotGraz	2	systems	$25,400
	Not cost-shared	LE + 10-foot setback using Polywire	2	systems	$13,400
	SL-10T	Grazing Land Protection	40	acres	$3,080
Harvested forest		Forest harvesting BMP			
Transitional		Erosion and sediment control BMPs			
Channel Erosion	WP-2A	Streambank Stabilization	300	linear feet	$30,000
Springs	WP-1	Sediment retention, erosion, or water control structures	1	systems	$25,000
		Technical Assistance		person-yrs	$125,000
		Total Costs			**$765,145**

Table 6-4. Staged Implementation Costs for Long Meadow Run

Landuse Type	BMP ID	Control Measure Name	Implementation Extent		Extent Units	Implementation Costs	
			Stage I (5 years)	Stage II (5 years)		Stage I ($)	Stage II ($)
Row Crops	FR-1	Aforestation of erodible crop and pastureland	12	8	acres	$12,000	$8,000
	FR-3, CRFR-3	Woodland buffer filter area	3	2	acres	$3,375	$2,250
	NM-1A	Nutrient Management Plan Writing and Revisions	120	100	acres	$4,200	$3,500
	NM-3C	Split Application of Nitrogen to Corn using Pre-sidedress Nitrate Test to Determine Need for Sidedress Nitrogen	1500	2500	acres	$7,500	$12,500
	SL-1	Permanent Vegetative Cover on Cropland	30	50	acres	$4,650	$7,750
	SL-15A	Continuous No-Till System	108	180	acres	$5,940	$9,900
	SL-8B	Small Grain cover crop for Nutrient Management	600	1000	acres	$60,000	$100,000
	SL-8H	Harvestable Cover Crop	360	600	acres	$36,000	$60,000
	WP-1	Sediment retention, erosion, or water control structures	1	0	systems	$4,600	$0
	WQ-4	Legume Cover Crop	150	250	acres	$13,500	$22,500
AFO/CAFO		Barnyard runoff controls	3	1	systems	$20,205	$6,735
	WP-4	AWMS (Winter feeding facility)	3	2	systems	$150,000	$100,000
	WP-4	AWMS (Poultry dry-stack facility)	3	1	systems	$114,000	$38,000
	WP-4B	Loafing Lot Management System	1		systems	$80,000	$0
	WP-4C	Composter Facilities	4	2	systems	$89,200	$44,600
		Manure Transport*	2085	3475	tons	$0	$0
Pasture/Hay	FR-1	Aforestation of erodible crop and pastureland	12	8	acres	$12,000	$8,000
	FR-3, CRFR-3	Woodland buffer filter area	3	2	acres	$3,375	$2,250
	SL-7	Extension of CREP Watering Systems	60	40	acres	$15,000	$10,000
	SL-11	Permanent Vegetative Cover on Critical Areas	10	5	acres	$9,250	$4,625
	SL-6, CRSL-6, SL-6T, LE-1T	LE + Alt. Water + PrecRotGraz	22	16	systems	$968,440	$704,320
	WP-2, CRWP-2, WP-2T	LE + Limited Access	8	5	systems	$91,360	$57,100
	LE-2, LE-2T	LE + 10-foot setback + Alt. Water + PrecRotGraz	14	8	systems	$593,180	$338,960
	LE-2, LE-2T	LE + 10-foot setback + Limited Access + PrecRotGraz	8	5	systems	$101,600	$63,500
	Not cost-shared	LE + 10-foot setback using Polywire	9	15	systems	$60,300	$100,500
	SL-10T	Grazing Land Protection	72	48	acres	$5,544	$3,696
	WP-1	Sediment retention, erosion, or water control structures	0	0	systems	$0	$0
	WQ-1	Grass filter strips (Hayland conversion)	6	10	acres	$1,560	$2,600
	WQ-11, CRWQ-11	Agricultural Sinkhole Protection	6	4	number	$16,882	$11,254
		Brush Management	450	750	acres	$157,500	$262,500
Harvested forest		Forest harvesting BMP					
Transitional		Erosion and sediment control BMPs					
Channel Erosion	WP-2A	Streambank Stabilization	300	200	linear feet	$30,000	$20,000
Septics	RB-1	Septic Tank Pumpout	67	111	systems	$18,425	$30,525
	RB-2	Septic Connections	6	3	systems	$33,600	$16,800
	RB-3	Septic tank system repair	24	16	systems	$144,000	$96,000
	RB-4	Septic tank system installment/replacement	9	6	systems	$72,000	$48,000
	RB-4P	Septic tank system installment/replacement with pump	6	4	systems	$66,000	$44,000
	RB-5	Alternative on-site waste treatment systems	9	6	systems	$225,000	$150,000
Springs	IA-747	Denitrifying Bioreactor	1	1	systems	$40,000	$40,000
		Technical Assistance	7.5	5.0	person-yrs	$375,000	$250,000
		Total Costs				**$3,645,186**	**$2,680,365**

* Manure Transport provides a net benefit to the farmer when sold as fertilizer.

Stage I costs for both watersheds consists of $3,910,331 in agricultural and residential implementation practices and $500,000 in technical assistance, for a total of $4,410,331; while Stage II costs for the Long Meadow Run watershed consists of

$2,430,365 in implementation practices and $250,000 in technical assistance, for a total of $2,680,365. The combined cost for both stages in both watersheds is $7,090,696.

6.3. *Reasonable Assurance*

Public participation is an integral part of the IP development and is critical in gaining support for both the voluntary and regulated implementation activities that are being planned. During the public participation process, stakeholders in the watershed and local conservation agency personnel were involved in Working Groups and public meetings, and provided additional information through email and phone conversations. This participation by the major watershed stakeholders provides a reasonable assurance that the public was contributing to the TMDL process and had input into the selection of management and implementation practices recommended by this IP.

A Turley Creek and Long Meadow Run TMDL IP Steering Committee formed following development of the implementation plan will continue to provide oversight for implementation as needed, with guidance provided by DCR, DEQ, and the local Shenandoah Valley SWCD, ensuring continuity of leadership and vision. Funding for implementation measures to improve water quality in Turley Creek and Long Meadow Run will be sought from Virginia's §319 allocation. Additional grant funding will be sought to fund and monitor a demonstration installation of a denitrifying bioreactor in Long Meadow Run, ensuring continued interest, participation, and support from this community.

Implementation to address the nitrogen and sediment-related biological impairments on Turley Creek and Long Meadow Run will be carried out primarily through the use of voluntary best management practices and education. While available cost-share programs will be utilized to the extent possible to provide incentives (typically at 75% of installation costs) to targeted watershed stakeholders, it is recognized that it may be necessary in some instances to raise the level of incentives to 100% to ensure participation by some stakeholders. Grant funding will be sought to provide this additional incentive, which we expect will increase participation from specific targeted stakeholders that would otherwise be reticent to participate.

Taken together, all of these planning components comprise a reasonable assurance that implementation will progress as planned and will lead to restoration of water quality in Turley Creek and Long Meadow Run.

6.4. *Implementation Tracking*

Tracking of agricultural and residential practices will be done by the Shenandoah Valley SWCD through the existing BMPCSP tracking maintained by VADCR, supplemented by NRCS-reported practices installed and funded using only by federal funds. Tracking information will include the locations and numbers of practices installed in the watershed. Strategies to facilitate implementation, such as educational programs and other outreach activities will also be tracked. The IP Steering Committee will continue to provide oversight and direction as needed during implementation.

