Upper Stroubles Creek Watershed
TMDL Implementation Plan
Montgomery County, Virginia

Submitted to:

The Stakeholders of the Stroubles Creek Watershed

Prepared by:

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Virginia Water Resources Research Center

In Cooperation With:

Virginia Department of Environmental Quality

and

Virginia Department of Conservation and Recreation

Revised: May 24, 2006

VT-BSE Document No. 2005-0013

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The Duck Pond – the beginning of Stroubles Creek

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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)
CWA – Clean Water Act, the origin of the Total Maximum Daily Load Program
E&S – erosion and sediment
EPA – United States Environmental Protection Agency
EPT – three classes of sensitive stream organisms, *Ephemeroptera*, *Plecoptera*, and *Tricoptera*
GWLF – Generalized Watershed Loading Functions, a nonpoint source simulation model
IP – Implementation Plan
LA – Load Allocation, the load allocated to nonpoint and background sources
LID – low impact development, a general class of urban infiltration management practices
MFBI – Modified Family Biotic Index, one of the biological metrics
MOS – Margin of Safety, a load reflecting uncertainty in the modeling process
MS4 – Municipal Separate Storm Sewer Systems, Phase II Stormwater Management Program
N - nitrogen
NPS – nonpoint source, referring to diffuse sources of pollution, such as from runoff
NRCS – Natural Resources Conservation Service
P - phosphorus
RBP – Rapid Bioassessment Protocols, the procedures used for biological monitoring and assessment
SCI – Stream Condition Index, an index under development for use in assessing stream health in Virginia
SSO – sanitary sewer overflow
STE – the three letter abbreviation used to identify Stroubles Creek at DEQ monitoring sites
SWCB – State Water Control Board
SWCD –Soil and Water Conservation District
SWM – storm water management
TAA – Technical Assistance and Administration
TBD – to be determined
TMDL – Total Maximum Daily Load (Study)
TOB – Town of Blacksburg
VAC – Virginia Administrative Code
VCE – Virginia Cooperative Extension
VVDCR – Virginia Department of Conservation and Recreation
VVDEQ – Virginia Department of Environmental Quality
VDOF – Virginia Department of Forestry

VDOT – Virginia Department of Transportation
VPDES – Virginia Pollutant Detection and Elimination System
VT – Virginia Tech
WLA – Waste Load Allocation, the load allocated to point sources
WQIF – Water Quality Improvement Fund
WQMIRA – Water Quality Monitoring, Information and Restoration Act

1.0 EXECUTIVE SUMMARY

A Total Maximum Daily Load (TMDL) study was conducted on Stroubles Creek from April 2002 through October 2003 and approved by EPA in January 2004 (Benham et al., 2003). The TMDL specified the maximum sediment load that Stroubles Creek can handle in a manner that is protective of the habitat for benthic macroinvertebrates, in particular, and aquatic life, in general, so that it is in compliance with Virginia water quality standards. This document serves as the Total Maximum Daily Load (TMDL) implementation plan (IP) for Stroubles Creek in Montgomery County and the Town of Blacksburg, Virginia. The implementation plan is the next step in the TMDL process that specifies where and how the sediment reductions called for in the TMDL study will be made to remove the benthic impairment on Stroubles Creek.

The impaired stream segment on Stroubles Creek, as delineated by VDEQ, extends from the outlet of the Virginia Tech Duck Pond to its downstream confluence with Wall Branch. This 4.98-mile stream reach is designated by the Commonwealth of Virginia as Waterbody Segment ID VAW-N22R_STE04A00.

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 through Virginia's 1997 Water Quality Monitoring, Information, and Restoration Act.

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.

Stroubles Creek is a tributary of the New River (VAW-N22R, HUC 05050001). The headwaters of the creek originate in the northeastern part of the town of Blacksburg, flowing in a generally southwestern direction. Stroubles Creek is formed from two main tributaries – Central Branch and Webb Branch – and receives flow from a number of other unnamed perennial streams. The two named tributaries flow into the Duck Pond on the Virginia Tech campus, with the main Stroubles Creek channel beginning at the pond's outfall. The Upper Stroubles Creek watershed (Figure 2.1) contributing to the impaired section of Stroubles Creek (upstream of Wall's Branch) is 2,476 hectares (6,119 acres), oriented along a northeast-southwest axis. This watershed contains a significant urban area associated with, or incorporated in, the Town of Blacksburg, and a majority of the main campus of Virginia Tech.

The benthic TMDL for Stroubles Creek is comprised of three required load components – the waste load allocation (WLA) from point sources, the load allocation (LA) from nonpoint sources, and a margin of safety (MOS), as shown in Table 1.1. The individual permitted constituents of the WLA component are shown below the WLA load in the table.

Table 1.1. Upper Stroubles Creek TMDL* Sediment Load

TMDL (t/yr)	WLA (t/yr)	LA (t/yr)	MOS (t/yr)
2,145.6	233.2	1,697.9	214.6
	VAR050441 - Litton Systems Inc Poly Scientific Div : 2.7 VAR050508 - VT - Central Heating Plt: 0.46 VAR10042 - VT - Dairy Science Center: 2.37 VAR10267 - VT - Campus: 15.43 VAR10275 - Hawthorne Ridge Town Houses: 0.77 VAR10282 - Carriage Court II: 0.54 VPG120011 - VT - Dairy Science Center: 0 MS4s (VAR040019, VAR040049, VAR040016): 210.88		

* Total Maximum Daily Load

Because of expected future growth in the watershed, TMDL modeling for the allocation runs was performed using the future land use scenario for Stroubles Creek. The recommended TMDL allocation scenario called for a 77% reduction in sediment loads from agricultural sources and channel erosion, and a 54% reduction from urban sources.

The Toms Creek watershed upstream from Deerfield Drive was used as the TMDL reference watershed for Stroubles Creek. The TMDL to address the benthic impairment in Stroubles Creek was developed to meet the existing sediment load from the area-adjusted Toms Creek watershed. The selected benthic TMDL for Stroubles Creek requires sediment reductions from the two major source categories – "agriculture" and "channel erosion", together with equal reductions from both the non-MS4 and MS4 urban areas. The TMDL to address the benthic impairment in Stroubles Creek is 2,145.6 t/yr of sediment and will require an overall reduction from projected future loads equal to 71% of the existing load. The majority of additional sediment generated by future land use changes is likely to be due to increased total and peak runoff from an increasing amount of impervious area that can affect both surface erosion and channel erosion. Much of this increase in runoff and sediment load is expected to be attenuated through compliance with the new MS4 discharge regulations that should accompany future development.

The TMDL was developed to take into account all major sediment sources in the watershed from both point and nonpoint sources, and to consider future land use changes. The sediment loads were averaged over a 10-year period to take into account both wet and dry periods, and the model inputs took into consideration seasonal variations and critical conditions related to sediment loading. The allocated loads were 10% less than the calculated TMDL to account for the required margin of safety.

The following watershed conditions were identified as issues during the stressor analysis in the Stroubles Creek TMDL study:

1. Lack of streamside forest
2. Livestock access to streams
3. Agricultural runoff
4. Increasing development and peak flows from stormwater runoff
5. Stream channel modifications
6. Sewer overflows
7. Downtown business wastewater disposal
8. Pollutant buildup on impervious surfaces
9. Enforcement of Erosion & Sediment regulations at construction sites
10. Improper disposal of grass clippings and trash

Public participation in the development of the IP was achieved through a series of Focus Groups that were formed around Agricultural/Rural, Urban/Residential, and Public Works issues. Recommendations from the Focus Groups were then refined by a Steering Committee, under the facilitation of the Project Support Team.

Because the Stroubles Creek watershed contains a combination of rural, suburban, and urban land uses, implementation actions consist of a variety of management practices to address human impacts arising from these various land uses. Proposed actions include agricultural BMPs, stream channel BMPs, stormwater management BMPs, sanitary sewer system improvements, and urban/residential education components. Because both the Town of Blacksburg and Virginia Tech are in the process of developing and implementing NPDES Phase II MS4 programs, some of these actions have already been outlined in the respective MS4 plans, while other proposed new actions arose out of the public participation process through Focus Group and Steering Committee meetings.

Since modeling was performed as part of the TMDL study, several issues have arisen which have changed the numeric target loads and percent reductions, though not the direction of the TMDL, as summarized in Table 1.2. First, a software coding error was detected that overestimated the channel erosion load. Then a misclassification of land use was detected and corrected, and finally, advances in model parameter value estimation procedures were incorporated for implementation planning purposes. When the model corrected channel erosion rates were compared with an estimate from initial field measurements currently being made on one stretch of Stroubles Creek, the model estimates were about 6 times lower. Therefore, the channel erosion estimates from each sub-watershed and from the reference watershed were all multiplied by 6 to provide more realistic channel erosion and target loads. Implementation Planning will proceed with the revised estimate of percent reduction for three main reasons: 1.) The IP is being developed in a staged approach using sediment load reduction as a surrogate measure for benthic health improvement, 2.) the reference watershed approach sets a “relative” target load based on the reference watershed, and 3.) the revised TMDL load is actually lower than in the TMDL study.

Table 1.2. Changes in TMDL Target % Reductions

Land Use Scenario		Sediment Load (tons/yr)	Channel Erosion (tons/yr)	TMDL (tons/yr)	Target Load (tons/yr)	% Reduction
TMDL Study	Future	7,552.6	2,404.6	2,365.1	2,128.6	71.8%
Model Correction	Future	5,180.9	32.9	2,001.2	1,801.0	65.2%
Land Use Correction	Interim	4,924.2	27.5	2,001.2	1,801.0	63.4%
Revised Parameter Estimates	Interim	3,251.5	54.8	1,515.2	1,363.7	58.1%
Adjusted Channel Erosion Rates	Interim	**3,525.6**	**328.9**	**1,599.2**	**1,439.3**	**59.2%**

Interim and IP load reductions were calculated through a combination of modeling and application of efficiency coefficients that will result in the attainment of the revised TMDL target load, as shown in Table 1.3.

Table 1.3. Summary of Load Reductions for Stroubles Creek

Loads and *Reductions*	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)
TMDL Revised Existing Load	37,202.5	16,647.6	3,525.6
Interim Reduction	3,151.5	3,151.2	845.1
Reductions Due to Anticipated Future Land Use Changes	-835.8	210.6	71.5
IP Upland Reductions	7,620.7	4,145.4	956.0
IP Channel Reductions	280.1	506.7	213.8
Load after Implementation	26,986.0	8,633.8	**1,439.1**
% Reduction Achieved	27.5%	48.1%	59.2%
TMDL			1,599.2
TMDL Target Load (TMDL-MOS)			**1,439.3**

The next three tables list the agricultural, stream channel and stormwater management BMPs to be installed to address the identified water quality issues in Stroubles Creek during the implementation period, together with expected sediment load reductions and their cost/ton of sediment.

In addition to the above practices, programs will be implemented to eliminate Sanitary Sewer System Overflows, and to provide education to a variety of targeted audiences throughout the watershed on pollution prevention and creek stewardship.

Table 1.4. Agricultural BMP Cost Benefit Analysis

Agricultural BMPs	IP Reductions			Implementation Costs			Cost/Load Reduction
	N	P	Sed				
	(lbs/yr)	(lbs/yr)	(tons/yr)	Installation	TAA	Total	($/ton Sed)
Riparian forest buffer	4,323.9	2,894.6	766.7	$16,208	$3,242	$19,449	$25.37
Livestock exclusion + limited access	1,042.92	199.13	56.54	$35,789	$7,158	$42,946	$759.56
Loafing lot management + diversion	37.02	28.48	0.00	- TBD -			

Table 1.5. Stream Channel BMP Cost Benefit Analysis

Sream Channel BMPs	IP Reductions			Implementation Costs			Cost/Load Reduction
	N	P	Sed				
	(lbs/yr)	(lbs/yr)	(tons/yr)	Installation	TAA	Total	($/ton Sed)
Stream channel restoration	280.1	506.7	213.8	$1,066,555	$143,985	$1,210,540	$5,661.09

Table 1.6. Stormwater Management BMP Cost Benefit Analysis

Stormwater Management BMPs	IP Reductions			Implementation Costs			Cost/Load Reduction
	N	P	Sed				
	(lbs/yr)	(lbs/yr)	(tons/yr)	Installation	TAA	Total	($/ton Sed)
Riparian forest buffer	581.7	186.2	16.4	$3,938	$1,063	$5,002	$304.84
Infiltration practices (additional)	66.46	11.42	2.25	$142,784	$38,552	$181,336	$80,517.56
Bioretention areas (additional)	57.15	13.21	1.88	$223,242	$15,782	$239,024	$127,359.05
Street sweeping (additional)	778.95	58.09	16.15	$12,746		$12,746	$789.42
Hydrodynamic separator	192.76	10.54	1.54	$100,000		$100,000	$64,744.62
Increase E&S program efficiency	382.92	715.92	90.00	$50,000		$50,000	$555.56

Riparian forest buffers and livestock exclusion practices are likely to offer the greatest reduction in sediment loads in Stroubles Creek, and should be implemented first. Many of the actions proposed, such as sanitary sewer improvements and illicit discharge detection are already included in local MS4 plans and will be locally funded. A part-time watershed coordinator will be hired in conjunction with the New River Watershed Roundtable to facilitate implementation, tracking, and educational components of the IP.

Funding for implementation in Stroubles Creek will come from a variety of sources, including available cost-sharing programs, grant sources, and in-kind services from the Town of Blacksburg and Virginia Tech. The amount of funding available from each source is expected to vary from year to year and grant funding will be contingent on receipt of awards. However, since the implementation plan will be phased in over a period of years, a number of funding opportunities will be available during implementation, thereby increasing the likelihood of receiving the requested funding. Since implementation planning for Stroubles Creek was initiated by VDEQ instead of VDCR, it was inadvertently left off of the state's current priority list for receiving §319 program funds. However, funding from §319 grants may be available for the watershed starting in 2007. Many of the activities in this plan are ones that the Town and University have already planned and funded on their own, so although they may not offer the greatest benefit per dollar, their funding, nevertheless, is assured.

2.0 Introduction

A Total Maximum Daily Load (TMDL) study was conducted on Stroubles Creek from April 2002 through October 2003 and approved by EPA in January 2004 (Benham et al., 2003). The TMDL specified the maximum sediment load that Stroubles Creek can handle in a manner that is protective of the habitat for benthic macroinvertebrates, in particular, and aquatic life, in general, so that it is in compliance with Virginia water quality standards. This document serves as the Total Maximum Daily Load (TMDL) implementation plan (IP) for Stroubles Creek in Montgomery County and the Town of Blacksburg, Virginia. The implementation plan is the next step in the TMDL process that specifies where and how the sediment reductions called for in the TMDL study will be made to remove the benthic impairment on Stroubles Creek.

A benthic impairment is a condition whereby a stream is assessed as having chronic or recurring monitored violations of the state general standard as shown through biomonitoring results. Biological monitoring (biomonitoring) has been conducted since 1994 by the Virginia Department of Environmental Quality (VDEQ) at station STE007.29 (Merrimac Road) on Stroubles Creek. Monitoring was generally conducted twice a year and assessed every two years based on the previous 5-years results. Assessments in 1998, 2000, and 2002 were the basis for listing this stream segment as impaired, and subsequently listed on Virginia’s 303(d) list. Each assessment indicated decreased numbers and diversity of organisms in the benthic macro-invertebrate populations that live in and around the stream bottom, leading to the assessment of Stroubles Creek being “not fully supportive” of its designated use and, therefore, “impaired”.

VDEQ listed nonpoint source agricultural and urban pollution as the probable causes of the benthic impairment (VDEQ, 2002). The Stroubles Creek TMDL study identified sediment as the primary stressor impacting the habitat of these organisms, with additional significant contributions from nutrients and organic matter. TMDL studies and associated target loads are developed for individual pollutants, but an implementation plan is to address all sources of pollutants in a watershed. Therefore during development of the IP, management measures should be selected with these other pollutant sources, as well. The TMDL, however, was developed specifically for sediment and called for reductions from the three major contributing sediment source categories in the watershed (Table 2.1).

Table 2.1. Reductions Required in the TMDL* Allocation.

Source Category	% Sediment Reduction
Agriculture	77%
Urban	54%
Channel Erosion	77%

* Total Maximum Daily Load

The impaired stream segment on Stroubles Creek, as delineated by VDEQ, extends from the outlet of the Virginia Tech Duck Pond to the confluence with Wall Branch. This stream reach is designated by the Commonwealth of Virginia as Waterbody Segment ID VAW-N22R_STE04A00, and is 4.98 miles in length.

An impairment in a stream segment arises from nonpoint sources scattered throughout all portions of the upstream area draining to the impaired segment. This drainage area is known as its watershed, and a TMDL must consider pollutant contributions from all portions of its watershed. The watershed is defined by the furthest downstream point on the impaired segment, so that the watershed associated with the impaired segment on Stroubles Creek encompasses 6,119 acres. Since Stroubles Creek extends to its confluence with New River, this document will refer to the Upper Stroubles Creek watershed, or the Stroubles Creek TMDL watershed, as the upstream portion corresponding to the impaired segment (Figure 2.1). The Upper Stroubles Creek watershed is located in Montgomery County, Virginia and includes major portions of the Town of Blacksburg and the Virginia Tech main campus.