6.5. *Water Quality Monitoring*

Virginia's 1997 Water Quality Monitoring, Information and Restoration Act requires that TMDL IPs include measurable goals and milestones for attaining water quality standards. Implicit in those milestones is the requirement of a method to measure progress. Water quality improvement will be evaluated through water quality monitoring conducted by DEQ. DEQ will monitor four locations in the watersheds to assess implementation progress as listed in Table 6-5 and shown in Figure 6-1.

Table 6-5. DEQ Water Quality Monitoring Stations

Station ID	*Stream Name*	*Station Type*	*Location*
1BLOM000.24	Long Meadow Run	Ambient/biological	Upstream of Rt. 211 bridge
1BLOM001.45	Long Meadow Run	Ambient	Upstream of Rt. 793 bridge
1BTRL000.02	Turley Creek	Ambient/biological	Upstream of Rt. 259 bridge
1BBRO000.34	Brock Creek	Biological	Upstream of Rt. 776 bridge

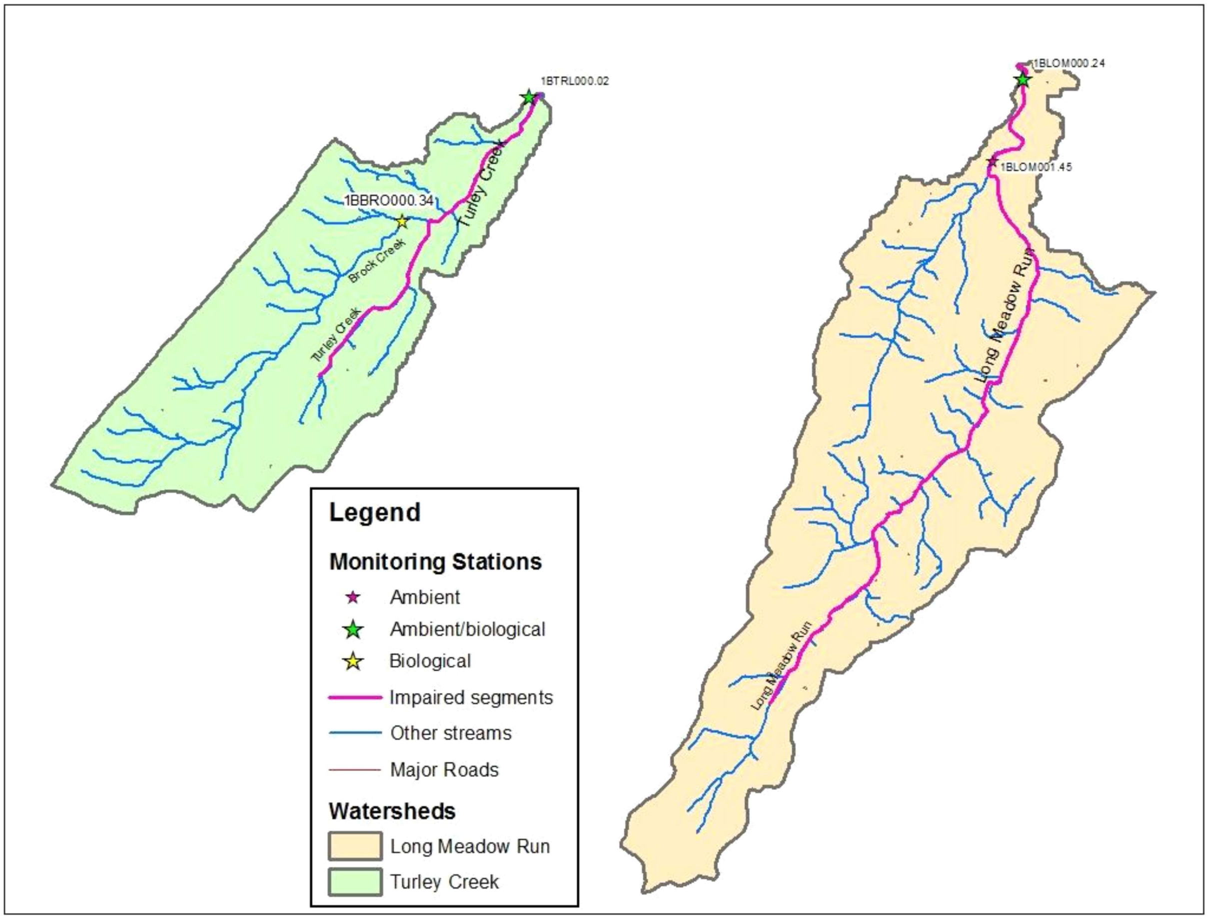


Figure 6-1. DEQ Monitoring Station Locations

DEQ will conduct monthly or bi-monthly sampling at each of the existing ambient monitoring sites on both Turley Creek and Long Meadow Run. Sampling at the DEQ biological stations will be performed twice a year, in spring and fall. Metrics will be calculated for these samples for evaluation of the VSCI index.

6.6. *Evaluation of Progress*

An annual evaluation of implementation progress and water quality in Turley Creek and Long Meadow Run will be made by the Steering Committee. During each annual evaluation, a reassessment of implementation priorities will be made by the Steering Committee to readjust and fine-tune the targeting approach in concert with the staged implementation approach. Periodic re-evaluation is especially critical during these times of economic uncertainty, where increasing energy prices and fluctuating market prices are bound to affect stakeholders in the agricultural sector and their willingness to commit resources for conservation, especially if they are struggling to maintain their viability as a farming enterprise.

If reasonable progress toward implementing the management practices is not demonstrated, the Steering Committee will consider additional implementation actions. If it is demonstrated that reasonable and feasible management measures have been implemented for a sufficient period of time and TMDL targets are still not being met, the TMDL will be reevaluated and revised accordingly. If after five years the Steering Committee determines that load reductions are being achieved as management measures are implemented, then the recommended appropriate course of action would be to continue management measure implementation and compliance oversight. If it is determined that all proposed control measures have been implemented, yet the TMDL is not achieved, further investigations will be made to determine whether: 1) the control measures are not effective; 2) sediment loads are due to sources not previously addressed; or 3) the TMDL is unattainable.

7.0 STAKEHOLDERS' ROLES AND RESPONSIBILITIES

Stakeholders are individuals who live or have land management responsibilities in the watershed, including government agencies, businesses, private individuals and special interest groups. Stakeholder participation and support is essential for achieving the goals of this TMDL effort (i.e. improving water quality and removing streams from the impaired waters list). The purpose of this chapter is to identify and define the roles of the stakeholders who will work together to put the IP into practice. The roles and responsibilities of some of the major stakeholders are described below.

7.1. *Federal Government*

U.S. Environmental Protection Agency (EPA) has the responsibility of overseeing the various programs necessary for the success of the Clean Water Act. However, administration and enforcement of such programs falls largely to the states. The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) is the federal agency that works hand-in-hand with US citizens to conserve natural resources on private lands. NRCS assists private landowners with conserving their soil, water, and other natural resources. Local, state and federal agencies and policymakers also rely on the expertise on NRCS staff. NRCS is also a major funding stakeholder for impaired water bodies through the Conservation Reserve Enhancement Program (CREP) and the Environmental Quality Incentive Program (EQIP). For more information on NRCS, visit (antiquated link removed; see NRCS website).

7.2. *State Government*

In the Commonwealth of Virginia, water quality problems are dealt with through legislation, incentive programs, education, and legal actions. Currently, there are five state agencies responsible for regulating and/or overseeing statewide activities that impact water quality in the Turley Creek and Long Meadow Run watersheds. These agencies are:

Virginia Department of Environmental Quality (VADEQ): The State Water Control Law authorizes the State Water Control Board to control and plan for the reduction of pollutants impacting the chemical and biological quality of the State's waters resulting in the degradation of the swimming, fishing, shell fishing, aquatic life, and drinking water uses. For many years the focus of VADEQ's pollution reduction efforts was the treated effluent discharged into Virginia's waters via the VPDES permit process. The TMDL process has expanded the focus of VADEQ's pollution reduction efforts from the effluent of wastewater treatment plants to the nonpoint source pollutants causing impairments of the streams, lakes, and estuaries. The reduction tools are being expanded beyond the permit process to include a variety of voluntary strategies and BMPs.

VADEQ is the lead agency in the TMDL process. The Code of Virginia directs VADEQ to develop a list of impaired waters, develop TMDLs for these waters, and develop IPs for the TMDLs. VADEQ administers the TMDL process, including the public participation component, and formally submits the TMDLs to EPA and the State Water Control Board for approval. VADEQ is also responsible for implementing point source WLAs, assessing water quality across the state, and conducting water quality standard related actions. VADEQ also provided funding for the development of the Turley Creek and Long Meadow Run IP.

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

Virginia Department of Agriculture and Consumer Services (VDACS): The Agricultural Stewardship Act (ASA) program is administered by the VDACS Commissioner's Office which will receive complaints of water pollution from agricultural activities. If a complaint falls under the jurisdiction of the ASA (§3.2-400-410), the local Soil and Water Conservation District is contacted and given the opportunity to investigate. After a complaint is investigated, the Commissioner's Office reviews the findings and determines if the complaint is founded and requires further action under the ASA. If so, the farmer is required to develop a plan to correct the problem and then complete plan implementation within a specified timeframe. The Commissioner's Office will perform subsequent visits to the site to determine compliance after plan implementation.

<u>Virginia Department of Health (VDH):</u> The VDH is responsible for maintaining safe drinking water measured by standards set by the EPA. Like VDACS, VDH is complaint driven. Complaints can range from a vent pipe odor that is not an actual sewage violation and takes very little time to investigate, to a large discharge violation that may take many weeks or longer to effect compliance. Their duties also include septic system regulation and regulation of biosolids land application. For TMDLs, VDH has the responsibility of enforcing actions to correct failed septic systems and/or eliminate straight pipes (Sewage Handling and Disposal Regulations, 12 VAC 5-610-10 et seq.).

<u>Virginia Department of Forestry (DOF):</u> The DOF has prepared a manual to inform and educate forest landowners and the professional forest community on proper BMPs and technical specifications for installation of these practices in forested area. Forestry BMPs are directed primarily to control erosion. For example, streamside forest buffers provide nutrient uptake and soil stabilization, which can benefit water quality by reducing the amount of nutrients and sediments that enter local streams. DOF's BMP program is voluntary.

Another state entity with responsibilities for activities that impact water quality in the Turley Creek and Long Meadow Run watersheds is:

<u>Virginia Cooperative Extension (VCE):</u> VCE is an educational outreach program of Virginia's land grant universities (Virginia Tech and Virginia State University), and a part of the national Cooperative State Research, Education, and Extension Service, an agency of the United States Department of Agriculture. 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. VCE has published several publications that deal specifically with TMDLs and partners with DCR on the NEMO program. For more information on these publications and to find the location of county extension offices, visit (antiquated link removed; see Virginia's Cooperative Extension website.

7.3. *Regional and Local Government*

Regional and local government groups work closely with state and federal agencies throughout the TMDL process; these groups possess insights about their regional and local community that may help to ensure the success of TMDL implementation. These stakeholders have knowledge about a community's priorities, how decisions are made locally, and how the watershed's residents interact. Some local government groups and their roles in the TMDL process are listed below.

Shenandoah Valley (Rockingham County) SWCD: Soil and Water Conservation Districts (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. District staff work closely with watershed residents and have valuable knowledge of local watershed practices.

Central Shenandoah Planning District Commission: Planning District Commissions (PDCs) were organized to promote the efficient development of 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.

Rockingham County: County government staff members work closely with PDCs and state agencies to develop and implement TMDLs in concert with their comprehensive plan. They may also help to promote education and outreach to citizens, businesses and developers to introduce the importance of the TMDL process.

7.4. *Businesses, Community Groups, and Citizens*

While successful implementation depends on stakeholders taking responsibility for their role in the process, the primary role falls on the local groups that are most affected; that is, businesses, community watershed groups, and citizens.

Valley Conservation Council (VCC): Valley Conservation Council promotes land use that sustains the farms, forests, open spaces, and cultural heritage of the Shenandoah Valley region of Virginia. Founded in 1990, Valley Conservation Council is a member-supported, private, non-profit land trust and citizens organization. VCC now shares stewardship responsibility for over 14,000 acres of privately owned conservation land in 11 counties.

Community Watershed Groups: (Friends of the North Fork of the Shenandoah River [FNFSR], Save Our Streams, etc.) Local watershed groups offer a meeting place for river groups to share ideas and coordinate preservation efforts and are also a showcase site for citizen action. Watershed groups also have a valuable knowledge of the local watershed and river habitat that is important to the implementation process.

Shenandoah Pure Water Forum: A 501c (3) non-profit organization working to achieve clean water by involving citizens in planning, education, coordination, attracting funding and serving as advocates for water resources.

Citizens and Businesses: The primary role of citizens and businesses is simply to get involved in the TMDL process. This may include participating in public meetings (Section 5.1), assisting with public outreach, providing input about the local watershed history, and/or implementing best management practices to help restore water quality.

Community Civic Groups: Community civic groups take on a wide range of community service including environmental projects. Such groups include the 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.

Secondary Schools: Long-term solutions to our water quality problems must include education of future generations regarding the need to make changes in our personal and social habits and traditions, in order to preserve and maintain our land and water resources. Towards this end, environmental education, especially that which includes hands-on interaction with natural resources through field trips and class projects, is highly recommended. Activities, such as those included in the Future Farmers of America, "Trout in the Classroom", and Envirothon programs, help our youth understand how they can maintain and enhance these precious resources.

Riverkeeper Network: The Riverkeeper Network is committed to acting as an advocate to protect water quality. Although the program began in New York, the Riverkeeper program has expanded to 200 different programs across the US and beyond. The Shenandoah Riverkeeper's stated mission is to "stop pollution and to restore clean water in the Potomac and Shenandoah Rivers and tributaries through enforcement and community engagement".

8.0 INTEGRATION WITH OTHER WATERSHED PLANS

Each watershed within the state is under the jurisdiction of a multitude of individual yet related water quality programs and activities, many of which have specific geographical boundaries and goals. These include, but are not limited to, Total Maximum Daily Loads, water quality management plans (WQMPs), sediment and erosion control regulations, stormwater management (SWM), Source Water Assessment Program (SWAP), and local comprehensive plans.