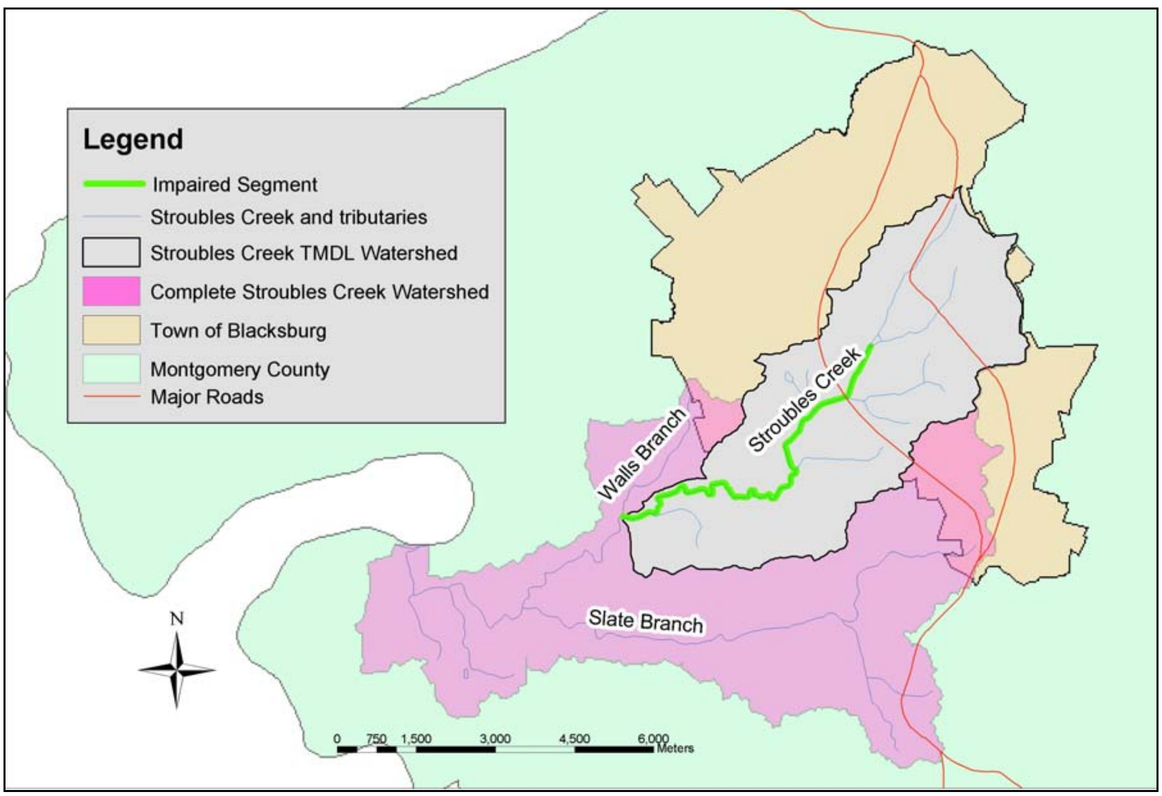

Figure 2.1. Location of Stroubles Creek Impaired Segment and TMDL Watershed.

2.1. *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 section 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 section 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 Commonwealth of Virginia was also a signatory to the June 11, 1999 consent decree settling federal case no. 98-979-A "American Canoe Association, Inc. and the American Littoral Society v. EPA and EPA – Region III." By signing the consent decree, Virginia committed to develop TMDL studies by 2010 for all Virginia water segments listed on the 1998 303(d) Impaired Waters list.

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

> All state waters 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, 2003)

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:

> All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are … 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, 2003)

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

3.0 State and Federal Requirements for TMDL Implementation Plans

3.1. *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.

3.2. *State Requirements*

The TMDL 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 (VDEQ) 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.

3.3. *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.

3.4. *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.

3.5. *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.

4.0 Review of the Stroubles Creek TMDL Study

4.1. *Watershed Characteristics*

Stroubles Creek is a tributary of the New River (VAW-N22R, HUC 05050001). The headwaters of the creek originate in the northeastern part of the town of Blacksburg, flowing in a generally southwestern direction. Stroubles Creek is formed from two main tributaries – Central Branch and Webb Branch – and receives flow from a number of other unnamed perennial streams. The two named tributaries flow into the Duck Pond on the Virginia Tech campus, with the main Stroubles Creek channel beginning at the pond's outfall. The Upper Stroubles Creek watershed (Figure 2.1) contributing to the impaired section of Stroubles Creek (upstream of Wall's Branch) is 2,476 hectares (6,119 acres), oriented along a northeast-southwest axis. This watershed contains a significant urban area associated with, or incorporated in, the Town of Blacksburg.

Stroubles Creek continues for another 4.72 miles downstream from the impaired segment, where it enters the New River, which flows north to the Kanawha River. The Kanawha is a tributary of the Ohio River, which flows into the Mississippi River, with the Mississippi discharging into the Gulf of Mexico.

The main general soil map units found in the Upper Stroubles Creek watershed are the Groseclose-Poplimento-Duffield and the Berks-Weikert associations. The Groseclose-Poplimento-Duffield soils (silty loam) are deep and well drained with clayey subsoil. These soil types are typically found on moderately dissected uplands. The Berks-Weikert soils (shaly silt loam) are moderately deep to shallow, well-drained soils with loamy subsoil. In the Upper Stroubles Creek watershed, Berks-Weikert is found primarily on Price Mountain. In upland areas, both of these soils are underlain by limestone bedrock (SCS, 1985).

For watershed modeling purposes during the TMDL study, the climate of the watershed was represented by meteorological observations made at the National Weather Service station in Blacksburg, Virginia. This station is located in the Corporate Research Center on the Virginia Tech campus. The station is located just south of the watershed boundary, but is only 1.27 miles from the centroid of the watershed. Average annual precipitation at the Blacksburg station is 40.43 inches with 52.6% of the precipitation occurring during the crop-growing season (May-October). Average annual snowfall is 23.1 inches with the highest snowfall occurring during January. Average annual daily temperature is 51.5°F. The highest average daily temperature of 71.2°F occurs in July while the lowest average daily temperature of 30.6°F occurs in January (SERCC, 2002).

The main land use category in the Upper Stroubles Creek watershed is urban/residential, comprising approximately 46% of the total watershed area. Forest, pasture, and cropland acreage accounts for about 28%, 21%, and 5% of the watershed area, respectively, as shown in Figure 4.1. The urban and residential area is mainly in the northeastern (upstream) section of the watershed; the forested area is mainly downstream in the southwestern corner; with the agricultural area in the mid-section.

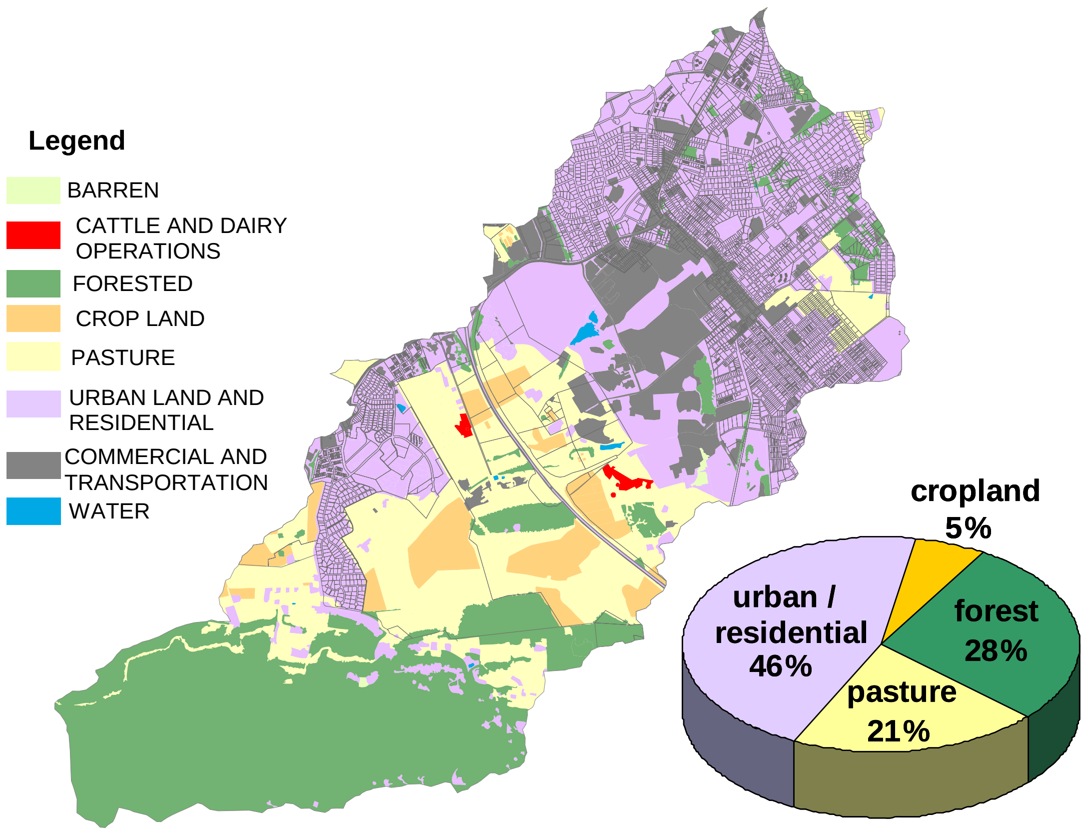

Figure 4.1. Existing Land Use in Upper Stroubles Creek Watershed

The Upper Stroubles Creek watershed is experiencing urban development and growth, so changes in land use were estimated for modeling future loads as part of the TMDL allocation procedure. Future land use scenarios were created based on an analysis of trends between 2001 land use and future land use zoning projected to the year 2046 by the Town of Blacksburg, and a sub-watershed-by sub-watershed analysis of land use changes likely to occur in the foreseeable future.

The analysis of the Blacksburg data indicated a virtual elimination of forested and agricultural land by 2046 within the Blacksburg portion of the watershed. An exception to this trend was made for land operated by the Virginia Tech farm which is expected to maintain its functionality for both production and research. However, the major trend from this analysis – that agricultural land would be shifting to urban residential, commercial and institutional uses – was consistent with that of a growing urban community such as the one found in the Upper Stroubles Creek watershed. Within the context of this major trend, expected land use changes in the near future were estimated within each sub-watershed. On a watershed basis, the future scenario consisted of the changes shown in Table 4.1.

Table 4.1. Landuse Change between Existing and Future Scenarios

	Existing	% Change	Future
Agriculture	25.7%	**-5.9%**	19.8%
Urban	46.6%	**7.5%**	54.1%
Forest	27.7%	**-1.6%**	26.1%

4.2. *Chemical and Biological Monitoring*

Virginia VDEQ has monitored chemical water quality in the watershed since 1979. Ambient monitoring at station STE002.41 was performed quarterly from February 1994 through February 1999, bi-monthly from May 1999 through April 2001, monthly from June 2001 through June 2003, and bi-monthly from July 2003 through the present. Biological monitoring was conducted at station STE007.29 from October 1994 through March 2003. Beginning in July 2002, ambient water quality monitoring was also conducted at this second site in order to provide co-located information for analyzing stressors to the monitored biological community. Ambient monitoring at STE007.29 was performed monthly between July 2002 and June 2003, and bimonthly between July 2003 and May 2003. The locations of these two stations are shown in Figure 4.2.

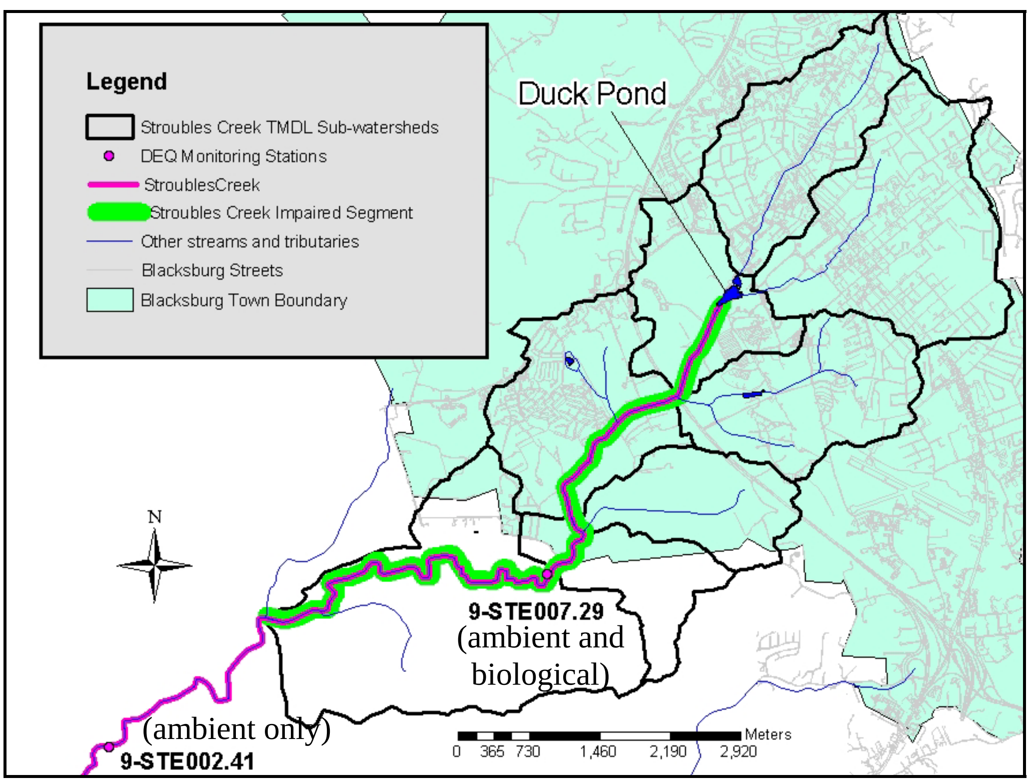

Figure 4.2. Stroubles Creek Monitoring Sites

Biological communities at station STE007.29 were monitored annually or semi-annually during the monitoring period. Biennial assessments for each 305(b) report are based on the past five years of monitoring data. Since biomonitoring only began in 1994, the earlier assessments were made on less than 5 full years of data. For the 1998, 2000, and 2002 assessments, Stroubles Creek received an overall rating of “moderately impaired” based on 5, 8, and 9 samples, respectively. In each assessment period, the Upper Stroubles Creek watershed was not fully supportive of its Aquatic Life designated use.

The Rapid Bioassessment Protocol II (RBP II) is the official protocol used to assess compliance with the general standard in Virginia (EPA, 1999). The RBP II procedure evaluates the benthic macroinvertebrate community by comparing individual network biomonitoring stations with reference biomonitoring stations. Reference biomonitoring stations have been identified by regional biologists that are both representative of regional physiographic and ecological conditions and have a healthy, unimpaired benthic community. Sinking Creek, located in Giles County, Virginia, was originally used as the reference watershed for Stroubles Creek. However, beginning in 2001, Toms Creek, located adjacent to Stroubles Creek on its northern boundary, was chosen as the new biological reference for Stroubles Creek (Devlin et al., 2003). This change was made by the VDEQ regional biologist on the basis that the habitat and stream power in Stroubles Creek was more comparable to the Toms Creek site than it was with the Sinking Creek site. (At the monitoring locations, both Stroubles Creek and Toms Creek are second order streams, while Sinking Creek is a fourth order stream). The watershed contributing to the Toms Creek site is also much closer is size to that of Stroubles Creek.

Table 4.2. RBP II Scores for Stroubles Creek (STE007.29)

← 1998 Assessment Period → (10/12/94 – 10/15/96)
← 2000 Assessment Period → (10/12/94 – 10/21/98)
← 2002 Assessment Period → (10/19/95 – 11/06/00)
← 2004 Assessment Period → (05/21/98 – 10/31/02)