8.1. *Continuing Planning Process*

According to Perciasepe (1997) the continuing planning process (CPP) established by Section 303(e) of the Clean Water Act provides a good framework for implementing TMDLs, especially the NPS load allocations. Under the Section 303(e) process, states develop and update statewide plans that include TMDL development and adequate implementation of new and revised water quality standards, among other components. The water quality management regulations at 40 CFR 130.6 require states to maintain WQMPs that are used to direct implementation of key elements of the continuing planning process, including TMDLs, effluent limitations, and NPS management controls. These state WQMPs are another way for states to describe how they will achieve TMDL load allocations for NPSs. The CPP in Virginia is implemented in various state programs, all aimed toward achieving and maintaining the state water quality standards. Virginia Code Sections 62.1-44.15(10) & (13), 62.1-44.17:3, and 62.1-44.19:7 give the Virginia State Water Control Board (Board) the duty and authority to conduct the CPP in Virginia. Under the authority of Virginia Code Section 10.1-1183, VADEQ serves as the administration arm of the Board. Virginia WQMPs consist of initial plans produced in accordance with Sections 208 and 303(e) of the CWA and approved updates to the plans. Currently, Virginia has a total 18 WQMPs developed under Sections 208 and 303(e). Many of these plans are outdated, and efforts are underway to update them. The updated plans will serve as repositories for all TMDLs approved by EPA and adopted by the Board, as well as IPs approved by the Board.

8.2. *Watershed and Water Quality Management Planning Programs in Virginia*

TMDLs – TMDLs are the maximum amount of pollutant that a water body can assimilate without surpassing state water quality standards. TMDLs are developed for water bodies that are listed on a state's 303(d) list, known as the "Impaired Waters List." The TMDL develops a waste load allocation for point sources and a load allocation for NPSs and incorporates a "margin of safety" in defining the assimilation capacity of the water body. The IP outlines strategies to meet the allocations.

This project watershed is within the Chesapeake Bay Watershed Implementation Plan drainage area. Implementation plans that reduce nutrients and sediment from entering local waterways also benefit the downstream waters of the Chesapeake Bay. With overlapping BMP implementation goals, coordination between lead agencies and the documentation of work completed is important.

WQMPs – Water Quality Management Plans (WQMPs) are produced and updated by VADEQ in accordance with Sections 208 and 303(e) of the CWA as outlined in the CPP section above. These plans will be the repository for TMDLs and TMDL IPs.

Sediment and Erosion Control Regulations – VADEQ implements the state Erosion and Sediment Control (ESC) Program according to the Virginia Erosion and Sediment Control Law, Regulations, and Certification Regulations (VESCL&R). The ESC Program goal is to control soil erosion, sedimentation, and nonagricultural runoff from regulated "land-disturbing activities" to prevent degradation of property and natural resources. The regulations specify "Minimum Standards," which include criteria, techniques and policies that must be followed on all regulated activities. These statutes delineate the rights and responsibilities of governments that administer a local ESC program and those of property owners who must comply. For more information, visit (antiquated link removed; see DEQ's website).

SMP –Stormwater Management (SWM) programs are implemented according to the Virginia Stormwater Management Law and Virginia Stormwater Management Regulations (VSWML&R). These statutes are specifically set forth regarding land development activities to prevent water pollution, stream channel erosion, depletion of ground water resources, and more frequent localized flooding to protect property values and natural resources. SWM programs operated according to the law are designed to address these adverse impacts and comprehensively manage the quality and quantity of stormwater runoff on a watershed-wide basis. VADEQ oversees regulated activities undertaken on state and federal property, while localities have the option to establish a local program to regulate these same activities on private property in their jurisdiction and for those disturbed areas < 5 acres in size. For more information, visit (antiquated link removed; see the DEQ website).

SWAP – Section 1453 of the 1986 Amendments of the Safe Drinking Water Act (SDWA) requires each state to develop a Surface Water Assessment Plan (SWAP) that will delineate the boundaries of the assessment areas from which public water systems receive drinking water using hydrogeologic information, water flow, recharge, and discharge and other reliable information. The VDH is the primary agency for drinking water and is therefore responsible for SWAP. In Virginia, all 187 surface water intakes serving 151 public waterworks have completed surface water assessments. All 4,584 ground water source assessments, serving nearly 4,000 public waterworks, were completed by the end of 2003.

Local Comprehensive Plans – (Rockingham County) – Virginia state law requires all local governments have an adopted comprehensive plan. Typical topics addressed in a comprehensive plan include the analysis of population change, land use and trends, natural and environmental features, transportation systems, and community facilities and services. Local comprehensive plans should be referred to in the TMDL development process as well as TMDL implementation, especially the latter for urbanized watersheds. These are discussed in more detail in the next chapter.

9.0 POTENTIAL FUNDING SOURCES

A list of potential funding sources available for implementation has been developed. Detailed descriptions can be obtained from the Shenandoah Valley SWCD, VADCR, Natural Resources Conservation Service (NRCS), and Virginia Cooperative Extension (VCE). While some assistance is available for agricultural BMPs and technical assistance for farmers through pre-existing programs, an additional funding commitment is needed to implement the residential and urban practices included in the plan.

Chesapeake Bay Watershed Initiative

This initiative was authorized in the 2008 Farm Bill for 2009-2012. It provides technical and financial assistance to producers to implement practices that reduce sediment and nutrients to help protect and restore the Chesapeake Bay. Priority has been given to the Shenandoah and Potomac River Basins and selected watersheds that have impaired streams due to high levels of nutrients and sediment. Producers who live in an NRCS high priority Cheasapeake Bay watershed receive additional consideration in the funding ranking process.

Clean Water State Revolving 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. As loan recipients make payments back into the fund, money is available for new loans to be issued to other recipients. Eligible projects include point source, nonpoint source and estuary protection projects. Point source projects typically include building wastewater treatment facilities, combined sewer overflow and sanitary sewer overflow correction, urban stormwater control, and water quality aspects of landfill projects. Nonpoint source projects include agricultural, silvicultural, rural, and some urban runoff control; on-site wastewater disposal systems (septic tanks); land conservation and riparian buffers; leaking underground storage tank remediation, etc.

Conservation Reserve Enhancement Program (CREP)

The Conservation Reserve Enhancement Program (CREP) is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. CREP is an offshoot of the country's largest private-lands environmental improvement program -- the Conservation Reserve Program (CRP). Like CRP, CREP is administered by USDA's Farm Service Agency (FSA). CREP addresses high-priority conservation issues of both local and national significance, such as impacts to water supplies, loss of critical habitat for threatened and endangered wildlife species, soil erosion, and reduced habitat for fish populations such as salmon. CREP is a community-based, results-oriented effort centered on local participation and leadership. CREP contracts require a 10- to 15-year commitment to keep lands out of agricultural production. A federal annual rental rate, including an FSA state committee-determined maintenance incentive payment, is offered, plus cost-share of up to 50 percent of the eligible costs to install the practice.

Environmental Quality Incentives Program (EQIP)
The USDA Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) was established to provide a voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. Approximately 65% of the EQIP funding for the state of Virginia is directed toward “Priority Areas.” These areas are selected from proposals submitted by a locally led conservation work group. The remaining 35% of the funds are directed toward statewide priority concerns of environmental needs. EQIP offers 5 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 statewide or in the priority area. Eligibility is limited to persons who are engaged in livestock or agricultural production.