a. RBP II Metric Values																	
Sample Date	**10/12/94**	**05/03/95**	**10/19/95**	**06/06/96**	**10/15/96**	**10/09/97**	**05/21/98**	**10/21/98**	**03/18/99**	**11/02/99**	**04/27/00**	**11/06/00**	**10/18/01**	**04/11/02**	**10/31/02**	**03/05/03**	**Ave.**
Taxa Richness	11	6	8	12	9	11	13	8	12	13	11	10	17	10	17	18	**12**
MFBI	5.61	5.81	6.36	5.48	5.49	5.42	5.44	6.19	7.69	5.47	6.06	5.97	5.79	5.39	5.81	5.54	**5.85**
SC/CF	0.14	0.15	0.03	1.00	0.14	0.43	0.57	0.03	0.70	0.55	0.21	0.02	0.30	1.03	0.62	0.2	**0.38**
EPT/Chi Abund	17.37	0.65	8.17	5.05	10.20	6.82	2.93	2.44	0.11	1.80	0.12	3.70	9.83	1.00	8.43	1.44	**5.00**
% Dominant	59.22	47.37	69.81	35.42	59.43	50.89	28.05	58.88	60.87	42.41	51.43	51.34	49.55	31.19	34.31	28.72	**47.43**
Dominant Species *	HYD	CHA	HYD	ELM	HYD	HYD	SIM	HYD	CHB	HYD	CHA	HYD	HYD	CHA	HYD	HYD/CHA	
EPT Index	3	1	1	2	3	5	4	3	4	5	3	4	5	3	6	4	**4**
Comm. Loss Index	0.64	2.50	1.38	0.83	0.78	0.73	0.69	1.25	1.00	0.69	1.27	1.30	0.29	1.20	0.35	0.44	**0.96**
SH/Tot	0.97	0.88	0.00	5.21	0.00	0.89	0.00	0.00	0.00	1.27	0.71	0.89	3.60	0.00	0	0.05	**0.90**
b. Reference Metric Values																	
Reference Station	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**SNK**	**TOM**	**TOM**	**TOM**	**TOM**	**Ave.**
Reference Sample Date	**10/12/94**	**05/19/95**	**11/12/95**	**06/06/96**	**10/15/96**	**10/14/97**	**05/21/98**	**10/21/98**	**03/11/99**	**11/02/99**	**04/27/00**	**11/06/00**	**10/18/01**	**04/11/02**	**10/31/02**	**03/05/03**	
Taxa Richness	20	20	15	17	13	14	15	13	19	14	19	22	17	20	16	13	**17**
MFBI	3.57	3.15	3.28	3.81	3.76	3.50	3.78	3.17	3.62	3.39	3.69	3.52	4.34	4.90	4.44	4.44	**3.77**
SC/CF	0.81	1.07	0.35	1.05	1.16	0.57	0.22	3.14	0.71	0.79	0.46	0.86	0.57	0.50	0.86	0.33	**0.84**
EPT/Chi Abund	36.04	76.19	44.55	13.43	21.00	17.84	23.43	97.00	9.31	28.94	31.76	22.95	6.30	2.07	31.67	8.44	**29.43**
% Dominant	22.13	19.05	35.83	24.27	30.90	28.21	29.82	36.80	17.27	25.23	22.88	29.76	31.06	23.33	32.28	22.22	**26.94**
EPT Index	8	12	7	10	6	8	8	8	10	8	11	12	10	9	5	8	**9**
Comm. Loss Index																	
SH/Tot	4.10	2.72	3.33	2.91	0.00	0.64	1.75	0.00	2.16	7.21	5.08	2.42	4.55	0.02	0.03	0.06	**2.31**
Reference Biological Score	46	48	44	46	44	46	46	44	48	46	46	46	44	46	44	46	**46**
c. RBP II Metric Ratios																	
Taxa Richness	55.0	30.0	53.3	70.6	69.2	78.6	86.7	61.5	63.2	92.9	57.9	45.5	100.0	50.0	106.3	138.5	**72.4**
MFBI	63.5	54.2	51.6	69.5	68.5	64.6	69.5	51.2	47.1	61.9	60.8	59.0	74.9	90.9	76.4	80.1	**65.2**
SC/CF	17.2	14.2	7.7	95.0	12.3	76.1	261.9	0.9	98.0	69.3	45.8	2.3	53.0	206.0	72.1	60.6	**68.3**
EPT/Chi Abund	48.2	0.9	18.3	37.6	48.6	38.2	12.5	2.5	1.2	6.2	0.4	16.1	156.0	48.3	26.6	17.1	**29.9**
% Dominant	59.2	47.4	69.8	35.4	59.4	50.9	28.0	58.9	60.9	42.4	51.4	51.3	49.5	31.2	34.3	28.7	**47.4**
EPT Index	37.5	8.3	14.3	20.0	50.0	62.5	50.0	37.5	40.0	62.5	27.3	33.3	50.0	33.3	120.0	50.0	**43.5**
Comm. Loss Index	0.64	2.50	1.38	0.83	0.78	0.73	0.69	1.25	1.00	0.69	1.27	1.30	0.29	1.20	0.35	0.44	**0.96**
SH/Tot	23.7	32.2	0.0	178.8	0.0	139.3	0.0	0.0	0.0	17.6	14.0	36.9	79.2	0.0	0.0	83.3	**37.8**
d. RBP II Metric Scores																	
Taxa Richness	2	0	2	4	4	4	6	4	4	6	2	2	6	2	6	6	**3.8**
MFBI	2	2	2	2	2	2	2	2	0	2	2	2	4	6	4	4	**2.5**
SC/CF	0	0	0	6	0	6	6	0	6	6	4	0	6	6	6	6	**3.6**
EPT/Chi Abund	2	0	0	2	2	2	0	0	0	0	0	0	6	2	2	0	**1.1**
% Dominant	0	0	0	2	0	0	4	0	0	0	0	0	0	2	2	4	**0.9**
EPT Index	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	**0.4**
Comm. Loss Index	4	2	4	4	4	4	4	4	4	4	4	4	6	4	6	6	**4.3**
SH/Tot	2	2	0	6	0	6	0	0	0	0	0	4	6	0	0	6	**2.0**
Total RBP II Score	12	6	8	26	12	24	22	10	14	18	12	12	34	22	32	32	**18.5**
% of Reference	26.09	12.50	18.18	56.52	27.27	52.17	47.83	22.73	29.17	39.13	26.09	26.09	77.27	47.83	72.73	69.57	**40.7**
RBP II Assessment~	**MD**	**SV**	**BJ**	**SL**	**MD**	**BJ**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**SL**	**MD**	**SL**	**SL**	

* HYD = hydropsychidae; CHA = chironimidae(A); CHB = chironimidae(B); ELM = elmidae; SIM = simuliidae
~ SL = slight impairment; MD = moderate impairment; SV = severe impairment; BJ = borderline score, best professional judgement used.

The RBPII scores are calculated relative to the chosen biological reference site. VDEQ is currently investigating use of the Stream Condition Index (SCI) (TetraTech, 2003) whose metrics are scored against a fixed, rather than a relative scale, and therefore would remove any bias caused by a change in biological reference. The SCI scores for Stroubles Creek are shown in a graph in Figure 4.3. The SCI trend line also shows a gradual improvement in scores over time, similar to the change noted in the predominant RBP II ratings from "moderately impaired" to "slightly impaired", so the improvements appear to be real, and not just an artifact of the change in biological reference used for the RBP II assessment. The SCI scores do confirm the RBP II assessments that Stroubles Creek, nonetheless, is still clearly impaired.

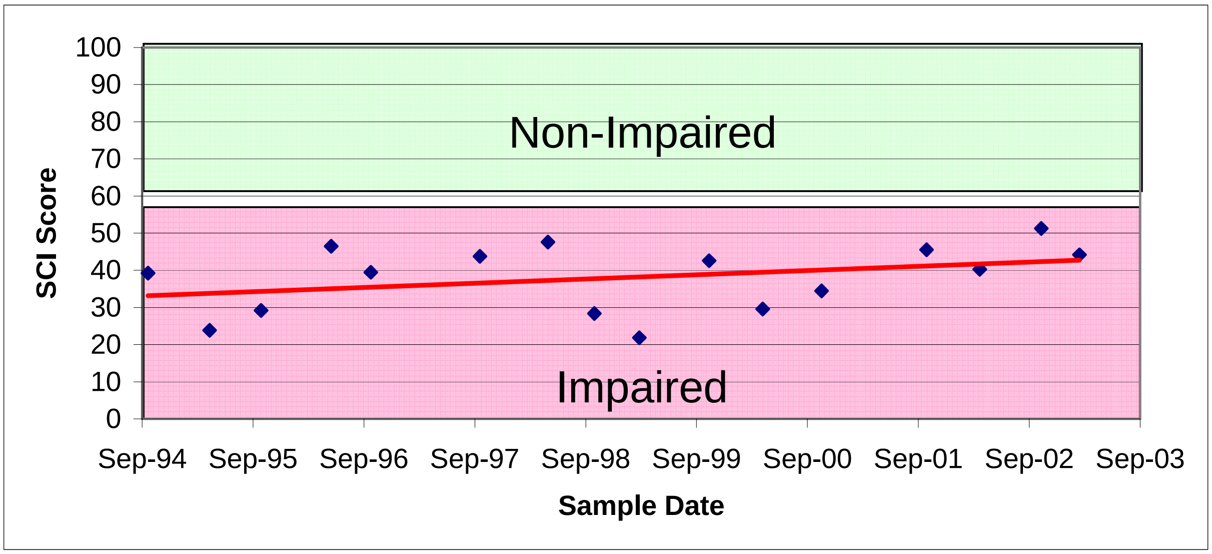

Figure 4.3. SCI Scores for Stroubles Creek at STE007.29

A qualitative analysis of various benthic habitat parameters was conducted in conjunction with each biological sampling. The habitat parameter scores for Stroubles Creek are given in Table 4.3. Each of the 10 habitat parameters has a maximum score of 20, indicating the most desirable condition, and a minimum score of 0, indicating the poorest habitat conditions.

Table 4.3. RBP II Benthic Habitat Evaluation Scores for Stroubles Creek

Habitat Metrics	Sampling Dates																
	10/12/94	05/03/95	10/19/95	06/06/96	10/15/96	10/09/97	05/21/98	10/21/98	03/18/99	11/02/99	04/27/00	11/06/00	10/18/01	04/11/02	10/31/02	03/05/03	Average Score
Channel Alteration	13	11	10	13	13	13	13	No Data Collected	11	15	No Data Collected	14	15	15	14	15	13.2
Bank Stability	9	9	14	12	12	13	16		11	15		11	20	5	11	8	11.9
Vegetative Protection	9	9	13	12	12	13	16		15	18		12	12	3	16	10	12.1
Embeddedness	12	9	10	12	12	11	15		9	16		9	18	16	12	18	12.8
Channel Flow Status	14	15	15	16	16	18	18		16	18		13	17	19	20	20	16.8
Frequency of Riffles	16	14	15	16	16	12	18		17	15		16	18	16	17	20	16.1
Riparian Vegetative Zone Width	6	1	1	5	3	2	3		0	0		12	4	2	8	6	3.8
Sediment Deposition	5	10	9	10	10	8	10		6	7		9	15	7	13	10	9.2
Substrate/Available Cover	15	12	13	12	12	13	17		11	9		12	13	13	17	12	12.9
Velocity/Depth Regime	18	11	11	12	12	16	17		15	14		12	15	16	16	18	14.5
Total Habitat Score	**117**	**101**	**111**	**120**	**118**	**119**	**143**		**111**	**127**		**120**	**147**	**112**	**144**	**137**	**123**

4.3. *Benthic Stressor Analysis*

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 (EPA, 2000) was used to identify the critical stressor for Stroubles Creek. A list of candidate causes was developed from the listing information, biological data, published literature, and stakeholder input. Chemical and physical monitoring data were then used as initial evidence to either support or eliminate the potential candidate causes. RBPII ratings provided the basis for the initial impairment listing, but individual metrics and habitat evaluations were also used to look for links with specific stressors, where possible. Volunteer monitoring data, land use distribution, and visual assessment of conditions in and along the stream corridor provided additional information to support or refute the candidacy of specific potential stressors. Logical pathways were explored between observed effects in the benthic community, potential stressors, and intermediate steps or interactions that would be consistent in establishing a cause and effect relationship with each candidate cause. The candidate benthic stressors considered were temperature, pH, toxics, organic matter, nutrients, and sediment.

Since the impairment listing for Upper Stroubles Creek was based on the benthic community samples from 1996 to 2000, data from this time period were included in this stressor analysis. As described previously, the historic ambient water quality monitoring station for chemical and physical data was located approximately five miles downstream from the benthic monitoring station, and so did not directly relate to stream conditions at the benthic station. Between July 2002 and May 2004, ambient water quality monitoring was also conducted at the site of the benthic station. Data through August 2003 were included in this stressor analysis. Although the focus for this analysis was on the 1996-2000 assessment data, all available data for this stream were considered.

Sediment was initially identified as the most probable stressor for Upper Stroubles Creek, as presented at the first public meeting. Confidence was somewhat limited in this assessment, since the available benthic and chemical monitoring data were not collected at the same site, but were 5 miles apart, a sufficient stream length to constitute a recovery zone. Further concerns raised at the public meeting by the regional biologist eventually led to an additional 6 months of monitoring with the addition of chemical sampling at the biological monitoring site – station STE007.29. After analyzing the data collected at this site, together with the previous data, no single unambiguous stressor emerged during the stressor analysis. Three stressors, however, – nutrients, organics, and sediment – showed potential impacts.

After further discussion with state VDCR and VDEQ personnel, the regional biologist, and the TMDL coordinator, a decision was made to use sediment as the representative stressor around which to develop a staged implementation TMDL to address the benthic impairment in Upper Stroubles Creek. Sediment was chosen based on the following rationale:

- Impacts from the three possible stressors – nutrients, organic matter, and sediment – are inter-connected.
- Best management practices employed to control sediment would result in decreases in the other possible stressors as well. Best management practices that might be used during implementation include those that would address the open canopy, streambank stability, riparian buffer zones, urban and construction runoff, livestock access to the stream, and runoff from agricultural fields. Additionally, BMPs that would decrease stream power and erosive energy, e.g. those that increase infiltration and delay runoff from impervious areas during peak runoff events, might also be appropriate. Some examples of the synergistic reductions from sediment BMPs are:
    - Reducing livestock access to stream also reduces inputs of organic manure and nutrients
    - Increasing riparian buffers and tree canopy reduces inputs of nutrients as they replace heavily fertilized riparian urban lawns
    - Delaying runoff from impervious areas would allow not only sediment, but also suspended organic matter and attached nutrients to settle out prior to entering the stream.
- The ultimate criteria for judging the success of the TMDL will be the restoration of the benthic community itself. The staged implementation approach may include combinations of the above categories of BMPs in order to address all three possible stressors. As implementation proceeds, progress will be monitored, and the effectiveness of the implementation strategy will be evaluated.

4.4. *Modeling*

Because Virginia has no numeric in-stream criteria for sediment, a "reference watershed" approach was used to define allowable TMDL loading rates in the impaired watershed. The reference watershed approach pairs two watersheds – one whose streams are supportive of their designated uses and one whose streams are impaired. This approach is based on the assumption that reduction of the stressor loads in the impaired watershed to the level of the loads in the reference watershed will result in restoration of the benthic community to a "non-impaired" state.

The reference watershed approach involves selection of an appropriate reference watershed, model parameterization of the reference and TMDL watersheds, and definition of the TMDL endpoint using modeled output from the reference watershed.

The Toms Creek watershed was selected as the TMDL reference for Upper Stroubles Creek. The TMDL sediment target load was defined as the modeled sediment load for existing conditions from the non-impaired Toms Creek watershed, area-adjusted to Upper Stroubles Creek.

The Generalized Watershed Loading Function (GWLF) model (Haith et al., 1992) was selected for comparative modeling of the impaired and reference watersheds in this TMDL study. Model parameter values were comparably evaluated using the same data sources and procedures recommended in the GWLF Users Manual (Haith et al., 1992) for the land uses and conditions found in these watersheds.

4.5. *Sources of Sediment*

Sediment is delivered to the impaired segment of Stroubles Creek through the processes of surface runoff, channel and streambank erosion, and from point source inputs, as well as from background geologic processes. Natural sediment generation is accelerated through human-induced land-disturbing activities related to a variety of agricultural, forestry, and urban land uses. During runoff events, sediment loading occurs from both pervious and impervious surfaces in the watershed. Streambank erosion is caused by reduction in riparian cover resulting in stream bank instability and increased runoff rates related to anthropogenic sources in the watershed. Animals grazing on pastures in riparian areas with access to streams also contribute to streambank erosion. Hardening of stream channels, as observed along much of Stroubles Creek and its tributaries, reduces upstream channel scour but increases scour downstream. Transport of sediment is further increased by increasing areas of imperviousness in a watershed from urban growth and development, which increase the flow volume and peak rates of surface runoff.

4.6. *TMDL Allocations and Load Reductions*

The objective of TMDL allocations is to distribute allowable loads among different pollutant sources so that the appropriate control actions can be taken to achieve water quality standards (EPA, 1994).

The benthic TMDL for the Upper Stroubles Creek watershed was developed using sediment as the pollutant and a reference watershed approach, with Toms Creek watershed as the TMDL reference watershed. Since different size watersheds would be expected to produce different size sediment loads, the area of the TMDL reference watershed (Toms Creek) was adjusted to the area of the impaired watershed (Upper Stroubles Creek), so that model output was compared between two equal-sized watersheds. As Toms Creek watershed was slightly smaller than the Upper Stroubles Creek watershed, the area of each land use in the Toms Creek watershed was increased in proportion to the ratio of the area of the impaired watershed to that of the TMDL reference watershed, producing an area-adjusted Toms Creek watershed equal in size with the land area in the impaired Stroubles Creek watershed (2,471 ha). The average annual sediment load (t/yr) from the area-adjusted Toms Creek watershed was then used to define the TMDL sediment load for the impaired Upper Stroubles Creek watershed.

4.6.1. Modeling Procedures

The increased spatial variability of sediment sources by land use and sub-area in the impaired watershed is important when defining where and how reductions are made for the allocation scenarios and during future planning for implementation of control measures. Therefore to provide more information on the spatial variability of the sediment loads for the implementation phase, the Upper Stroubles Creek watershed was subdivided into eight sub-watersheds, as shown in Figure 4.4. The Toms Creek watershed was not subdivided since its purpose is to set the overall target sediment goal. Modeling was then performed on the eight Upper Stroubles Creek sub-watersheds and on the area-adjusted Toms Creek watershed. Model output was then entered into a spreadsheet where watershed outlet loads from surface and channel erosion loads for each sub-watershed were calculated. To focus on the comparison between the impaired and reference watershed, all loads in the following discussion are reported only as watershed totals for the impaired Stroubles Creek watershed and its area-adjusted TMDL reference watershed – Toms Creek.

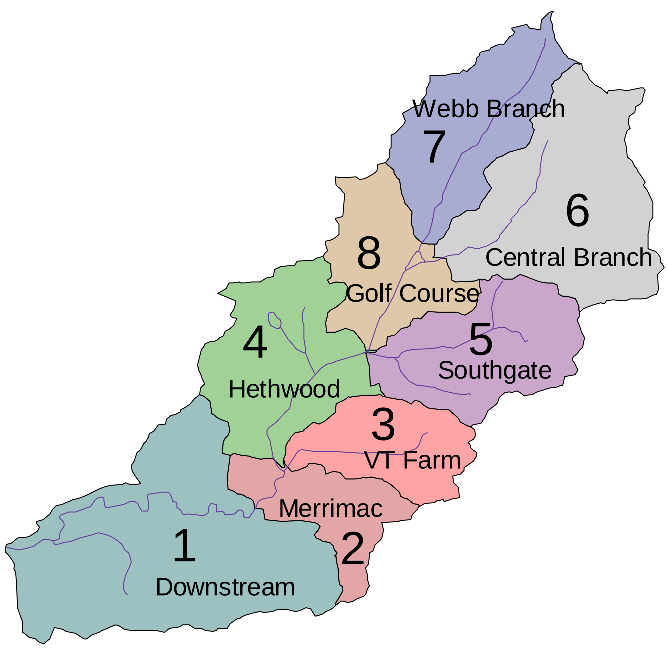

Figure 4.4. GWLF Modeling Subwatersheds for Upper Stroubles Creek

The existing sediment loads were modeled for each watershed and are listed in Table 4.4 by sediment source as average annual (t/yr) and unit-area (t/ha) loads. The target TMDL sediment load in Stroubles Creek – 2,146 t/yr - was defined as the average annual sediment load for the area-adjusted Toms Creek watershed under existing conditions. The Municipal Separate Storm Sewer Systems (MS4) loads shown in the table are loads from the residential and urban areas that lie within the Town of Blacksburg and Virginia Tech, that are subject to reductions under Phase II of EPA's stormwater management program.