EPA Section 319 Grant Project Funds
Through Section 319 of the Federal Clean Water Act, Virginia is awarded grant funds to implement NPS programs. The VADCR administers the money annually on a competitive grant basis to fund TMDL implementation projects, outreach and educational activities, water quality monitoring, and technical assistance for staff of local sponsor(s) coordinating implementation. In order to meet eligibility criteria established for 319 funding, all proposed project activities must be included in the TMDL implementation plan covering the project area. In addition, this plan must include the nine key elements of a watershed based plan identified by EPA (see Guidance Manual for Total Maximum Daily Load Implementation Plans, Virginia Department of Conservation and Recreation and Department of Environmental Quality, July 2003).

National Fish and Wildlife Foundation
Grant proposals for this funding are accepted throughout the year and processed during fixed sign up periods. There are two decision cycles per year. Each cycle consists of a pre-proposal evaluation, a full proposal evaluation, and a Board of Directors’ decision. Grants generally range between $10,000 and $150,000. Grants are awarded for the

purpose of conserving fish, wildlife, plants, and their habitats. Special grant programs are listed and described on the NFWF website. If the project does not fall into the criteria of any special grant programs, a proposal may be submitted as a general grant if it falls under the following guidelines: 1) it promotes fish, wildlife and habitat conservation, 2) it involves other conservation and community interests, 3) it leverages available funding, and 4) project outcomes are evaluated.

Southeast Rural Community Assistance Project (SE/R-CAP)
The mission of this project is to promote, cultivate, and encourage the development of water and wastewater facilities to serve low-income residents at affordable costs and to support other development activities that will improve the quality of life in rural areas. Staff members of other community organizations complement the SE/R-CAP staff across the region. They can provide (at no cost): on-site technical assistance and consultation, operation and maintenance/management assistance, training, education, facilitation, volunteers, and financial assistance. Financial assistance includes $1,500 toward repair/replacement/ installation of a septic system and $2,000 toward repair/replacement/installation of an alternative waste treatment system. Funding is only available for families making less than 125% of the federal poverty level. For more information, visit (antiquated link removed; see SE/R-CAP Website).

Virginia Agricultural Best Management Practices Cost-Share Program
The Virginia Agricultural Best Management Practices (BMPs) Cost-Share Program provides funds to help install conservation practices that protect water and make farms more productive. Funding availability varies by SWCD. The state provides SWCDs with funds to target areas with known water quality needs. Areas with the greatest need receive the greatest funding. The cost-share program supports using various practices in conservation planning to treat animal waste, cropland, pastureland and forested land. Some are paid for at a straight per-acre rate. Others are cost-shared on a percentage basis up to 85 percent. In some cases, USDA also pays a percentage. In fact, the cost-share program's practices can often be funded by a combination of state and federal funds, reducing the landowner’s expense to less than 30 percent of the total cost. Cost-share funds are also available for approved innovative BMP demonstration projects intended to improve water quality.

Virginia Agricultural Best Management Practices Loan Program
The Virginia Agricultural Best Management Practices Loan Program provides a source of low interest financing which will encourage the use of specific best management practices which reduce or eliminate the impact of Agricultural Nonpoint Source (NPS) pollution to Virginia's waters. VADEQ's Virginia Ag BMP loan program is a subset of the parent Virginia Clean Water Revolving Loan Fund (VCWRLF) loan program and is intended to create a continuing source of low interest financing that will be available to

Virginia's agricultural producers to assist them in their efforts to reduce agricultural non-point source pollution. Unlike other assistance programs, the Ag BMP loan program is not dependent on legislative appropriations for its fund availability. All repayments of principle and interest from previous Ag BMP loans are returned to the Fund and used to provide additional loans to other Virginia farmers. In addition to the revenue available from repayments, VADEQ will request that the State Water Control Board (SWCB) consider making additional funding set-asides from the VCWRLF revenue as deemed necessary in order to meet Virginia's agricultural non-point source pollution reduction needs. Loan requests are accepted through VADEQ. The interest rate is 3% per year and the term of the loan coincides with the life span of the practice. To be eligible for the loan, the BMP must be included in a conservation plan approved by the local SWCD Board. The minimum loan amount is $5,000; there is no maximum limit. Eligible BMPs include 23 structural practices such as animal waste control facilities, and grazing land protection systems. The loans are administered through participating lending institutions.

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

Virginia Environmental Endowment
The Virginia Mini-Grant Program supports community-based efforts to strengthen environmental education and to promote stewardship of Virginia's waterways. Preference is given to modest local projects. Public and private schools (K-12) and nongovernmental, nonprofit community organizations in Virginia are eligible to apply for one-year Mini-Grant awards up to $5,000. Local, state, and federal government agencies and programs are not eligible.

Virginia Open-Space Lands Preservation Trust Fund
Farmland, forest land, and open space land are important to our heritage in Virginia. These lands are under increasing pressure from urban development in parts of the Commonwealth. The 1997 Virginia General Assembly created a new fund (Va. Code Sections 10.1801-2) to assist landowners with the costs of conveying conservation easements and the purchase of all or part of the value of the easements. The fund is

operated by the Virginia Outdoors Foundation. Conservation easements preserve farmland, forestland, and natural and recreational areas by restricting intensive uses, such as development and mining, which would alter the conservation values of the land. An easement is a voluntary legal agreement between a landowner and a public body or conservation group in which the parties agree to protect the open-space and natural resource values of the land. Each easement is tailored to reflect the conservation values of the property and is recorded in the local courthouse as a permanent part of the property records. Easements do not grant public access to a landowner's property. Costs that the fund may reimburse include legal costs, appraisal and other costs, and all or part of the easement's value. To be eligible, the easement must be perpetual in duration.

Virginia Small Business Environmental Assistance Fund Loan Program
The Fund, administered through VADEQ, is used to make loans or to guarantee loans to small businesses for the purchase and installation of environmental pollution control equipment, equipment to implement voluntary pollution prevention measures, or equipment and structures to implement agricultural BMPs. The loans are available in amounts up to $50,000 and will carry an interest rate of 3%, with favorable repayment terms based on the borrower’s ability to repay and the useful life of the equipment being purchased or the life of the BMP being implemented. To be eligible for assistance, a business must employ 100 or fewer people and be classified as a small business under the federal Small Business Act.

Virginia Water Quality Improvement Fund
The purpose of the Virginia Water Quality Improvement Act of 1997 (WQIA) is to restore and improve the quality of state waters and to protect them from impairment and destruction for the benefit of current and future citizens of the Commonwealth of Virginia (Section 10.1-2118 of the Code of Virginia). The purpose of the fund is to provide water quality improvement grants to local governments, soil and water conservation districts and individuals for point and nonpoint source pollution prevention, reduction and control programs (Section 10.1-2128.B. of the Code of Virginia). Nonpoint source pollution is a significant cause of degradation of state waters. The Virginia Department of Environmental Quality (VADEQ) is responsible for administering point source grants and the Virginia Department of Conservation and Recreation (VADCR) administers nonpoint source grants. WQIF funds are provided, in accordance with the guidelines, to help stimulate nonpoint source pollution reduction through the Virginia Agricultural Best Management Practices Cost-share Program and water quality improvement projects. VADCR staff provides technical assistance, as well as financial assistance. During implementation in the Long Meadow Run and Turley Creek watersheds, standards, specifications, cost-share, and tax credits for practices

under the Virginia Agricultural BMP Cost-share Program will be followed for funding eligibility.