Table 4.4. Existing Sediment Loads

Sediment Sources	Upper Stroubles Creek (t/yr)	Upper Stroubles Creek (t/ha)	Area-adjusted Toms Creek (t/yr)	Area-adjusted Toms Creek (t/ha)
High Till	434.4	46.08	62.7	60.48
Low Till	2,963.9	25.13	427.8	33.00
Pasture	366.5	0.73	702.1	1.42
Urban grasses	338.5	1.08	40.0	2.27
Hay	8.1	1.74	0.0	0.00
Forest	106.6	0.16	241.5	0.16
Transitional	110.8	6.09	0.0	0.00
Pervious Urban	95.1	0.24	280.3	0.76
Impervious Urban	22.4	0.05	56.4	0.52
Channel Erosion	1,845.9	0.75	334.8	0.14
MS4	421.8		0.0	
Permitted Point Sources	0.0		0.0	
Watershed Totals	**6,713.9**		**2,145.6**	
		Target Sediment TMDL Load =	**2,145.6**	**t/yr**

The benthic TMDL for Stroubles Creek is comprised of three required load components – the waste load allocation (WLA) from point sources, the load allocation (LA) from nonpoint sources, and a margin of safety (MOS), as shown in Table 4.5. The individual permitted constituents of the WLA component are shown below the WLA load in the table.

Table 4.5. Upper Stroubles Creek TMDL* Sediment Load

TMDL (t/yr)	WLA (t/yr)	LA (t/yr)	MOS (t/yr)
2,145.6	233.2	1,697.9	214.6
	VAR050441 - Litton Systems Inc Poly Scientific Div : 2.7 VAR050508 - VT - Central Heating Plt: 0.46 VAR10042 - VT - Dairy Science Center: 2.37 VAR10267 - VT - Campus: 15.43 VAR10275 - Hawthorne Ridge Town Houses: 0.77 VAR10282 - Carriage Court II: 0.54 VPG120011 - VT - Dairy Science Center: 0 MS4s (VAR040019, VAR040049, VAR040016): 210.88		

* Total Maximum Daily Load

The margin of safety (MOS) was explicitly defined as 10% of the calculated TMDL to reflect the relative uncertainty associated with benthic impairment modeling. The MS4 load in Table 4.4 was calculated for existing conditions and estimates loads prior to implementation of MS4 regulations. The MS4 allocation in Table 4.5 was calculated assuming 50% reductions of the modeled sediment load from urban land uses with implementation of Phase II MS4 measures being planned by the Town and University. The waste load allocation (WLA) is equal to the MS4 load plus loads from specific industrial stormwater and construction permits. The load allocation (LA) – the allowable sediment load from nonpoint sources – was calculated as the target TMDL load minus the MOS minus the WLA. Since the MOS is excluded from allocation, the target load for allocation purposes in Upper Stroubles Creek becomes the TMDL minus the MOS (2,145.6 – 214.6 = 1,931.1 t/yr).

Because of expected future growth in the watershed, TMDL modeling for the allocation runs was performed using the future land use scenario for Stroubles Creek. The projected future sediment loads in Stroubles Creek watershed by land use category and subwatershed are shown in Table 4.6.

Table 4.6. Projected Future Sediment Loads

Sediment Sources	Upper Stroubles Creek (t/yr)	Upper Stroubles Creek (t/ha)	Area-adjusted Toms Creek (t/yr)	Area-adjusted Toms Creek (t/ha)
High Till	401.6	46.06	62.7	60.48
Low Till	2,735.0	25.07	427.8	33.00
Pasture	324.5	0.89	702.1	1.42
Urban grasses	331.3	1.09	40.0	2.27
Hay	8.1	1.73	0.0	0.00
Forest	100.6	0.16	241.5	0.16
Transitional	110.6	6.08	0.0	0.00
Pervious Urban	150.9	0.29	280.3	0.76
Impervious Urban	30.9	0.06	56.4	0.52
Channel Erosion	2,181.4	0.88	334.8	0.14
MS4	454.6		0.0	
Permitted Point Sources	22.3		0.0	
Watershed Totals	**6,851.7**		**2,145.6**	

4.6.2. Load Allocation Scenarios

TMDL allocation scenarios were developed by consolidating nonpoint source loads into 5 categories – agriculture, urban, forestry, channel erosion, and MS4s – and then comparing category loads from the Stroubles Creek watershed to those of its area-adjusted reference watershed – Toms Creek – in Table 4.7. The loads for the Urban and MS4 categories were calculated identically. The difference is that the Urban load comes from urban landuses outside of the Town and University boundaries within the Upper Stroubles Creek watershed, while the MS4 load comes from urban landuses within the MS4 boundaries. The comparison in Table 4.7 shows that the annual average sediment loads from forestry and point sources were relatively minor, and therefore were not subjected to reductions under this TMDL allocation. Furthermore, point source allocations must be specified at their permitted limits and, therefore, are not subject to reduction.

Table 4.7. Categorized Sediment Loads for Upper Stroubles Creek

Source Category	**Future** Upper Stroubles Creek (t/yr)	**Reference** Toms Creek (t/yr)
Agriculture	3,469.1	1,192.6
Urban	623.7	376.7
Forestry	100.6	241.5
Channel Erosion	2,181.4	334.8
MS4	454.6	0.0
Point Sources	22.3	0.0
Total	**6,851.7**	**2,145.6**

Existing MS4 loads were assumed to be representative of loads generated in areas covered by the MS4 permits prior to implementation of the Phase II MS4 regulations. The allocated MS4 load was based on the assumption that implementation of BMPs under the MS4 regulations to the "maximum extent practicable" would reduce existing loads by 50% and prevent any increases in the projected future scenario in Table 4.8. Equal percentage reductions were required from the two largest load categories – agriculture and channel erosion. Since urban source loads were relatively smaller than the two largest load categories, the first alternative requires no reduction from the non-MS4 urban areas, while the second alternative applies the same percent reduction for both existing MS4 and "urban" source loads. These loads are listed separately, since MS4 loads are required to be included in the WLA portion of the TMDL. The recommended TMDL allocation scenario is Alternative 2, as it requires reductions from all land use categories with loads greater than its reference watershed counterparts, and is consistent with previous interpretations of incorporating MS4 loads into the TMDL.

Table 4.8. TMDL+ Allocation Scenarios for Upper Stroubles Creek

Source Category	**Future** Stroubles Creek (t/yr)	**Upper Stroubles Creek TMDL Sediment Load Allocations**			
		TMDL Alternative 1		**TMDL Alternative 2**	
		(% reduction)	(t/yr)	(% reduction)	(t/yr)
Agriculture	3,469	**83%**	598	**77%**	803
Urban	624	0%	624	**54%**	289
Forestry	101	0%	101	0%	101
Channel Erosion	2,181	**83%**	376	**77%**	505
MS4*	455	**54%**	211	**54%**	211
Point Sources	22		22		22
Total	**6,852**		**1,931**		**1,931**

+ Total Maximum Daily Load
* Permit allocations to Municipal Separate Storm Sewer Systems

4.7. *Summary*

The Toms Creek watershed upstream from Deerfield Drive was used as the TMDL reference watershed for Stroubles Creek. The TMDL to address the benthic impairment in Stroubles Creek was developed to meet the existing sediment load from the area-adjusted Toms Creek watershed. The selected benthic TMDL for Stroubles Creek requires sediment reductions from the two major source categories – "agriculture" and "channel erosion", together with equal reductions from both the non-MS4 and MS4 urban areas. The TMDL to address the benthic impairment in Stroubles Creek is 2,145.6 t/yr of sediment and will require an overall reduction from projected future loads equal to 71% of the existing load. From the two alternative scenarios, Alternative 2 was recommended because it required reductions from all land use categories with loads greater than its reference watershed counterparts, and was consistent with previous interpretations of incorporating MS4 loads into the TMDL. The majority of additional sediment generated by future land use changes is likely to be due to increased total and peak runoff from an increasing amount of impervious area that can affect both surface erosion and channel erosion. Much of this increase in runoff and sediment load is expected to be attenuated through compliance with the new MS4 discharge regulations that should accompany future development. The impacts of future development and BMPs installed since the completion of the TMDL study, including MS4 measures, will be accounted for with modeling during IP development and their effects documented through VDEQ's continuing biological and ambient water quality monitoring. Because increased upstream impervious runoff could negate the effect of downstream restoration, it is recommended that during implementation, upstream impervious runoff be addressed prior to, or at least concurrent with, work on downstream stream bank stabilization.

The TMDL was developed to take into account all major sediment sources in the watershed from both point and nonpoint sources, and to consider future land use changes. The sediment loads were averaged over a 10-year period to take into account both wet and dry periods, and the model inputs took into consideration seasonal variations and critical conditions related to sediment loading. The allocated loads were 10% less than the calculated TMDL to account for the required margin of safety.

5.0 Public Participation

An essential step in developing and carrying out a TMDL implementation plan is gathering input from a broad range of individuals, agencies, organizations and businesses with interest in and familiarity with local water quality needs and conditions. Watershed stakeholders are best suited to identify and resolve sources of water quality problems within their own communities. Public participation facilitates dialogue between local stakeholders and government agencies, encourages the commitment of resources for TMDL implementation, such as funding and technical support, and facilitates implementation of feasible solutions to water quality problems.

Prior to the submission of the proposal for this implementation plan, the idea was discussed with two major watershed stakeholders – the Town of Blacksburg and Virginia Tech (Office of Site & Infrastructure). A letter of support from each of these two major stakeholders in the watershed accompanied the proposal to the Virginia Department of Environmental Quality (VDEQ) requesting funds to develop an Implementation Plan (IP) for Stroubles Creek.

The Project Team for this project included members of the Biological Systems Engineering (BSE) Department, the Virginia Water Resources Research Center, VDEQ, and the Virginia Department of Conservation and Recreation (VDCR).

Prior to the first public meeting, informational meetings were held on March 31st and April 4, 2005, where governmental agency personnel, individuals representing key constituents identified from participant lists from previous public meetings during the TMDL study on Stroubles Creek, and others suggested by the Project Team were given an overview of the Implementation Process and an invitation requesting their participation. In addition to members of the Project Team, the following constituents were present at the meetings:

Citizens
Environmental consultants
Montgomery County
New River Valley Planning District Commission
Skyline Soil and Water Conservation District
Town of Blacksburg
Virginia Department of Game and Inland Fisheries
Virginia Tech – Architect's Office
Virginia Tech – Biology (Stream Team)
Virginia Tech Foundation
Virginia Tech – Site & Infrastructure
Izaac Walton League Save Our Streams Program (volunteer monitoring)

The following variety of means was used to advertise public meetings and to make discussions, presentations, and decisions made at these meetings available to the general public. Personal phone calls were initially placed to all key constituents. An email list was developed and kept current from past attendees to Stroubles Creek TMDL meetings and of all attendees to any of the meetings related to IP development for Stroubles Creek. This list was notified of all meetings and activities related to this project on a regular basis. Additionally, several newspaper articles increased interest in the public meetings, and public meetings were also posted to on-line calendars for Montgomery County and the Town of Blacksburg. Finally, a website forum was initiated and maintained by the BSE Department that contained links to downloadable handouts, presentations, and discussions from all public meetings, to facilitate full and open access to all materials, especially for those stakeholders unable to attend the meetings (http://www.tmdl.net/forum/forum.asp?FORUM_ID=11).

Public participation in the development of the IP was achieved through a series of Focus Groups, whose ideas and inputs were then refined by a Steering Committee, under the facilitation of the Support Team.

The first public meeting on the development of a TMDL implementation plan (IP) for the Stroubles Creek watershed was held on June 1, 2005 in the Blacksburg Town Council Chambers from 7:00 – 9:00 pm. The focus of this meeting was a review of details from the TMDL study, information about current activities in the watershed, presentation of an anticipated timeline for development, and an invitation to the public to be involved in the IP development through the Focus Groups and the Steering Committee.

The following three Focus Groups were developed representing interests related to each stakeholder sector: Agriculture/Rural, Residential/Urban, and Public Works. Three meetings were held on June 29th, July 27th, and September 21, 2005 with all the focus groups. Each group was given the following common set of tasks to identify problems related to their Focus Group:

1. Quantify the extent and probable locations of problems.
2. Propose best management practices (BMPs) or other ways to correct problems at each location.
3. Evaluate technical assistance needed and how to administer assistance.
4. Identify constraints faced by stakeholders in correcting these problems.
5. Identify potential sources of funding for BMPs or other implementation measures.
6. Develop a strategy to educate and involve stakeholders in implementing the needed changes.

The Steering Committee consisted of a combination of governmental agency personnel, representatives from each of the Focus Groups, the Support Team, and other interested stakeholders. The first meeting of the Steering Committee was held on July 14, 2005 to review the results of the first round of Focus Group meetings and to make suggestions for the next round of deliberations. A second Steering Committee meeting was held on August 11, 2005 to review an initial draft of chapters 2 through 4 for the Implementation Plan report. A third Steering Committee meeting was held on November 21, 2005 to review a draft of chapters 5 through 10 for the Implementation Plan report. A final set of joint meetings of the Focus Groups and Steering Committee were held on February 7th and 8th in 2006 to finalize edits on the draft IP.

The following watershed tours were also conducted to further facilitate the discussions of problems and appropriate solutions within the Focus Groups:

July 21, 2005 – Tour of Virginia Tech farm land and facilities requested by the Agriculture/Rural Focus Group

August 10, 2005 – Tour of urban watershed sites identified by the Residential/Urban Focus Group

The Project Team also continued outreach efforts to work with key watershed constituencies through the following meetings:

May 17, 2005 – Presentation to Blacksburg Town Council
August 5, 2005 – Meeting with Virginia Tech Foundation

Table 5.1. Summary of Stroubles Creek TMDL Implementation Plan Meetings

Meeting Date	Meeting Time	Meeting Type	Location
September 8, 2004	9:00-10:00 am	Project Planning	VT S&I Conference Room
March 15, 2005	10:00-noon	Project Planning	WAL Conference Room
March 31, 2005	9:00-10:00 am	Project Planning	1810 Litton-Reaves Hall
April 4, 2005	5:00-7:00 pm	Project Planning	Donaldson Brown CEC Auditorium
April 20, 2005	3:30-4:30 pm	Project Team	Teleconference
May 17, 2005	11:00 am	Blacksburg Town Council	Blacksburg Police Dept. Conference Room
May 26, 2005	3:00-4:00 pm	Project Team	WAL Conference Room
June 1, 2005	7:00-9:00 pm	Public Meeting	Blacksburg Town Council Chambers
June 14, 2005	3:00-4:00 pm	Project Team	Teleconference
June 23, 2005	3:00-4:00 pm	Project Team	WAL Conference Room
June 23, 2005	8:00-9:00 am	Project Team	Teleconference
June 29, 2005	7:00-9:00 pm	Focus Group	Blacksburg Library
July 1, 2005	1:30-2:30 pm	Project Team	Teleconference
July 14, 2005	9:00-10:30 am	Steering Committee	1810 Litton-Reaves Hall
July 21, 2005	8:00-10:00 am	Agricultural Tour	Virginia Tech Farm
July 27, 2005	7:00-9:00 pm	Focus Group	1810 Litton Reaves-Hall
August 5, 2005	1:30-3:00 pm	Virginia Tech Foundation	VT CRC
August 8, 2005	2:30-3:30 pm	Project Team	Teleconference
August 10, 2005	9:00-noon	Urban Tour	Around Blacksburg and VT campus
August 11, 2005	9:00-10:00 am	Steering Committee	1810 Litton-Reaves Hall
September 21, 2005	7:00-9:00 pm	Focus Group	Blacksburg Library
October 19, 2005	10:00-11:00 am	Project Team	Teleconference
November 21, 2005	10:00-noon	Steering Committee	1810 Litton-Reaves Hall
February 7, 2006	7:00-9:00 pm	Focus Groups and Steering Committee	Blacksburg Library
February 8, 2006	1:00-3:00 pm		Blacksburg Library
February 28, 2006	7:00-9:00 pm	Final Public Meeting	Blacksburg Library

6.0 Implementation Actions

Sediment, nutrients, and organic matter were identified as probable stressors in the Stroubles Creek TMDL study contributing to the benthic impairment, with the TMDL based on sediment as the most probable stressor. The following watershed conditions were identified as issues during the stressor analysis in the Stroubles Creek TMDL study:

1. Lack of streamside forest
2. Livestock access to streams
3. Agricultural runoff
4. Increasing development and peak flows from stormwater runoff
5. Stream channel modifications
6. Sewer overflows
7. Downtown business wastewater disposal
8. Pollutant buildup on impervious surfaces
9. Enforcement of Erosion & Sediment regulations at construction sites
10. Improper disposal of grass clippings and trash

Because the Stroubles Creek watershed contains a combination of rural, suburban, and urban land uses, implementation actions consist of a variety of best management practices (BMPs) to address human impacts arising from these various land uses. Proposed actions include agricultural BMPs, stream channel BMPs, stormwater management BMPs, sanitary sewer system improvements, and urban/residential education components. Because both the Town of Blacksburg and Virginia Tech are in the process of developing and implementing NPDES Phase II MS4 programs, some of these actions have already been outlined in the respective MS4 plans, while other proposed new actions arose out of the public participation process through Focus Group and Steering Committee meetings.

Implementation practices were identified by the Focus Groups and reviewed by the Steering Committee. Extent of practices were defined by initially delineating lengths and/or areas on aerial photographs, converting the manual delineations to digital data layers, and then having the Focus Groups review the digital images. Extents were then calculated using tools within a GIS environment. Average unit costs for agricultural practices were obtained from the TMDL Implementation Plan Guidance Manual (VDCR, 2003). Costs for urban BMPs were estimated by the Town of Blacksburg and Virginia Tech's Site & Infrastructure personnel. The Steering Committee identified potential sources of funding for each of the following sets of BMPs.

Although a TMDL is developed for an individual pollutant, an Implementation Plan is intended to take a holistic approach and to address all sources of water quality-related problems in the watershed. Therefore, all problems in the above list, even those not directly related to sediment, will be addressed by the IP. The 2002 and 2004 303(d) Fact Sheets for Category Waters have also noted a bacteria impairment based on monitoring at station STE002.41, which is 1.6 miles downstream from, and outside, the watershed boundary defined in this IP (VDEQ, 2006). While a TMDL has not been developed for the bacteria impairment, implementation actions recommended for the Upper Stroubles Creek watershed will consider possible reductions of bacteria sources that could pro-actively forestall the need to develop the downstream TMDL for bacteria.

6.1. *Agricultural BMPs*

The Stroubles Creek TMDL report calls for a 77% reduction of sediment from agricultural sources. This reduction will be achieved primarily through the exclusion of livestock from the riparian corridor together with establishment of riparian forest buffers. A combination of field inventory and GIS analysis was used to define the extents of agricultural BMPs described in Table 6.1. The exact components and costs of the loafing lot management BMP will be determined as a conservation plan is developed during implementation.

Table 6.1. Agricultural BMPs Needed to meet Target Sediment Reductions

Problem Addressed	Agricultural BMPs	Total Extent	Units	Cost / Unit	Total Cost	Potential Funding Sources	
						Cost-Share	Grant
1	Agricultural riparian forest buffers	29.63	acres	$547.00	$16,208	1,2	A,B,C
2	Livestock exclusion	13,937	lin. ft.	$2.41	$33,589	1	A,B,D
2	Limited access crossing	100	lin. ft.	$22.00	$2,200	1,4	A,B,D
3	Loafing lot management	3.64	acres		- TBD -	1,4	
3	Diversion	1,476	lin. ft.	$2.21	$3,263	1,4	
TAA (Technical Assistance / Administration)		20%	of total cost		$11,052		
Total Cost Estimate							**$66,311**

Potential Cost-Share Sources
1. Virginia Ag BMP Cost-Share Program
2. USDA CREP Program
3. EPA §319 Program
4. DEQ Low Interest Program
5. Virginia Aquatic Resources Trust Fund (VARTF)

Potential Grant Sources
A. USFWS Private Stewardship Grant
B. Canaan Valley Institute
C. Five-Star Restoration Program
D. Virginia Water Quality Improvement Fund
E. Open Space Lands Preservation Trust Fund (VOF)

Stroubles Creek below Hethwood

Since completion of the TMDL study, a large voluntary BMP implementation effort was made on the Virginia Tech farm to plant forest buffers together with stream fencing in pasture areas along approximately 8,560 ft of stream, covering 13.76 acres of riparian area through the Conservation Reserve Enhancement Program (CREP). Additional buffering has been negotiated with the Virginia Tech farm and the Friends of the Huckleberry Trail for a minimum 50-foot buffer along their new 1,200 ft Phase II extension. This extension will be built in spring 2006 between Hethwood and Plantation Road along Stroubles Creek.

Costs were estimated based on the TMDL Implementation Plan Guidance Manual, assorted extension publications, and experience of local conservation personnel. These estimates will be refined as detailed site-specific plans are developed in consultation with the Virginia Tech farm and the Virginia Tech Foundation – the two principal agricultural land owners in the watershed.

The total estimated cost is $55,259. This estimate is for physical installations only and does not include cost for technical assistance and administration (TAA). For example, TAA in the Blackwater River IP amounted to roughly 27% of the physical installation costs. Since we intend to utilize volunteer labor from community and students for riparian tree plantings, we estimated our TAA costs at 20%. TAA costs would amount to $11,052, for a total agricultural BMP cost of $66,311. Locations of the targeted agricultural BMPs are shown in Figure 6.1.

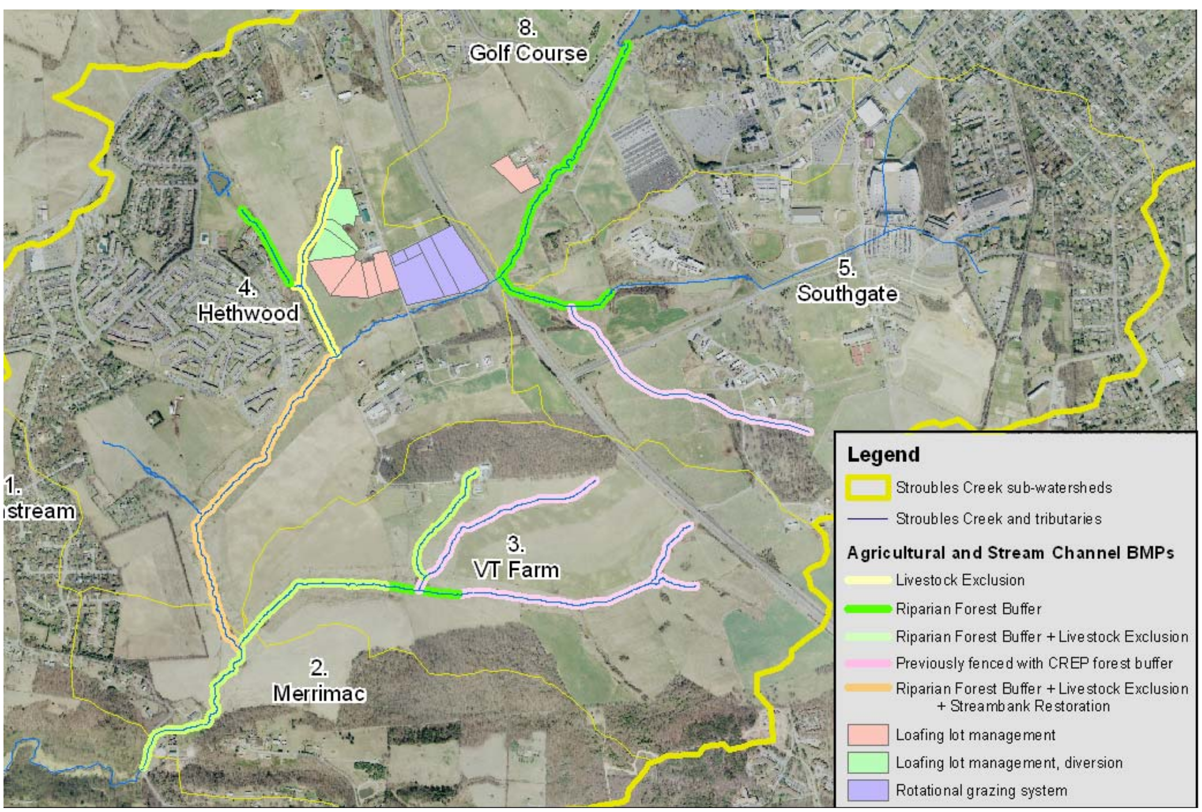

Figure 6.1. Targeted Areas for Agricultural and Stream Channel BMPs

6.2. *Stream Channel BMPs*

The Stroubles Creek TMDL calls for a 77% reduction of sediment from stream bank and channel erosion. This reduction will be achieved through the restoration of a large segment of the stream channel downstream from the Duck Pond in combination with the agricultural and urban riparian buffer BMPs. The exclusive stream channel BMPs are described in Table 6.2.

Stroubles Creek adjacent to Hethwood

Table 6.2. Stream Channel BMPs Needed to meet Target Sediment Reductions

Problem Addressed	Stream Channel BMPs	Total Extent	Units	Cost / Unit	Total Cost	Potential Funding Sources	
						Cost-Share	Grant
2, 5	Stream channel restoration	6,881	lin. ft.	$155	$1,066,555	1,5	A,B,C,D,E
5	Relocate riparian gravel road (Horse Farm to Rt. 460)	1,360	lin. ft.	$375	$510,000	VT	
5	Restore culvert capacity (Kabrich St.)				- TBD -	TOB	
5	Upgrade Rt. 460 culverts				$712,500	VT, VDOT	
TAA (Technical Assistance / Administration)		13.5%	of channel restoration		$143,985		
Total Cost Estimate							**$2,433,040**

Potential Cost-Share Sources
1. Virginia Ag BMP Cost-Share Program
2. USDA CREP Program
3. EPA §319 Program
4. DEQ Low Interest Program
5. Virginia Aquatic Resources Trust Fund (VARTF)

Potential Grant Sources
A. USFWS Private Stewardship Grant
B. Canaan Valley Institute
C. Five-Star Restoration Program
D. Virginia Water Quality Improvement Fund
E. Open Space Lands Preservation Trust Fund (VOF)

These stream channel needs were identified through a field inventory and through additional adjustments needed to satisfy the TMDL reductions. Additionally, the Town and the University are aware of the continual need to protect the riparian corridor, as development is an ongoing process in the watershed. Of the actions in Table 6.2, the restoration of the downstream stream channel segment was considered to be most directly related to the observed impact on the downstream benthic community impairment. The other actions may not prove to be practical economically unless incorporated as components of specific development projects in those sectors of the watershed.

Cost estimates were based on the TMDL Implementation Plan Guidance and estimates from local conservation and planning personnel. These estimates will be refined as detailed conservation plans are developed for each action. The total estimated cost for stream channel BMPs is $2,289,055. The stream channel restoration costs are for physical installations only and do not include TAA. The estimated 27% for TAA is expected to be cut in half for the stream channel restoration component, as members of the Biological Systems Engineering Department at Virginia Tech have volunteered to develop the channel restoration design in consultation with local conservation personnel. As the other stream channel BMPs would only be considered as part of other capital redevelopment projects, it is assumed that TAA costs would be covered by those larger projects. Wherever possible, community and student volunteers will also be recruited to assist with the stream restoration efforts. TAA costs are estimated as $143,985, for a total stream channel BMP cost of $2,433,040. Locations of the stream channel restoration projects are also shown in Figure 6.1.

6.3. *Stormwater Management BMPs*

The TMDL calls for a 54% reduction of sediment from urban and MS4 areas which will be achieved through stormwater management BMPs. Three active municipal MS4 permits in the Stroubles Creek watershed are held by the Town of Blacksburg, Virginia Tech, and the Virginia Department of Transportation (VDOT). The Town and University have developed detailed plans that apply within the watershed, while the VDOT MS4 is more generic and applies state-wide.

Several stormwater detention basins exist within the watershed, most notably the Duck Pond, and the VT Veterinary Medicine pond, together with several dry detention basins such as below Wallace Hall parking lot and the playground upstream from Owens Street. Since the TMDL study was completed in 2003, a new pond has also been constructed below the new VT alumni and conference center, and a series of ponds developed by the Town in Wong Park.

Virginia Tech has also completed plans for a new bioretention area to assist with managing the stormwater runoff quantity and quality from a new 375 space parking lot located adjacent to Smithfield Plantation Road and Duck Pond Road. This SWM cell will consist of a sediment forebay, engineered soils and heavy plantings within and around the perimeter of the cell. The bioretention area will allow for instrumentation to measure and analyze the water quality immediately after sheet flow off the asphalt lot and at its outfall for the cell. The anticipated cost for the construction of this bioretention area and its required appurtenances is $145,000.

The existing ponds trap a large amount of the coarse and medium-sized sediment particles, though fine particulates are still transported downstream during large flows, and detention ponds do not fully counteract the effect of increasing imperviousness. Upstream sediment sources contribute to impaired conditions in Webb Branch and Central Branch tributaries upstream of the Duck Pond, as shown by volunteer monitoring. However, the larger volumes and rates of runoff generated on upstream impervious areas during large runoff events will still increase downstream sediment transport and contribute to streambank erosion. These larger runoff volumes will be addressed through a variety of demonstration infiltration practices in the Town of Blacksburg and on the Virginia Tech campus. The stormwater management BMPs identified during implementation planning to address the water quality problems in Stroubles Creek are outlined in Table 6.3.

Table 6.3. Stormwater Management BMPs Needed to meet Target Sediment Reductions

Problem Addressed	Stormwater BMPs	Total Extent	Units	Total Cost	Potential Funding Sources	
					Cost-Share	Grant
1	Urban riparian forest buffers	7.20	acres	$3,938		B
1	Wetland development		acres	- TBD -	1,2	C
4	Infiltration trench retrofits	55,386	cu.ft.	$969,255	VT	D
4	Infiltration level spreaders	0.00	acres	$0	TOB	
4	Additional infiltration BMPs	9.83	acres	$142,784	VT	D
4	Bioretention area	0.89	acres	$164,790	VT	D
4	Additional bioretention BMPs	11.60	acres	$223,242	VT	D
4	Sediment pond stabilization		acres	- TBD -	VT	
7	Eliminate improper downtown business wastewater disposal				TOB	
8	Street sweeping (additional)	58.47	curb miles	$12,746	TOB	
8	Hydrodynamic solids separator	2	systems	$100,000	VT	D
9	Increase E&S program efficiency			$50,000	3, TOB	
10	Reduce improper disposal of grass clippings and trash				TOB	
TAA (Technical Assistance / Administration)		27%	of all except VT and TOB expenditures	$99,890		
Total Cost Estimate				**$1,766,647**		

Potential Cost-Share Sources
1. Virginia Ag BMP Cost-Share Program
2. USDA CREP Program
3. EPA §319 Program
4. DEQ Low Interest Program
5. Virginia Aquatic Resources Trust Fund (VARTF)

Potential Grant Sources
A. USFWS Private Stewardship Grant
B. Canaan Valley Institute
C. Five-Star Restoration Program
D. Virginia Water Quality Improvement Fund
E. Open Space Lands Preservation Trust Fund (VOF)

Costs were not calculated for problems 7 and 10 above, as these practices address problems raised in the TMDL study which have only a minor impact on sediment, but will reduce nutrients and organics which were also cited as potential pollutants. They are mentioned for completeness in following through with the identified problems and are being addressed through the MS4 programs of both VT and TOB. There are several areas with potential for development of constructed wetlands, but these will be subject to site specific analysis during the implementation phase. The stabilization costs for the VT alumni center sediment pond are unknown at this time, but will be covered by existing VT contracts.

Cost estimates were based on the TMDL Implementation Plan Guidance and estimates from the Town and University planning and engineering personnel. These estimates will be refined as detailed plans are developed for each action. The total estimated cost for stormwater management BMPs is $1,666,756. TAA was calculated at 27% only of those practices that are not part of VT or TOB previously funded or new capital projects for a total of $99,890, and a total stormwater management BMP cost of $1,766,647. Runoff controls in the stormwater management BMPs will emphasize infiltration of runoff, rather than the traditional detention approach. Grants from the Virginia Water Quality Improvement Fund have been requested for two infiltration retrofit projects, and Virginia Tech is proceeding with the purchase and design of two hydrodynamic solids separators to reduce solids loading from large parking lots around campus.


Site for infiltration trench demonstration BMP

During Focus Group discussions, a recommendation was made to increase E&S inspections, possibly through the addition of an additional inspector. The Town staff does not agree that simply hiring additional inspection staff will correct the E&S issues, but feels improvements can be made in the efficiency of how the program is operated. Currently the Town has a full time E&S inspector that is funded through the E&S inspection fees that the Town collects with each new development project. Town Staff is putting together a Request for Proposals from Professional Service Firms to evaluate how Low Impact Development management Practices could be included into the Town's existing E&S and Storm water management measures.

Grass pavers installed at Wong Park

Street sweeping is an ongoing management practice both around the Town of Blacksburg and Virginia Tech. Quantification of sweeping extent and impact during implementation planning will help identify means of improving its effectiveness. While VT already has a fairly efficient street sweeping program, there are improvements that could be made to improve the efficiency of the Town's program. The TOB owns one road sweeper, however the program is not currently organized in a fashion that is specifically geared to maximizing watershed management strategies. With the Town's implementation of the MS4 program the Town Staff is wanting to increase the street sweeping function as a major component in the overall management of the watershed. To this end the town is currently doing the following things: 1) purchasing new street sweeping equipment ($160,000), 2) Creating a GIS data base system to more effectively track and target areas in Town where additional street sweeping may benefit watershed quality, and 3) establishing a Watershed Management Workgroup that meets monthly to discuss watershed issues and more effective management strategies. Additional management actions in the Town of Blacksburg's MS4 plan include:

- Detect food service businesses discharging grease
- Adopt an ordinance for improved E&S construction site runoff control
- Develop program for more efficient handling of E&S complaints from the public
- Require long-term operation and maintenance of stormwater management facilities
- Develop controls for reducing the discharge of pollutants from publicly maintained areas

Locations of specific stormwater demonstration BMPs are shown in Figure 6.2.