Wildlife Habitat Incentive Program (WHIP)

WHIP is a voluntary program for landowners who want to develop or improve wildlife habitat on private agricultural lands. Participants work with NRCS to prepare a wildlife habitat development plan. This plan describes the landowner's goals for improving wildlife habitat and includes a list of practices and a schedule for installation. A 10-year contract provides cost-share and technical assistance to carry out the plan. Cost-share assistance of up to 75% of the total cost of installation (not to exceed $10,000 per applicant) is available for establishing habitat. Types of practices include: disking, prescribed burning, mowing, planting habitat, converting fescue to warm season grasses, establishing riparian buffers, creating habitat for waterfowl, and installing filter strips, field borders and hedgerows.

Wetland and Stream Mitigation Banking

Mitigation banks are sites where aquatic resources such as wetlands, streams, and streamside buffers are restored, created, enhanced, or in exceptional circumstances, preserved expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources. Mitigation banking is a commercial venture which provides compensation for aquatic resources in financially and environmentally preferable ways. Not every site or property is suitable for mitigation banking. Wetlands and streams are complex systems, and their restoration, creation, enhancement, or preservation often requires specialized ecological and engineering knowledge. Likewise, the mitigation banking process requires experience to efficiently navigate. Mitigation banks are required to be protected in perpetuity, to provide financial assurances, and long term stewardship. The mitigation banking processes is overseen by the Inter-Agency Review Team (IRT) consisting of several state and federal agencies and chaired by DEQ and Army Corps of Engineers. For more information, contact the Army Corps of Engineers or VADEQ's Virginia Water Protection Program.

Wetland Reserve Program (WRP)

This program is a voluntary program to restore and protect wetlands on private property. Landowners who choose to participate in WRP may receive payments for a conservation easement or cost-share assistance for a wetland restoration agreement. The landowner will retain ownership but voluntarily limits future use of the land. To be eligible for WRP, land must be suitable for restoration (formerly wetland and drained) or connect to adjacent wetlands. A landowner continues to control access to the land and may lease the land for hunting, fishing, or other undeveloped recreational activities.

10.0 REFERENCES

Brannan, K., B. Benham, G. Yagow, R. Zeckoski, and K. Hall. 2006. Bacteria Total Maximum Daily Load Development for Mill Creek, Stony Creek, and the North Fork of the Shenandoah River. A report prepared by the Biological Systems Engineering Department, Virginia Tech for the Virginia Department of Environmental Quality, Richmond.

Evans, B. M., S. A. Sheeder, K. J. Corradini, and W. S. Brown. 2001. AVGWLF version 3.2. Users Guide. Environmental Resources Research Institute, Pennsylvania State University and Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Haith, D. A., R. Mandel, and R. S. Wu. 1992. GWLF. Generalized Watershed Loading Functions, version 2.0. User's Manual. Department of Agricultural and Biological Engineering, Cornell University. Ithaca, New York.

ICPRB. 2011. Virginia Assessment Scenario Tool. Accessed: May, 2012.

NASS. 2009. Cropland Data Layer. USDA National Agricultural Statistics Service. Accessed 29 June 2011.

Perciasepe, Robert. 1997. New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs). Memorandum sent August 8, 1997. Washington, D.C.: U.S. Environmental Protection Agency.

SERCC. 2003. Historical climate summaries for Virginia. Southeast Regional Climate Center. South Carolina Department of Natural Resources, Water Resources Division. Columbia, South Carolina.

SWCB, 2011. 9 VAC 25-260 Virginia Water Quality Standards. Accessed: May, 2012.

Tetra Tech. 2003. A Stream Condition Index for Virginia Non-Coastal Streams. Prepared for US EPA Region 3, Wheeling, WV; US EPA Office of Science and Technology, Washington, DC; and Virginia Department of Environmental Quality, Richmond, VA. Accessed: May, 2012.

USDA-NRCS. 2010. VA 165 – Rockingham County, Virginia. Tabular and spatial data. Soil Data Mart. U.S. Department of Agriculture, Natural Resources Conservation Service. Accessed 10 January 2011.

USEPA. 2010a. Chesapeake Bay Phase 5.3 Community Watershed Model. Section 4: Land Use. EPA 903S10002 – CBP/TRS-303-10. December 2010. Annapolis, MD: U.S. Environmental Protection Agency, Chesapeake Bay Program Office. Accessed 31 January 2011.

USEPA. 2010b. Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment. Annapolis, MD: U.S. Environmental Protection Agency, Chesapeake Bay Program Office. Accessed 7 March 2011

USEPA. 2002. Mid-Atlantic Eco-regions. Accessed 21 December 2010.

USEPA, 2000. Stressor identification guidance document. EPA-822-B-00-025. U. S. Environmental Protection Agency, Office of Water and Office of Research and Development. Washington, D.C.

USEPA, 1994. Water quality standards handbook: Second edition. EPA-823-B-94-005. U. S. Environmental Protection Agency, Water Quality Standards Branch, Office of Science and Technology. Washington, D.C.

VCE. 2000. Feeder and stock health and management practices, by John F. Currin and W. D. Whittier, Extension Specialists, Virginia-Maryland Regional College of Veterinary Medicine, Virginia Tech. Publication Number 400-006. January 2000.

VCE. 1998a. Mastitis cost? by Gerald M. (Jerry) Jones, Extension Dairy Scientist, Milk Quality and Milking Management, Virginia Tech. Dairy Pipeline. December 1998.

VCE. 1998b. Safe water for horses, questions about water testing, by Larry Lawrence, Extension Animal Scientist, Horses, Animal and Poultry Sciences, Virginia Tech. Livestock Update. December 1998. Accessed 14 May 2012.

VADCR. 2003. Guidance manual for Total Maximum Daily Load Implementation Plans. Accessed 14 May 2012.

VADEQ. 2002. Virginia 303(d) Total Maximum Daily Load Priority List and Report. Virginia Department of Environmental Quality. March 3, 2003. Richmond, Virginia.

VADEQ. 2010. Virginia Water Quality Assessment 305(b)/303(d) Integrated Report. August 2010. Accessed 14 May 2012.

VADEQ. 2011. Water quality assessment guidance manual for 2012 305(b)/303(d) Integrated Water Quality Report. June 2011. Richmond, VA.: Virginia Department of Environmental Quality.

Yagow, G. and W.C. Hession. 2007. Statewide NPS Pollutant Load Assessment in Virginia at the Sixth Order NWBD Level: Final Project Report. VT-BSE Document No. 2007-0003. Submitted to the Virginia Department of Conservation and Recreation, Richmond, Virginia.

Yagow, G., K. Kline, and B. Benham. 2015. TMDLs for Turley Creek (sediment) and Long Meadow Run (sediment and nitrogen); Rockingham County, Virginia. VT-BSE Document No. 2014-0007. Prepared for the Virginia Department of Environmental Quality. August 7, 2015.

Zeckoski, R., B. Benham, and C. Lunsford. 2007. Streamside livestock exclusion: A tool for i ncreasing farm income and improving water quality. VCE Publication No. 442-766. Virginia C ooperative Extension. Accessed: 29 December 2008.

Appendix A. Glossary of BMP and other Control Measure Definitions

Adaptive fencing: This term refers to livestock exclusion fencing that is typically installed on a voluntary basis using less expensive poly-wire fencing, and is typically installed with a smaller buffer width, resulting in more available grazing acreage.