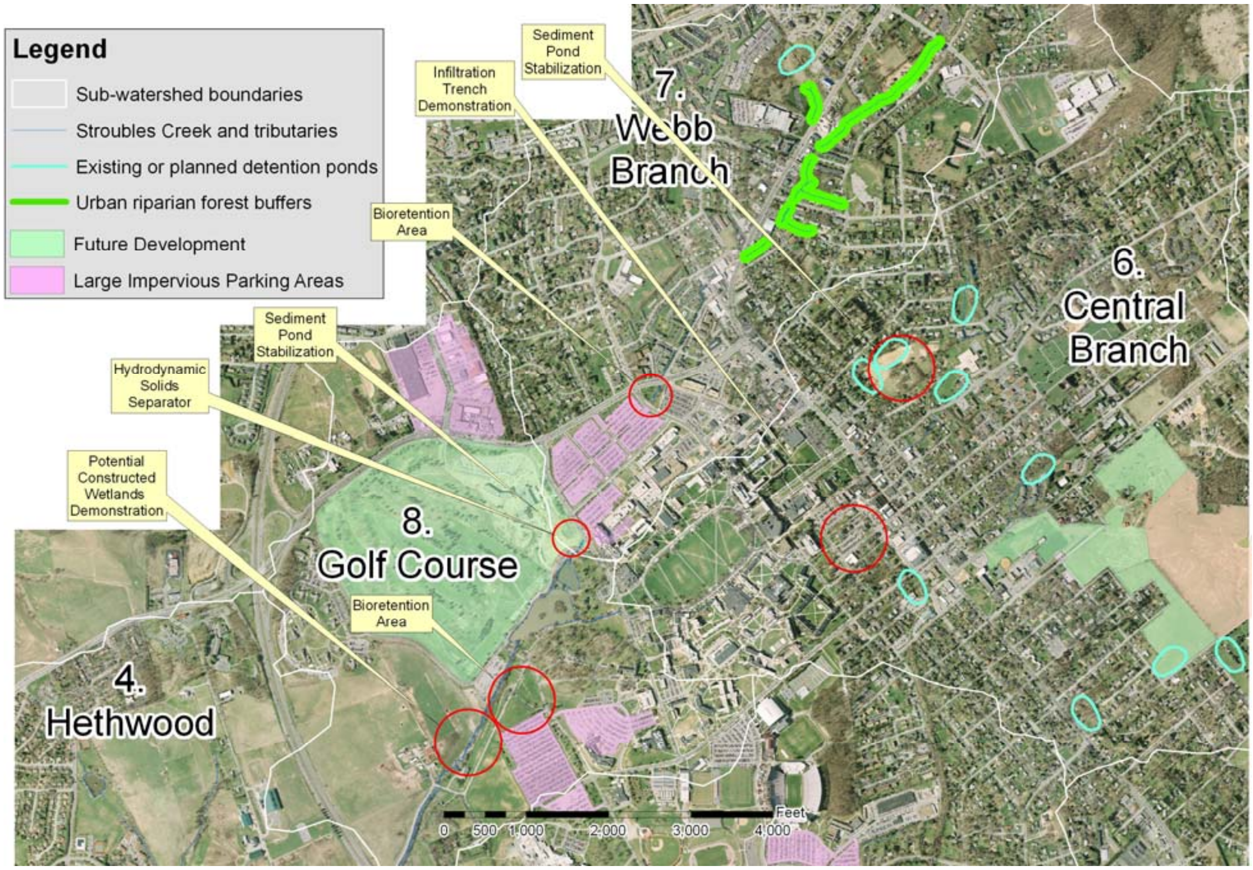

Figure 6.2. Locations of Urban Stormwater Management BMPs

6.4. *Sanitary Sewer System Improvements*

Although sanitary sewer system overflows (SSOs) contribute minor amounts of solids and/or sediment directly related to the sediment issues in the watershed, they contribute nutrients, organic matter, and bacteria that are also water quality concerns in the watershed. The Town of Blacksburg is addressing the SSO issue directly and has included the following related actions in its MS4 plan:

- Detect and eliminate illicit stormwater discharges to the sanitary sewer
- Establish an ordinance prohibiting illegal dumping and non-storm water discharges to the stream
- Develop and implement a stormwater ordinance designed to reduce stormwater runoff impacts (encourage infiltration)

Virginia Tech, in conjunction with the Town of Blacksburg and BVPI Sanitation Authority, is in the process of upgrading an existing sanitary sewer interceptor that traverses the Virginia Tech Commuter Lot. The total combined cost estimate for this project is approximately $2,225,000, which will assist with eliminating the current SSO's in the Sanitation Authority's line.

Additionally, the Town is currently spending $250,000 in formulating a Town wide sewer model and system wide analysis to identify other sections of the Town's sewer in the

Stroubles Creek area that may experience capacity and condition issues that may adversely affect the surrounding watershed. The project is in two phases: Phase 1 will identify capacity and condition issues around the existing system and is to be finalized by the May 2006, Phase II will provide estimated costs and a strategy on how the TOB may address the capacity and condition issues. Therefore, cost estimates for these two projects amount to $2,475,000, as provided by the Town of Blacksburg and VT.

6.5. *Urban/Residential Education Program*

The Town of Blacksburg has allocated $40,000 to address all MS4 compliance issues, and has included the following public education measures in its MS4 plan:

- Conduct an outreach program on the disposal of household hazardous waste
- Educate businesses on the impact of non-storm water discharges into the stream
- Conduct stakeholder meetings for watershed management and storm water quality management

The following activities have also been identified during the Focus Group meetings as supplemental educational measures needed to improve the awareness and practice of good environmental stewardship in the Stroubles /Creek watershed, not only to address the issues at hand, but also to prevent future water quality issues by creating an informed citizenry:

- Steer/encourage future development using smart development guidelines and compliance with existing stormwater management plans,
- Develop partnerships with developers to protect existing riparian buffers and to encourage use of bioretention, low impact development (LID), and infiltration practices,
- Conduct erosion and sedimentation workshops,
- Conduct homeowners association (and neighborhood) workshops to include information on the use of rain barrels, rain gardens, and downspout disconnects, on lawn fertilization protective of water quality, and on where to report water quality problems, and
- Expand citizen involvement in SEEDS (local community group) Adopt-A-Stream program, the Save Our Streams monitoring program, and other established environmental education programs, such as through the Skyline SWCD.

During the first five years when the primary implementation activities will occur, a half-time coordinator will be hired to coordinate grant writing, implementation tracking, communication with stakeholders, and educational aspects of the plan. Ideally this person would have an office in the watershed in liaison with the New River Roundtable, the Virginia Water Resources Research Center, the Center for TMDL and Watershed Studies, the Skyline Soil and Water Conservation District, or other appropriate watershed group.

The total costs for the educational component of the Stroubles Creek Implementation Plan are estimated as $200,000 based on:

- Part-time Watershed Coordinator ($35,000/yr over a 5-year period)
- Materials, supplies, travel, miscellaneous ($5,000/yr over a 5-year period)

Educational costs are already included as part of the overall TAA for implementation in Stroubles Creek.

The total costs for the various components of the Stroubles Creek Implementation Plan are shown in Table 6.4.

Table 6.4. Implementation Cost Summary

Implementation Action Type	Cost
Agricultural BMPs	$66,311
Stream Channel BMPs	$2,433,040
Stormwater Management BMPs	$1,766,647
Sanitary Sewer System Improvements	$2,475,000
Urban/Residential Education Program ($200,000 included in various TAA)	
Total Implementation Cost	**$6,740,997**

6.6. *Estimated Load Reductions*

Since modeling was performed as part of the TMDL study, several issues have arisen which have changed the numeric target loads and percent reductions, though not the direction of the TMDL. First, a modeling software error was uncovered that overestimated channel erosion load, and corrected. Then a misclassification of land use was noticed and updated, and finally, advances in model parameter value estimation procedures were incorporated into the load estimates for implementation planning purposes. Changes in the overall sediment load, the TMDL, the target load (TMDL – MOS), and the required percent reductions for each of these changes, each of which incorporates previous corrections, are shown on successive rows in Table 6.5. Finally, when the model corrected channel erosion rates were compared with an estimate from initial field measurements currently being made on one stretch of Stroubles Creek, the model estimate for that reach was about 6 times lower than the field measurements. Therefore, in the last row of Table 6.5, the channel erosion estimates from each sub-watershed and from the reference watershed were all multiplied by a factor of 6 to provide more realistic channel erosion and target loads.

For implementation planning, therefore, our beginning sediment load is 3,525.6 tons/yr and our target sediment load is 1,439.3 tons/yr, which requires an overall reduction of 59.2%. Implementation Planning will proceed with the revised estimate of percent reduction for three main reasons: 1.) The IP is being developed in a staged approach using sediment load reduction as a surrogate measure for benthic health improvement, 2.) the reference watershed approach sets a “relative” target load based on the reference watershed, and 3.) the revised TMDL load is actually lower than in the TMDL study.

Table 6.5. Changes in Estimates of TMDL Target Reduction Percentage

Land Use Scenario		Sediment Load (tons/yr)	Channel Erosion (tons/yr)	TMDL (tons/yr)	Target Load (tons/yr)	% Reduction
TMDL Study	Future	7,552.6	2,404.6	2,365.1	2,128.6	71.8%
Model Correction	Future	5,180.9	32.9	2,001.2	1,801.0	65.2%
Land Use Correction	Interim	4,924.2	27.5	2,001.2	1,801.0	63.4%
Revised Parameter Estimates	Interim	3,251.5	54.8	1,515.2	1,363.7	58.1%
Adjusted Channel Erosion Rates	Interim	**3,525.6**	**328.9**	**1,599.2**	**1,439.3**	**59.2%**

The steps taken to reduce the existing sediment load to the target sediment load are summarized in Table 6.6. The first step in calculating load reductions needed to meet the sediment TMDL reduction goal was to evaluate BMPs that had been installed in the watershed since completion of the TMDL study in 2003, as shown under the "Interim Sediment Reduction" column. Next, since a TMDL must take into consideration anticipated Future land use changes, we applied the model to the Future land use changes to look at changes in Future load for our various source categories, relative to our beginning sediment load in Table 6.5. We then modeled the reductions from the recommended suite of BMPs identified by the Focus Groups and Steering Committee. It was then necessary to increase the length of stream channel restoration and the urban area treated with bioretention and infiltration BMPs, from our initial extent estimates, in order to achieve the target sediment load, as shown in Table 6.6. The interim and IP load reductions were calculated through a combination of modeling and application of the efficiency coefficients shown in Table 6.7 to each BMP and pollutant combination.

Table 6.6. Summary of Load Reductions for Stroubles Creek

Allocation Categories	Existing TMDL Sediment Load	Reductions				Sediment Load after Implementation	% Reduction Achieved
		Interim Sediment Reduction	Reductions Due to Anticipated Future Land Use Changes	IP Upland Sediment Reductions	IP Channel Sediment Reductions		
	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(tons/yr)	(%)
Agriculture	2,457.1	739.7	181.1	767.7	0.0	768.7	68.7%
Urban/MS4	715.0	105.5	-57.0	188.3	0.0	478.1	33.1%
Channel Erosion	328.9	0.0	-52.6	0.0	213.8	167.7	49.0%
Permitted Point Sources	24.6	0.0	0.0	0.0	0.0	24.6	0.0%
Total Sediment Load	**3,525.6**	**845.1**	**71.5**	**956.0**	**213.8**	**1,439.1**	**59.2%**
					TMDL Target Load =	1,439.3	59.2%

The original TMDL called for reductions of 77% from agricultural and channel sources and reductions of 54% based on an overall required reduction of 71.8%. With the revised modeling performed to recalculate a new starting and ending target for implementation, the overall required reduction was 59.2% which is met with the Stroubles Creek Implementation Plan. The distribution of reductions varies somewhat from the TMDL recommendations with a slightly larger percent reduction from agriculture, which was justifiable from two points of view. The first was that, as shown under the cost benefit analysis section that follows, the agricultural BMPs in general were less expensive and much more cost effective. The second view was that, although the reductions from the initial extent of agricultural BMPs recommended by the Focus Groups were estimated as already exceeding the percent reduction called for in the TMDL from agricultural sources, they were deemed important by the Focus Group. After this initial assessment, the estimated reduction from all sources was insufficient to reach the overall TMDL sediment reduction target, so all additional reductions were based on additional extents of stream channel or stormwater management BMPs.

Table 6.7. BMP Efficiency Coefficients

Implementation BMP	Efficiency Coefficients			
	N	P	Sed	Source
Riparian forest buffer	0.57	0.70	0.70	1
Livestock exclusion	0.75	0.75	0.75	1
Constructed wetlands	0.45	0.50	0.50	2
Vegetative buffer	0.43	0.53	0.53	1
Livestock exclusion + alternative water system + Riparian forest buffer	0.89	0.93	0.93	1
Stream channel restoration	0.90	0.90	0.90	5
Loafing lot management + diversion	1.00	1.00	0.00	2
Infiltration practices	0.50	0.70	0.90	2
Level spreader	0.30	0.30	0.60	3
Bioretention areas	0.43	0.81	0.75	3
Sanitary sewer overflow prevention	1.00	1.00	1.00	
Street sweeping	0.58	0.28	0.79	4
Hydrodynamic separator	0.65	0.32	0.75	6
Increased E&S inspections	0.33	0.50	0.50	2

1 - DCR, 2002
2 - CBP, 2005
3 - Tetra Tech, 2003
4 - Montgomery Co. Maryland DEP, 2002
5 - Tess Wynn, personal communication
6 - NJDEP, 2005

Although the TMDL was developed for sediment, nutrients were also considered likely contributors, so load and load reductions for nitrogen (N) and phosphorus (P) are included as well in the overall pollutant reduction summary in Table 6.8. Further details and documentation on the procedures used for modeling reductions from BMPs are included in Appendix B.

Table 6.8. Overall Pollutant Reduction Summary for the Stroubles Creek IP

Loads and *Reductions*	**N (lbs/yr)**	**P (lbs/yr)**	**Sed (tons/yr)**
Existing TMDL Load	37,202.5	16,647.6	3,525.6
Interim Reduction	3,151.5	3,151.2	845.1
Reductions Due to Anticipated Future Land Use Changes	-835.8	210.6	71.5
IP Upland Reductions	7,620.7	4,145.4	956.0
IP Channel Reductions	280.1	506.7	213.8
Load after Implementation	26,986.0	8,633.8	1,439.1
% Reduction Achieved	27.5%	48.1%	59.2%

6.7. *Cost Benefit Analysis*

A cost benefit analysis for a mixed-use watershed is an inexact exercise, as costs for the sanitary sewer system improvements are only indirectly related to sediment loading and any estimate of sediment load reductions from education programs would be highly speculative. Therefore, cost benefit analyses are only included for those BMPs with physical installations to illustrate the relative cost advantages among these practices. As mentioned previously, many of the costs included in these analyses for physical installations are also subject to change when site specific plans are developed during implementation. These analyses make the assumption that the actions proposed would accomplish the required reductions. In the following three tables, total load reductions are included for N, P, and sediment, together with their implementation costs. Although the benefits of implementing these BMPs consist of more than just sediment load reductions, the cost/load reduced is calculated only on sediment in order to assess the relative advantage of individual BMPs for the primary targeted pollutant. Minor differences in $/ton ratios are insignificant given the unknowns, but order-of-magnitude differences do offer some guidance as to where dollars might be spent more effectively. The magnitude of figures, however, may also be somewhat misleading, as any decreases in flow and its associated hydrological benefits from infiltration BMPs are not captured in the application of efficiency coefficients. However, a better analysis of the infiltration and bioretention practices, and the hydrodynamic separator will be available through the companion research monitoring that will accompany the installation of the initial demonstration sites.

Table 6.9. Agricultural BMP Cost Benefit Analysis

Agricultural BMPs	IP Reductions			Implementation Costs			Cost/Load Reduction
	N	P	Sed				
	(lbs/yr)	(lbs/yr)	(tons/yr)	Installation	TAA	Total	($/ton Sed)
Riparian forest buffer	4,323.9	2,894.6	766.7	$16,208	$3,242	$19,449	$25.37
Livestock exclusion + limited access	1,042.92	199.13	56.54	$35,789	$7,158	$42,946	$759.56
Loafing lot management + diversion	37.02	28.48	0.00	- TBD -			

Table 6.10. Stream Channel BMP Cost Benefit Analysis

Sream Channel BMPs	IP Reductions			Implementation Costs			Cost/Load Reduction
	N	P	Sed				
	(lbs/yr)	(lbs/yr)	(tons/yr)	Installation	TAA	Total	($/ton Sed)
Stream channel restoration	280.1	506.7	213.8	$1,066,555	$143,985	$1,210,540	$5,661.09

Table 6.11. Stormwater Management BMP Cost Benefit Analysis

Stormwater Management BMPs	IP Reductions			Implementation Costs			Cost/Load Reduction
	N	P	Sed				
	(lbs/yr)	(lbs/yr)	(tons/yr)	Installation	TAA	Total	($/ton Sed)
Riparian forest buffer	581.7	186.2	16.4	$3,938	$1,063	$5,002	$304.84
Infiltration practices (additional)	66.46	11.42	2.25	$142,784	$38,552	$181,336	$80,517.56
Bioretention areas (additional)	57.15	13.21	1.88	$223,242	$15,782	$239,024	$127,359.05
Street sweeping (additional)	778.95	58.09	16.15	$12,746		$12,746	$789.42
Hydrodynamic separator	192.76	10.54	1.54	$100,000		$100,000	$64,744.62
Increase E&S program efficiency	382.92	715.92	90.00	$50,000		$50,000	$555.56

6.8. *Prioritization*

From the limited cost benefit analysis above, riparian forest buffers, livestock exclusion, and management practices to improve the efficiency of existing practices, such as street sweeping and the E&S program, are likely to offer the greatest reduction in sediment loads in Stroubles Creek, and should be implemented first. Many of the actions proposed, such as sanitary sewer improvements and illicit discharge detection are already included in local MS4 plans and will be locally funded. A part-time watershed coordinator to be hired in conjunction with a local watershed or conservation group will be key in facilitating implementation, tracking, and educational components of the IP.

Funding for implementation in Stroubles Creek will come from a variety of sources, including available cost-sharing programs, grant sources, and in-kind services from the Town of Blacksburg and Virginia Tech. Each of these sources is described in detail in Chapter 10. The amount of funding available from each source is expected to vary from year to year and grant funding will be contingent on receipt of awards. However, since the implementation plan will be phased in over a period of years, a number of funding opportunities will be available during implementation, thereby increasing the likelihood of receiving the requested funding. Since implementation planning for Stroubles Creek was initiated by VDEQ instead of VDCR, it was inadvertently left off of the state's current priority list for receiving §319 program funds. However, grant funding through the §319 program may be available for the watershed starting in 2007. Many of the activities in this plan are ones that the Town and University have already planned and funded on their own, so although they may not offer the greatest benefit per dollar, their funding, nevertheless, is assured.

7.0 Goals and Measurable Milestones

The ultimate goal of this implementation plan is to bring Stroubles Creek segment VAW-N22R_STE04A00 into compliance with water quality standards, which will result in its removal from the 303(d) list of impaired waters. Progress towards this goal will be measured by improvement in the Stream Condition Index based on biological monitoring, but milestones along the way will include both water quality measurements and the implementation of best management practices. Implementation goals must keep in mind the TMDL allocation goals. The TMDL called for 77% reduction of sediment from agricultural and channel erosion sources and a 54% reduction from urban areas. The major goal to bring Stroubles Creek into compliance is broken down into the following sub-goals and objectives. These address the watershed issues outlined in the previous sections of this report:

GOAL #1: Implement cost-shared best management practices (BMPs) to achieve targeted agricultural reductions.

- Objective: Educate targeted landowners in funding available and procedures for implementing BMPs on their properties.
- Objective: Install appropriate BMPs such as fencing, riparian buffers, alternative water systems, and stream crossings on pastures.