Agricultural sinkhole protection: A protection method to improve groundwater quality from surface contamination, by removing sources of pollution from sinkholes and providing an adequate buffer to trap and filter sediments and nutrients from surface flows that enter the groundwater through sinkholes. Cost-sharing may include measures to remove and properly dispose of all foreign materials and debris dumped in and around sinkholes, associated structural and agronomic measures to provide adequate vegetation for filtering and sediment trapping of surface run off, and for fencing in order to provide livestock exclusion and personal safety in these areas.

Alternative water system: A structural practice that will provide an alternative water source for livestock to discourage animal access to streams. Cost-sharing and/or tax credits may apply to construction or deepening of wells; development of springs or seeps, including fencing of the area where needed, to protect the development from pollution by livestock; construction or repair of dugouts, dams, pits, or ponds; and the installation of pipelines, storage facilities, cisterns, troughs and artificial watersheds.

Critical area stabilization: Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices. This practice is used in areas with existing or expected high rates of erosion or degraded sites that usually cannot be stabilized by ordinary conservation treatment.

Cover crops: A fall-seeded grass or legume crop planted after the harvest of corn or soybeans to maintain a vegetative cover over the winter.

Fencing: A constructed barrier to livestock, wildlife or people. Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences shall consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice.

Hardened crossing: A controlled stream crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment.

Improved pasture management: This practice consists of a series of measures to improve vegetative cover on, and reduce bacteria loading from, pasture areas and may include soil testing, application of lime and fertilizer based on soil testing results, maintenance of a 3-inch minimum grass height through the growing season except for droughts, mowing to control woody vegetation, and chain-harrowing to break-up manure piles after livestock are moved from field.

Livestock exclusion: Excluding livestock from areas where grazing or trampling will cause erosion of stream banks and lowering of water quality by livestock activity in or adjacent to the water. Limitation is generally accomplished by permanent or temporary fencing. In addition, installation of an alternative water source away from the stream has been shown to reduce livestock access.

Livestock exclusion fencing: This practice consists of installing fencing, both temporary and stream exclusion (permanent), for grazing distribution and to restrict stream access in connection with newly developed watering facilities. State cost-sharing requires that the stream exclusion fence be placed a minimum of 35 feet away from the stream, except as designed in areas immediately adjacent to livestock crossings and controlled hardened accesses.

Livestock exclusion buffers: In the implementation plan, this term is used to differentiate the filtering benefits of the buffer, as opposed to the removal of livestock and their directly deposited bacteria loads from the stream. Removal of the livestock has an immediate effect in removing bacteria loads, while the buffer mitigates loading from surface runoff during storm events.

Manure storage facility: This practice consists of a planned system designed to manage liquid and solid waste from areas where livestock and poultry are concentrated. The storage allows for the farm operator to apply the manure on fields during optimum times of the year, and increases the die-off of bacteria in the animal waste.

Reforestation of erodible pastureland: This practice consists of planting trees (hardwoods and/or conifers) on land currently used as cropland or pastureland in order to make a permanent land use conversion to forest, so as to more effectively control the soil and nutrient loss from surface runoff, thus improving water quality. As part of the practice, a permanent vegetative cover is to be established on gullied or eroded areas and shall be maintained until trees provide a protective canopy.

Riparian forest buffer: A protection method used along streams to reduce erosion, sedimentation, and the pollution of water from agricultural nonpoint sources. An area of trees and shrubs 35 – 300 feet wide located up gradient, adjacent, and parallel to the edge of a water feature.

Riparian grass buffer: Grass filter strips are vegetative buffers that are located along the banks of water courses to filter runoff, anchor soil particles, and protect banks against scour and erosion. The strips also improve water quality by filtering out fertilizers, pesticides, and microorganisms that otherwise might reach waterways. In addition, grass filter strips along streams serve as environmental corridors.

Septic system pump out: This preventative control measure consists of periodic maintenance of septic tank systems by having the tank pumped to remove solids and to inspect the septic tank. This practice also allows for the identification of systems which are not functioning properly. The practice also may include inspection of the distribution box to determine if the effluent is being properly distributed to the drainfields and the system is functioning in accordance to design.

Septic system repair: This measure consists of the correction of a malfunctioning on-site sewage disposal system to remove the presence of raw or partially treated sewage on the ground's surface, or in adjacent ditches or waterways, or in ground water.

Septic system, alternative: An alternative on-site waste treatment system is needed to correct a malfunctioning on-site sewage disposal system or to replace an identified straight pipe in situations where the installation/replacement of a septic tank system cannot be permitted. Alternative systems may include the following: aerobic treatment units, low pressure distribution systems, drip distribution systems, sand filters, elevated sand mounds, constructed wetlands, peat filters, vault privies, incinerator toilets, and composting toilets.

Septic system, new: This control measure consists of the installation of a septic tank system to replace an identified straight pipe which delivers sewage directly to a stream, pond, lake, or river or an installation to correct a malfunctioning on-site sewage disposal system. Cost-sharing may include the pump out and removal of solids from the malfunctioning septic tank, the installation of a septic tank and subsurface drainfield components, and the re-stabilization of disturbed areas by planting seed.

Septic system, new with pump: Same as for a new septic system, with the inclusion of a pump as a primary component to move waste to a higher elevation.

Sewer hookup, new: This practice consists of connecting a malfunctioning on-site sewage disposal system to public sewer, or replacing an identified straight pipe by a connection to public sewer. Cost-sharing may be authorized for the connection fee, which is the fee allowing the dwelling to be connected to the public sewer system, for the construction cost associated with connecting the dwelling to a sewer line, for re-stabilization of disturbed areas, and for the pump-out and removal of solids from the septic tank.

Vegetated filter strip: A densely vegetated strip of land engineered to accept runoff from upstream development as overland sheet flow. It may adopt any naturally vegetated form, from grassy meadow to small forest. The purpose of a vegetated filter strip is to enhance the quality of stormwater runoff through filtration, sediment deposition, infiltration and absorption.

Winter feeding facility: Winter feeding facilities are specially designed to allow for the feeding of livestock in combination with the safe storage of manure, and to prevent contamination of nearby water corridors and streams. Winter feeding facilities are typically sized for individual farms, based on number of head of livestock fed through the winter; are designed to hold 5-7 days of feed; and to store waste for at least 120 days. This practice may also include the following components: gutters & downspouts redirect runoff, livestock watering facilities, heavy use area protection around the facility, and all-weather access roads to the structure.

Appendix B. BMP Codes and Practice Names

CRFR-3: CREP riparian forest buffer
CRSL-6: Stream exclusion with CREP riparian forest buffer
FR-1: Reforestation of erodible crop and pastureland
FR-3: Woodland buffer filter area
LE-1T: Livestock exclusion with 35-foot riparian buffer
LE-2T: Livestock exclusion with reduced setback (10 feet)
NM-1A: Nutrient Management Plan Writing and Revisions
NM-3C: Split nitrogen application based on PSNT
RB-1: Septic tank pump out
RB-2: Connection of malfunctioning on-site sewage disposal system or straight pipe to public sewer
RB-3: Septic tank system repair
RB-4: Septic tank system installation/replacement
RB-4P: Septic tank system installation/replacement with pump
RB-5: Alternative on-site waste treatment system
SL-1: Permanent vegetative cover on cropland
SL-6: Stream exclusion with grazing land management
SL-6T: Stream exclusion with grazing land management
SL-8B: Small grain cover crop for nutrient management and residue management
SL-8H: Small grain harvestable cover crop
SL-9: Grazing land management
SL-11: Permanent vegetative cover on critical areas
SL-15A: Continuous no-till system
WP-1: Sediment retention, erosion, or water control structures
WP-2, WP-2T: Stream protection systems
WP-4: Animal waste manure storage facility
WP-4B: Loafing lot management system
WP-4C: Mortality composter
WP-7: Extension of CREP watering systems
WQ-1: Grass filter strips
WQ-4: Legume cover crop
WQ-11: Agricultural sinkhole protection