GOAL #2: Implement stream channel BMPs for additional reductions, where cost-effective.

- Objective: Restore and protect stream banks.
- Objective: Minimize and correct stream channel modifications.

GOAL #3: Reduce inputs in urban, university, and residential areas through education.

- Objective: Encourage installation of urban streamside forest buffers, where possible.
- Objective: Encourage installation of homeowner Low Impact Development measures.
- Objective: Educate homeowners in funding available for forested buffers and LID practices.
- Objective: Use media to increase awareness of water quality issues and good stewardship practices.
- Objective: Include education about water quality and stewardship in local school curricula.
- Objective: Offer educational programs and literature through homeowners' associations and other neighborhood or civic organizations.
- Objective: Expand the state Adopt-a-Stream program in the watershed.

GOAL #4: Implement storm water management practices to reduce inputs from public works.

- Objective: Install and monitor demonstration Low Impact Development sites.

Objective: Improve enforcement of Erosion and Sediment Control regulations.
Objective: Improve efficiency of street sweeping practices.
Objective: Seek opportunities for remediation and increased storm water infiltration with redevelopment and new construction.
Objective: Reduce sanitary sewer overflows.
Objective: Prevent infiltration/exfiltration from sanitary sewers.

GOAL #5: Through planning activities, identify and prioritize opportunities for stream protection and restoration, and ensure that codes and design standards are "water quality friendly."

Objective: Develop and revise as necessary master plans and action lists for watershed.
Objective: Review and adopt codes and design standards as needed.
Objective: Encourage future development using smart development guidelines.
Objective: Encourage stream restoration and incorporation of LID or other suitable infiltration practices in areas of redevelopment.
Objective: Enact illicit discharge ordinances.
Objective: Adopt pollution prevention plans for municipal and public facilities.

GOAL #6: Reduce urban and residential inputs by performing inspection, monitoring and maintenance activities to eliminate illicit discharges, ensure proper storm water system performance and prevent pollution.

Objective: Locate and inspect all storm water outfalls.
Objective: Detect and address non-storm water/illicit discharges.
Objective: Maintain and repair storm water structures.
Objective: Establish and maintain a pollution-prevention hotline.
Objective: Provide guidelines to downtown businesses regarding acceptable wastewater disposal procedures.

7.1. *Implementation and Water Quality Milestones*

Implementation milestones will establish the implementation actions to be completed within certain timeframes. As this IP primarily addresses a benthic impairment, the ultimate water quality milestone is the restoration of a healthy benthic community, denoted by two consecutive SCI scores in the non-impaired range. Annual assessments of progress will monitor improvements not only in the SCI scores, but also in two of the habitat metrics most related to sediment impacts – "sediment deposition" and "embeddedness". Because the relationship between sediment "load" 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 milestones. The milestones described here are intended to achieve full implementation within the first 5 years, with full benefits to water quality expected during the following 5 years. The two major milestones, therefore, are "Full implementation" at the 5 year mark, and "De-listing" at the 10 year mark.

Many implementation activities are already underway in the watershed. The Stroubles Creek Steering Committee strongly supports these activities and recommends that these efforts be continued. Implementation of sediment control measures that also reduce bacteria and nutrient loads are encouraged, as this may preclude the need for implementation of additional management measures for those sources.

The implementation of BMPs in the impaired watershed will be accomplished in stages. In general, the Commonwealth intends for the required reductions to be implemented in an iterative process that addresses first the sources with the largest impact on water quality. Because of the relatively few agricultural landowners in the watershed, an aggressive effort will be made to implement the majority of these practices during the first 2 years. Implementation in the urban area will rely on establishment of demonstration sites in the initial years to serve as focal points for educational programs targeted at residential homeowners, and pilot projects for the Town of Blacksburg (TOB) and Virginia Tech. These pilot projects will allow these governing entities to assess the performance and maintenance needs of the various management practices, before moving to wider implementation within their standard operating procedures. Monitoring will continue throughout the process to document progress toward goals and to provide a mechanism for evaluating the effectiveness of the implementation actions, as well as their suitability, for achieving intended water quality goals. The benefits of staged implementation are 1) as stream monitoring continues to occur, 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 model; 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.

7.2. *Linking Implementation Actions to Water Quality*

Because of the many uncertainties involved in relating sediment reductions to biological health, the assumption used during implementation planning is similar to the one used during the TMDL study – namely that the degree of improvement in water quality due to implementation actions will be directly related to the degree of improvement in the biological health of the stream.

Assessments of spatial data, watershed tours, group discussions, and recommended priorities for management changes from each Focus Group led to an identification and quantification of the extent of problems at each location. Because it was recognized that areas downstream from the Duck Pond likely have a greater influence on sediment loading to the impaired reach, addressing these sources is expected to produce the greatest and fastest improvements in benthic community health. This targeting will not only ensure optimum utilization of revenue and resources but is also consistent with the staged implementation approach.

7.3. *Implementation Schedule*

A list of BMPs for targeted locations and other general actions to be implemented during the first 5 years of the plan around the Stroubles Creek watershed is shown in Table 7.1.

Table 7.1. Implementation Timeline

2006		
Goal	**Measurable Milestone**	**Party Responsible***
1	Contact agricultural land owners to present and discuss BMP and funding options.	WSC
1	Apply for grants where cost-sharing is not available or supplemental incentives are needed.	WSC, SCSC
1	Plan and install livestock management BMPs on VT farm.	WSC, DCR, SWCD, NRCS
1	Plan and install livestock exclusion and limited access crossing BMPs on Heth farm.	WSC, BSE, SWCD, NRCS, VTF
1	Plan and install forested buffers on Heth farm.	WSC, VDGIF, SWCD, NRCS, VTF
2	Assess capacity of culverts at Rt. 460.	VT, VDOT
3	Employ a part-time watershed coordinator.	NRWR, SCSC
3	Develop a community educational workshop on water quality awareness and homeowner LID practices.	WSC, TOB
3	Develop an official Adopt-A-Stream program for service organizations on campus.	WSC, VT
4	Upgrade sanitary sewer line from Prices Fork Rd. to West Campus Drive.	VT, TOB
4	Plan, install, and monitor demonstration water quality, LID, and other innovative storm water management practices.	VT, TOB
4	Conduct field survey of potential areas for constructed wetlands.	WSC, BSE, SWCD, NRCS, VDCR
4	Arrange for external review and evaluation of the E&S Program as implemented in the watershed.	VT, TOB
5	Provide feedback on the Virginia Tech Master Plan to ensure consistency with Stroubles Creek IP.	WSC
5	Calibrate the water, storm, and sanitary sewer models for campus for analysis of water consumption and discharge.	VT
5	Link GIS mapping capabilities with discharge model to track illicit discharges and scheduled maintenance for storm water facilities.	VT
5	Complete town-wide sewer model and analysis to rank the severity and probability of sewer overflows throughout the TOB sewer system.	TOB
6	Construct a combined salt storage facility with TOB to prevent runoff.	VT, TOB
3	Employ a part-time watershed coordinator.	NRWR, SCSC
3	Plan and install urban forested buffers.	WSC, VDOF, SWCD, NRCS
3	Present the community educational workshop to homeowners and/or neighborhood associations at least annually.	WSC, SCSC
2007		
Goal	**Measurable Milestone**	**Party Responsible***
3	Employ a part-time watershed coordinator.	NRWR, SCSC
3	Plan and install urban forested buffers.	WSC, VDOF, SWCD, NRCS
3	Present a community educational workshop to homeowners and/or neighborhood associations.	WSC, SCSC, TOB
2	Plan, implement, and monitor stream restoration measures on Heth farm.	WSC, BSE, SWCD, NRCS, VTF
2008		
Goal	**Measurable Milestone**	**Party Responsible***
3	Employ a part-time watershed coordinator.	NRWR, SCSC
3	Plan and install urban forested buffers.	WSC, VDOF, SWCD, NRCS
3	Present a community educational workshop to homeowners and/or neighborhood associations.	WSC, SCSC
5	Conduct a town-wide study to identify capital projects that could address severity and probability of sewer overflows.	TOB
2009		
Goal	**Measurable Milestone**	**Party Responsible***
3	Employ a part-time watershed coordinator.	NRWR, SCSC
3	Plan and install urban forested buffers.	WSC, VDOF, SWCD, NRCS
3	Present a community educational workshop to homeowners and/or neighborhood associations.	WSC, SCSC
2010		
Goal	**Measurable Milestone**	**Party Responsible***
3	Employ a part-time watershed coordinator.	NRWR, SCSC
3	Plan and install urban forested buffers.	WSC, VDOF, SWCD, NRCS
3	Present a community educational workshop to homeowners and/or neighborhood associations.	WSC, SCSC

* WSC = Watershed Coordinator; SCSC = Stroubles Creek Steering Committee; DCR = Department of Conservation and Recreation; SWCD = Skyline Soil and Water Conservation District; BSE = VT Biological Systems Engineering Department; NRCS = USDA Natural Resource Conservarion Service; TOB = Town of Blacksburg; VDGIF = Virginia Department of Game and Inland Fisheries; VDOF = Virginia Department of Forestry; VDOT = Virginia Department of Transportation; VT = Virginia Tech; and VTF = Virginia Tech Foundation.

Table 7.1 (cont.)

Annually		
Goal	**Measurable Milestone**	**Party Responsible***
4	Conduct annual inspections of storm water outfalls and maintain facilities infrastructure database.	VT, TOB
5	Schedule routine inspection, maintenance, and repair of all storm water management facilities on	VT
5	Inventory area of street sweeping on an annual basis. Clean roadways/parking areas after major	VT, TOB
5	Inventory linear feet of streams cleaned up on an annual basis.	WSC
6	Educate staff on vehicle and equipment washing.	VT
6	Continue to monitor and maintain storm sewer intakes on an annual basis.	VT, TOB
6	Document locations and methods of hazardous material storage and inspect annually.	VT
6	Continue to update and evaluate existing campus Nutrient Management Plan.	VT
6	Publicize pollution prevention phone numbers and web site to report problems and/or illicit discharges	VT
Ongoing		
Goal	**Measurable Milestone**	**Party Responsible***
3	Plan and install demonstration homeowner Low Impact Development (LID) practices.	WSC, TOB
3	Apply for grants to fund homeowner and demonstration BMPs.	WSC, SCSC
3	Actively promote enrollment of sponsors for the Adopt-A-Stream program in the watershed.	WSC, TOB
3	Reinforce proper recycling and trash disposal plan to university students and staff.	VT
3	Educate university students and staff on VT Pollution Prevention plan.	VT
4	Invite review and feedback on Capital Projects to ensure effective storm water and erosion and sediment controls.	VT
4	Provide clear guidance to Project Managers on Erosion and Sediment Control requirements.	VT, TOB
4	Retrofit existing facilities with LID practices, where practical.	VT, TOB
4	Identify service vehicle areas on campus for installation of grass pavers.	VT
5	Maintain and update existing facility inventory database and GIS mapping on facilities, storm water conveyance and control structures, and receiving surface water bodies.	VT
6	Seek alternative methods to de-icing roadways and parking lots while minimizing salt usage.	VT, VDOT

* WSC = Watershed Coordinator; SCSC = Stroubles Creek Steering Committee; DCR = Department of Conservation and Recreation; SWCD = Skyline Soil and Water Conservation District; BSE = VT Biological Systems Engineering Department; NRCS = USDA Natural Resource Conservarion Service; TOB = Town of Blacksburg; VDGIF = Virginia Department of Game and Inland Fisheries; VDOF = Virginia Department of Forestry; VDOT = Virginia Department of Transportation; VT = Virginia Tech; and VTF = Virginia Tech

7.4. *Reasonable Assurance*

Public participation is an integral part of the IP development and is critical in gaining support for both the voluntary and MS4 compliant implementation activities that are being planned. During the public participation process, the major stakeholders in the watershed, the MS4 Coordinators for both the Town of Blacksburg and Virginia Tech, and a wide variety of local conservation agency personnel were involved in the Focus Group and Steering Committee meetings. This broad 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.

The Steering Committee formed during this implementation planning period will continue meeting through the implementation phase, ensuring continuity of leadership and vision. The Project Team, the Town of Blacksburg, and the Virginia Tech Site & Infrastructure entities are all independently, and cooperatively, pursuing WQIF and other grant opportunities for the purpose of funding specific components of the Stroubles Creek IP, ensuring their continuing interest, participation, and support.

The attention focused on Stroubles Creek during the implementation planning phase has raised the visibility of the Steering Committee in the community as a recognizable watershed partner, so that other planning entities, such as the Town of Blacksburg's Planning and Engineering Department, the Friends of the Huckleberry Trail, and the VT Site & Infrastructure planners have shared their future plans with the Steering

Committee to ensure mutual compatibility. This integration with existing planning entities, further discussed in Chapter 9, provides additional assurance that the implementation envisioned in this plan will be carried out.

Implementation to address the biological impairment on Stroubles Creek will be carried out primarily through the use of voluntary and MS4 compliant 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 used 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 Stroubles Creek.

7.5. *Tracking and Monitoring Plans*

7.5.1. Implementation Tracking

The Virginia Agricultural Best Management Practices Cost-Share Program will be used for tracking implementation actions involving agriculture, while the Watershed Coordinator, in coordination with the MS4 Coordinators for the Town of Blacksburg and Virginia Tech, will track implementation actions performed in the campus and urban areas.

7.5.2. Water Quality Monitoring

The monitoring program to assess implementation progress will be based on state VDEQ ambient and biological monitoring at the existing monitoring sites listed in Table 7.2, supplemented with additional monitoring from the Virginia Save Our Streams program.

Table 7.2. Existing VDEQ Water Quality Monitoring Sites

Station ID	Station Location	Stream Name	Station Type
9-STE002.41	Route 705 Bridge	Stroubles Creek	Ambient / Biology
9-STE007.29	Route 657 Bridge	Stroubles Creek	Ambient / Biology

VDEQ will take biological samples at 9-STE007.29 at least every other year spring and fall from July 2006 to July 2012. Metrics will be calculated for these samples for evaluation of the SCI index. Since many habitat metrics are particularly relevant to the impact of sediment, VDEQ will be requested to perform the habitat evaluation every spring and fall at both sites, regardless of whether biological samples are taken or not.

VDEQ has also agreed to sample the following physical and chemical parameters at both monitoring sites bi-monthly from July 2006 to July 2012: *E.coli*, temperature, dissolved oxygen, specific conductance, turbidity, total nitrogen, total phosphorus, total solids, and total suspended solids. Stream bank erosion rates are currently being assessed using erosion pins and topographic surveying by the Biological Systems Engineering Department at Virginia Tech. These measurements will continue post-restoration to document changes in bank retreat rates. Additional monitoring will be included in grants requested for specific urban BMPs, such as the bioretention area planned for the new Smithfield Road parking lot and installations of the hydrodynamic solids separators[1], and additional field measurements for estimating reductions in sediment loading due to channel and streambank restoration activities.

7.6. *The Staged Implementation Approach*

During each annual evaluation of implementation on Stroubles Creek, 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.

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.

[1] A hydrodynamic solids separator is a mechanical flow-through structure with a settling or separation unit to remove sediments and other pollutants from storm water runoff.

8.0 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 develop the IP. The roles and responsibilities of some of the major stakeholders are described below.

8.1. *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 http://www.nrcs.usda.gov/.

8.2. *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 Stroubles Creek watershed. These agencies are:

Virginia Department of Environmental Quality (VDEQ): 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 VDEQ'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 VDEQ'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.

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

Virginia Department of Conservation and Recreation (VDCR): VDCR is authorized to administer Virginia's NPS pollution reduction programs in accordance with §10.1-104.1 of the Code of Virginia and §319 of the Clean Water Act. EPA requires much of the §319 grant monies be used for the development of TMDLs. Because of the magnitude of the NPS component in the TMDL process, VDCR is a major participant in the TMDL process. VDCR has a lead role in the development of IPs to address correction of NPSs contributing to water quality impairments. VDCR also provides available funding and technical support for the implementation of NPS components of IPs. The staff resources in VDCR's TMDL program focus primarily on providing technical assistance and funding to stakeholders to develop and carry out IPs, and support to VDEQ in TMDL development related to NPS impacts. VDCR staff will also be working with other state agencies, Soil and Water Conservation Districts, and watershed groups to gather support and to improve the implementation of TMDL plans through utilization of existing authorities and resources.

Virginia Department of Agriculture and Consumer Services (VDACS): The VDACS Commissioner of Agriculture has the authority to investigate claims that an agricultural producer is causing a water quality problem on a case-by-case basis (Pugh, 2001). If deemed a problem, the Commissioner can order the producer to submit an agricultural stewardship plan to the local soil and water conservation district. If a producer fails to implement the plan, corrective action can be taken, which may include civil penalties. The Commissioner of Agriculture can issue an emergency corrective action if runoff is likely to endanger public health, animals, fish and aquatic life, public water supply, *etc*. An emergency order can shut down all or part of an agricultural activity and require specific stewardship measures.

Virginia Department of Health (VDH): The VDH is responsible for maintaining safe drinking water measured by standards set by the EPA. Their duties also include septic system regulation and regulation of biosolids land application. 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. 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*.).

Virginia Department of Forestry (DOF): 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 areas (www.dof.state.va.us/wq/wq-bmp-guide.htm). 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.

Other state entities with responsibilities for activities that impact water quality in Stroubles Creek watershed include:

Virginia Cooperative Extension (VCE): 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. For more information on these publications and to find the location of county extension offices, visit www.ext.vt.edu.

Virginia Tech (VT): Virginia Tech is a public land grant university whose main campus occupies the center of the Upper Stroubles Creek watershed. As a land-grant university, Virginia Tech maintains a large agricultural operation, part of which is adjacent to the main campus and within the Upper Stroubles Creek watershed. As a state entity, Virginia Tech maintains an up-to-date Conservation Plan on its agricultural areas that includes a Nutrient Management component and, with its ongoing construction projects related to expansion and development, complies with state Erosion and Sediment Control regulations. As part of its three-pronged missions of instruction, research, and outreach, Virginia Tech is actively involved in solving the problems of society through public service and outreach activities.