Appendix C. Documentation for Turley Creek and Long Meadow Run BMP Pollutant Load Reduction Modeling

Basis for BMP Extents

- Livestock exclusion: 2011 NHD stream lengths were intersected with the “pasture/grass” and “other pasture/hay” landuse categories from the 2009 NASS cropland data layer. Local NRCS estimates of the pasture/hay distribution as 85% pasture and 15% hay were then applied to the total riparian stream length. A visual estimate of 1-sided streams was made in Turley Creek (7.8%) and applied to both watersheds, and the remainder assessed as having 2-sided access. The total stream length requiring fencing was then multiplied by a 35-ft buffer, converted to acres and compared with the area in “degraded riparian pasture” used for modeling in each watershed. The modeled areas were 21-29% smaller than the calculated areas, so the stream length requiring fencing was reduced by those amounts, assuming that the difference was due to intermittent streams that do not require fencing. The distribution among the 6 variations was arrived at by trial-and-error to meet the required sediment load reductions.

- Sediment retention structure/denitrifying bioreactor: These were added in as individual systems and will be designed to treat the pollutant loads of sediment and nitrogen from springs in single locations in Turley Creek and Long Meadow Run watersheds, respectively.

- Failing septic system alternatives: Based on discussions with a representative from the Shenandoah Valley SWCD during the residential working group meeting and follow-up discussions with the Rockingham County Department of Environmental Services, it was estimated that 50% of failing septic systems could be repaired without installing a new system. Of those failing systems needing to be replaced, it was estimated that 40% would be conventional systems, 35% would need to be replaced with alternative waste treatment systems because of soil and bedrock limitations in the watershed, and 25% would need to include a pump to lift the septic tank effluent to the drain field. Septic tank pump-outs were discussed at the Residential Working Group meeting. It was estimated that 20% of the 555 non-sewered households in Long Meadow Run would volunteer to schedule pump-outs if they were made aware of the necessity and benefits of septic pump-outs.

Basis for Pollutant Load Reduction Calculations

Nitrogen and sediment load reductions were generally calculated from unit-area loads (UALs) associated with individual land use categories from the TMDL modeling, the area of the BMP, and the estimated effectiveness of the individual control measures, where the UALs vary by landuse and effectiveness values vary by pollutant.

Reductions from land use changes were simulated as the difference in the UALs between the two land uses and the area of the BMP, such as the example below for FR-1. The same formula applied to the SL-1, SL-11, and WQ-1, and buffer areas for the BMPs.

- Aforestation of erodible crop and pastureland (FR-1): $(UAL_{hi\text{-}till} - UAL_{for})$ * BMP area

The livestock exclusion practices (LE-2, SL-6, and WP-2) and other buffer practices (WQ-1, FR-3/CRFR-3) were associated with similar land use change calculations with additional filtering benefits, simulated as affecting some multiple of the buffer area. The upland multiplier (UM) = 4 for nitrogen and 2 for sediment. The following calculations were for sediment control practices. However, all BMPs had identical reduction calculations for nitrogen in Long Meadow Run, with the exception of using a different UM for the upland area filtered by the buffers created by the livestock exclusion practices.

- Livestock exclusion, alternative water (SL-6, CRSL-6):
  (length of fencing * 35 ft)/43,560 sq.ft/ac * [$(UAL_{trp} - UAL_{hyo})$ + UM * UAL_{pas} * BMP efficiency] + UAL_{pas} * associated PrecRotGraz area * BMP efficiency

- Livestock exclusion, limited access (WP-2):
  (length of fencing * 35 ft)/43,560 sq.ft/ac * [$(UAL_{trp} - UAL_{hyo})$ + UM * UAL_{pas} * BMP efficiency]

- Livestock exclusion, 10-ft buffer, alternative water (LE-2, LE-2T):
  (length of fencing * 10 ft)/43,560 sq.ft/ac * [$(UAL_{trp} - UAL_{hyo})$ + UM * UAL_{pas} * BMP efficiency] + UAL_{pas} * associated PrecRotGraz area * BMP efficiency

- Livestock exclusion, 10-ft buffer, limited access (LE-2, LE-2T):
  (length of fencing * 10 ft)/43,560 sq.ft/ac * [$(UAL_{trp} - UAL_{hyo})$ + UM * UAL_{pas} * BMP efficiency]

- Livestock exclusion, 10-ft buffer, polywire fencing:
  (length of fencing * 10 ft)/43,560 sq.ft/ac * [$(UAL_{trp} - UAL_{hyo})$ + UM * UAL_{pas} * BMP efficiency]

Efficiency-based reductions followed the example of the example SL-8 cover crop calculation below. Other BMPs that followed the same formula include nutrient management (NM-1A and NM-3C), no-till (SL-15A), grazing land management (SL-10T), extension of CREP watering systems (WP-7), and legume cover crops (WQ-4).

- Cover crops (SL-8B, SL-8H): $UAL_{hi\text{-}till}$ * BMP area * BMP efficiency

Some of the efficiency based reductions were applied to systems, typically with some assumed area associated with each system, as in the barnyard runoff controls (0.5 ac/system) example below. The same formula was used for the loafing lot management systems (WP-4B; 0.5 ac/system), ag sinkhole protection (WQ-11; 0.5 ac/system), and sediment retention structures (WP-1; 10 acres/system).

- Barnyard runoff controls: UAL_{afo} * no. of systems * ave. area/afo * BMP efficiency

The last category of reduction calculations used either a fixed load reduction per length of installed BMP (streambank stabilization, WP-2), an explicit load reduction for manure transport, explicit calculations of load reduced by the sediment retention structure BMP (WP-1) and the DNBR BMP to individual springs, and septic system BMPs. The latter examples were also combined with a BMP efficiency.

- Streambank stabilization (WP-2): BMP length (ft) * $ULL_{N,P}$

- Manure transport: no. of tons of manure/yr * 26.4 lbs N/ton manure

- Sediment retention structure (i.e., Brock Creek spring):
  (4.06 MGD * 7 mg TSS/L * 8.353 * 365 days/yr)/(2,000 lbs/ton) * BMP efficiency

- Denitrifying bioreactor (i.e., Holsinger spring):
  0.5 * 0.68 MGD * 8.32 mg TN/L * 8.353 * 365 days/yr * BMP efficiency

- New connection to sewer (RB-2): no. of systems * ave household size * 8.8184 lb NO3-N/person-yr

- Septic system BMPs (RB-1, RB-3, RB-4, RB-4P, RB-5):
  no. of systems * ave household size * 8.8184 lb NO_3-N/person-yr * BMP efficiency

The following BMPs were also identified as being needed in one or both watersheds, but currently lack an appropriate means of quantifying nitrogen or sediment reductions. Work by the Chesapeake Bay Expert Panels should be available to help quantify these BMPs during implementation and to allow adjustments in the extent needed of various BMPs:

- WP-4, AWMS (winter feeding facility)
- WP-4, AWMS (poultry litter dry-stack facility)
- WP-4C, Mortality composters
- Brush management