8.3. *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.

Skyline 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.

NRVPDC: 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.

Town of Blacksburg: Town government staff work closely with PDCs and state agencies to develop and implement TMDLs. They may also help to promote education and outreach to citizens, businesses and developers to introduce the importance of the TMDL process.

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

8.4. *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.

Community Watershed Groups: (Save Our Streams, SEEDS, Student Chapter American Forestry Society, Student Chapter Soil and Water Conservation Society, 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.

New River Watershed Roundtable: 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.

Friends of the Huckleberry Trail: A not-for-profit corporation dedicated to developing the Huckleberry Trail in Montgomery County. Many stretches of the trail follow the riparian corridor of Stroubles Creek.

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 Friends of the Huckleberry, Ruritan, Farm Clubs, Homeowner Associations and youth organizations such as 4-H and Future Farmers of America. These groups offer a resource to assist in the public participation process, educational outreach, and assisting with implementation activities in local watersheds.

Animal Clubs/Associations: Clubs and associations for various animal groups (*e.g.*, beef, equine, poultry, swine, and canine) provide a resource to assist and promote conservation practices among farmers and other land owners, not only in rural areas, but in urban areas as well, where pet waste has been identified as a source of bacteria in water bodies. Virginia's approach to correcting non-point source pollution problems continues to be encouragement of participation through education and financial incentives; that is, outside of the regulatory framework. If, however, voluntary approaches prove to be ineffective, it is likely that implementation will become less voluntary and more regulatory.

Other important stakeholders yet to be involved (Town of Blacksburg neighborhood associations, VDOT, homeowners associations, property managers, developers, etc.)

9.0 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. In some cases, an IP may even address multiple TMDLs (*e.g.,* bacteria and benthic) for the same impaired water body.

9.1. *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, VDEQ 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.

9.2. *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.

WQMPs – Water Quality Management Plans (WQMPs) are produced and updated by VDEQ 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 – VDCR 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 http://www.VDCR.state.va.us/sw/e&s.htm.

SWM – Stormwater Management (SWM) programs are implemented according to the *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. VDCR 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. For more information, visit http://www.VDCR.state.va.us/sw/stormwat.htm.

Municipal Separate Storm Sewer Systems (MS4) Permits, Phase II – (Town of Blacksburg, Virginia Tech, and VDOT) The Storm Water Phase II Regulations requires all operators of urban municipal separate storm sewer systems (MS4s) to: 1) obtain a NPDES permit and 2) develop a storm water management program designed to prevent harmful pollutants from being washed by storm water into the storm sewer, then discharged from the storm sewer into local water bodies. The program must contain elements for each of the following six minimum control measures:

- public education and outreach,
- public involvement and participation,
- illicit discharge and detection elimination,
- construction site stormwater runoff control,
- post-construction stormwater management in new development and redevelopment, and
- pollution prevention/good housekeeping for municipal operations.

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 – (Virginia Tech Master Plan, Town of Blacksburg 2046 Comprehensive Plan) 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.

10.0 Potential Funding Sources

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, silviculture, rural, and some urban runoff control; on-site wastewater disposal systems (septic tanks); land conservation and riparian buffers; leaking underground storage tank remediation, etc. Estuary protection projects include all of the above point and nonpoint source projects, as well as habitat restoration and other unique estuary projects. $1.091 billion

Environmental Quality Incentives Program 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. Nationally, it provides technical, financial, and educational assistance, sixty percent of it is targeted to livestock-related natural resource concerns and the rest to more general conservation priorities. EQIP is available primarily in nationwide where there are significant natural resource concerns and objectives. $ 992 million

Five-Star Restoration Program The EPA supports the Five-Star Restoration Program by providing funds to the National Fish and Wildlife Foundation and its partners, the National Association of Counties, NOAA's Community-based Restoration Program and the Wildlife Habitat Council. These groups then make subgrants to support community-based wetland and riparian restoration projects. Competitive projects will have a strong on-the-ground habitat restoration component that provides long-term ecological, educational, and/or socioeconomic benefits to the people and their community. Preference will be given to projects that are part of a larger watershed or community stewardship effort and include a description of long-term management activities. Projects must involve contributions from multiple and diverse partners, including citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, and tribal agencies and local governments. Each project would ideally involve at least five partners who are expected to contribute funding, land, technical assistance, workforce support, or other in-kind services that are equivalent to the federal contribution. $ 500,000 (approximate)

Landowner Incentive Program (Non-Tribal) The U.S. Fish and Wildlife Service's Landowner Incentive Program (LIP) grant program provides competitive matching grants to states, territories, and the District of Columbia to establish or supplement landowner incentive programs. These programs provide technical and financial assistance to private landowners for projects that protect and restore habitats of listed species or species determined to be at-risk. LIP projects will likely involve activities such as the restoration of marginal farmlands to wetlands, the removal of exotic plants to restore natural prairies, a change in grazing practices and fencing to enhance important riparian habitats, instream structural improvements to benefit aquatic species, road closures to protect habitats and reduce harassment of wildlife, and acquisition of conservation easements. Although not directly eligible for these grants, third parties such as nonprofit organizations may benefit from these funds by working directly with their states to see if either grants or partnering opportunities are available. $ 20 million

Nonpoint Source Implementation Grants (319 Program) Through its 319 program, EPA provides formula grants to the states and tribes to implement nonpoint source projects and programs in accordance with section 319 of the Clean Water Act (CWA). Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed. Examples of previously funded projects include installation of best management practices (BMPs) for animal waste; design and implementation of BMP systems for stream, lake, and estuary watersheds; Basinwide landowner education programs; and lake projects previously funded under the CWA section 314 Clean Lakes Program. $ 207,328,000

Southern Rivers Conservation Through the Southern Rivers Conservation Initiative, The National Fish and Wildlife Foundation supports projects to restore and enhance riparian and riverine habitat in twelve southeastern states (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV). The initiative funds projects that fall into the following three categories: (1) Stream Restoration (Restore Our Southern Rivers), (2) Freshwater Mussel Conservation (projects that support the National Strategy for Mussel Conservation), and (3) Southeastern Imperiled Fishes Management (projects that support the Southeastern Imperiled Fishes Management Plan). In addition, projects should demonstrate community-based approaches to environmental stewardship; benefit water quality; demonstrate partnerships with others; involve specific on-the-ground activities; demonstrate landscape- or ecosystem-level approaches that complement other existing or planned restoration efforts in the watershed; and have a landowner and/or public education component. Program temporarily on hold.

Transportation Equity Act for the 21st Century Funding Programs The Transportation Equity Act for the 21st Century (TEA-21) funds numerous transportation programs (Surface Transportation Program (STP), National Highway System, etc.) to improve the nation's transportation infrastructure, enhance economic growth, and protect the environment. States may spend up to 20 percent of the STP dollars used on certain projects to rehabilitate existing transportation facilities for environmental restoration and pollution abatement projects, including the construction of stormwater treatment systems. Additionally, each state sets aside 10 percent of STP funds for transportation enhancement projects, which can include acquisition of conservation and scenic easements and the mitigation of highway stormwater runoff water quality, as well as scenic beautification, pedestrian and bicycle trails, archaeological planning, and historic preservation. These varied project types can be used to protect source water areas during construction of transportation corridors. FY05 funding for the Surface Transportation Program in Virginia amounted to $114 million.

Urban and Community Forestry Challenge Cost-Share Grants The U.S. Forest Service's Urban and Community Forestry Challenge Cost-Share Grant Program seeks to establish sustainable urban and community forests by encouraging communities to manage and protect their natural resources. The program works to achieve a number of goals, including (1) effectively communicating information about the social, economic, and ecological values of urban and community forests; (2) involving diverse resource professionals in urban and community forestry issues; and (3) supporting a holistic view of urban and community forestry. In particular, the program supports an ecosystem approach to managing urban forests for their benefits to air quality, stormwater runoff, wildlife and fish habitat, and other related ecosystem concerns. The Forest Service awards these grants based on recommendations made by The National Urban and Community Forestry Advisory Council, a 15-member advisory council created by the 1990

Farm Bill to provide advice to the Secretary of Agriculture on urban and community forestry. $875,000

Water Quality Cooperative Agreements These EPA grants are provided to help states, Indian tribes, interstate agencies, and other public or nonprofit organizations develop, implement, and demonstrate innovative approaches relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. This includes watershed approaches for combined sewer overflow, sanitary sewer overflows, and storm water discharge problems, pretreatment and sludge (biosolids) program activities, decentralized systems, and alternative ways to measure the effectiveness of point source programs. The estimate of funds available for fiscal year 2003 includes $20 million that has been requested for a new Watershed Initiative (WSI) program. Details for that program are currently being developed. If funds are appropriated for this program separate guidelines will be developed for the submittal, review, and approval of WSI projects. $ 19 million (estimated)

CREP – Conservation Reserve Enhancement Program
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 around local participation and leadership. Like CRP, 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.

Virginia Ag BMP 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 district. The state provides districts 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 75 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.

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 (VDEQ) is responsible for administering point source grants, and the Virginia Department of Conservation and Recreation (VDCR) 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. VDCR staff provides technical assistance, as well as financial assistance.

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.

Canaan Valley Institute Small Grants Program – Canaan Valley Institute seeks to support local stakeholder organizations committed to restoring and protecting the natural resources of their watersheds. Therefore applications must address water quality or quantity issues or aquatic habitat. CVI encourages groups to submit projects that can show quantifiable/measurable outcomes. Priority will be given to projects that address wastewater, source water, flooding, stream restoration, or conservation planning that addresses water resources. Groups seeking organizational development funding such as watershed awareness can apply for up to $2,000; specific projects such as watershed assessments, restoration planning, project designs or implementation can apply for up to $5,000. Projects must be completed within two years.

Virginia Aquatic Resource Trust Fund (VARTF) – The Virginia Wetlands Restoration Trust Fund was established as a cooperative partnership between The Nature Conservancy and the Corps-Norfolk District in a Memorandum of Understanding (August, 1995). The fund is utilized when other on-site or off-site compensation alternatives are determined to be impracticable. VDEQ approved the use of the fund on December 19, 2001 as an acceptable form of compensatory mitigation for impacts to state waters, including wetlands, permitted under Virginia Water Protection individual and general permits. An amendment to the 1995 Memorandum of Understanding was made in December 2003. Among other things, the amendment changed the name of the fund to the Virginia Aquatic Resources Trust Fund and allowed for stream restoration contributions to be made.

Open Space Lands Preservation Trust Fund – Farmland, forest land and open spaced 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. Additional information is available at: http://www.virginiaoutdoorsfoundation.org/ptf.html .

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Appendix A. Glossary of BMP Definitions

Bioretention area: A depressed landscaping area that is allowed to collect runoff so it percolates through the soil below the area into an underdrain, thereby promoting pollutant removal.

Conservation landscaping: The placement of vegetation in and around stormwater management BMPs. Its purpose is to help stabilize disturbed areas, enhance the pollutant removal capabilities of a stormwater BMP, and improve the overall aesthetics of a stormwater BMP.

Critical area planting: 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.

Detention pond/basin: Detention ponds maintain a permanent pool of water in addition to temporarily detaining stormwater. The permanent pool of water enhances the removal of many pollutants. These ponds fill with stormwater and release most of it over a period of a few days, slowly returning to its normal depth of water.

Diversions: Establishing a channel with a supporting ridge on the lower side constructed along the general land slope which improves water quality by directing nutrient and sediment laden water to sites where it can be used or disposed of safely.

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.

Green rooftops: A thin layer of vegetation that is installed on top of a conventional flat or slightly sloping roof. It can consist of a light weight vegetated system, or an elaborate rooftop landscape or garden. Internal drainage layers serve to moderate the rate of runoff while allowing for water and nutrient uptake by vegetated materials. Green rooftops can often be engineered to conform to existing load requirements of most roofs—therefore enabling the retrofit of existing buildings.

Hydrodynamic solids separator: A manufactured BMP system which is specifically designed and sized by the manufacturer to intercept stormwater runoff and prevent the transfer of pollutants downstream. They are used solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible.

Infiltration Basin: A vegetated open impoundment where incoming stormwater runoff is stored until it gradually infiltrates into the soil strata. While flooding and channel erosion control may be achieved within an infiltration basin, they are primarily used for water quality enhancement.

Infiltration Trench: A shallow, excavated trench backfilled with a coarse stone aggregate to create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into the surrounding soils from the bottom and sides of the trench. The trench can be either an open surface trench or an underground facility.

Level spreader: A device used to disperse concentrated runoff uniformly over the ground surface as sheet flow.

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 access crossing facility: Providing a controlled crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment.

Porous pavement: An alternative to conventional pavement, it is made from asphalt (in which fine filler fractions are missing) or modular or poured-in concrete pavements. Its use allows rainfall to percolate through it to the subbase, providing storage and enhancing soil infiltration that can be used to reduce runoff and combined sewer overflows. The water stored in the subbase then gradually infiltrates the subsoil.

Rain garden: Rain gardens are landscaped gardens of trees, shrubs, and plants located in commercial or residential areas in order to treat stormwater runoff through temporary collection of the water before infiltration. They are slightly depressed areas into which stormwater runoff is channeled by pipes, curb openings, or gravity.

Range and pasture management: Systems of practices to protect the vegetative cover on improved pasture and native rangelands. It includes practices such as seeding or reseeding, brush management (mechanical, chemical, physical, or biological), proper stocking rates and proper grazing use, and deferred rotational systems.

Retention basin: A stormwater facility that includes a permanent pool of water and, therefore, is normally wet even during non-rainfall periods. Inflows from stormwater runoff may be temporarily stored above this permanent pool.

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.

Stream channel restoration: The process of converting an unstable, altered, or degraded stream corridor, including adjacent riparian zone (buffers) and flood-prone areas, to its natural stable condition considering recent and future watershed conditions.

Street sweeping: The practice of passing over an impervious surface, usually a street or a parking lot, with a vacuum or a rotating brush for the purpose of collecting and disposing of accumulated debris, litter, sand, and sediments. In areas with defined wet and dry seasons, sweeping prior to the wet season is likely to be beneficial; following snowmelt and heavy leaf fall are also opportune times.

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.

Wetland development/enhancement: The construction of a wetland for the treatment of animal waste runoff or stormwater runoff. Wetlands improve water quality by removing nutrients from animal waste or sediments and nutrients from stormwater runoff.

Appendix B. Documentation for Stroubles Creek BMP Modeling

Basis for BMP Extents

- Riparian forest buffer: delineated stream reaches where forest buffers would be applied, multiplied by a 35 foot buffer on each side of the channel (acres).
- Livestock exclusion: delineated stream reaches where fencing would be needed, doubling the length where fencing would be needed on both sides of the stream (lin.ft.).
- Constructed wetlands: when an area is identified,delineate area from maps, then ground-truth (acres).
- Vegetative buffer: delineate length of stream or waterbody multiplied by a 35 foot buffer on each stream side or around the waterbody (acres).
- Limited access crossing: estimated as the maximum of a 60-100 linear feet range provided by Chris Barbour (lin.ft.).
- Stream channel restoration: delineated as a stream reach length (lin.ft.). In addition to the stream length originally defined by the Focus Groups, additional stream lengths in sub-watersheds 2 and 8 were added to meet the channel reduction target.
- Loafing lot management: estimated as the lot area (acres).
- Diversion: estimated as the length of pasture area adjacent to the stream (lin.ft.).
- Infiltration practices: estimated as the square footage of the drainage area (sq.ft.); alternatively multiplied by 1" of runoff and converted to volume of storage needed (cu.ft.). In addition to areas currently under planning by VT and BSE, 2% of the "Medium Density Residential" land use categories were estimated as needing this practice to meet the urban/MS4 reduction target.
- Sanitary sewer upgrades: not evaluated
- Street sweeping: for Interim load calculations, the extent was estimated as the area of the "Impervious High Density Commercial" land use category in watershed 4 through 8. For improvements during implementation, the number of curb miles was estimated using the length of major Blacksburg roads within the watershed from GIS data and doubled to account for curbs on both sides of the road (curb mi.).
- Hydrodynamic separator: estimated as the number of systems (systems).
- Increased E&S inspections: estimated as the area of the transitional land use category (acres).
- Level spreader: estimated as a length parallel to the stream along which stormwater runoff could be distributed to prevent concentrated flow (lin.ft.).
- Bioretention area: estimated as the actual area of the practice, similar to constructed wetlands (acres). In addition to areas currently under planning by VT and BSE, 2% of the "Medium Density Residential" land use categories were estimated as needing this practiceto meet the urban/MS4 reduction target.

Basis for Acres Benefitted (AB)

- Riparian forest buffer: delineated upstream areas within each subwatershed that contribute overland flow through the buffer to the stream length being buffered, excluding those areas that might drain to non-buffered tributaries (acres).
- Livestock exclusion: delineated pasture areas adjacent to fenced stream lengths (acres).
- Constructed wetlands: delineated upstream areas draining into the ponded area (acres).
- Vegetative buffer: same as for riparian forest buffer (acres).
- Livestock exclusion + limited access crossing + riparian forest buffer: the area benefited by this BMP system was the same as for riparian forest buffer (acres).
- Stream channel restoration: evaluated as percent of total length in each sub-watershed.

- Loafing lot management + diversion: same as extent for loafing lot mangement (acres).
- Infiltration practices: estimated as the drainage area (acres) for identified and planned BMPs, the remainder as 2% of the “Medium Density Residential” area in each sub-watershed.
- Sanitary sewer overflow: not evaluated
- Street sweeping: estimated as the curb length swept multiplied times 10 feet (half of the estimated impervious width of road) for an area of impervious area swept (acres). This area was then divided by the total impervious area in the commercial land use category (imp_comm) to obtain an estimate of fraction of area swept. Improvements in street sweeping was estimated as changing from sweeping 4 times a year to monthly, but was estimated that each sweep would account for a 33% smaller amount each time to account for less buildup in-between sweeps.
- Hydrodynamic separator: estimated as the upstream impervious drainage area (acres).
- Increased E&S inspections: same as extent (acres).
- Level spreader: upstream area contributing to the storm sewer flow (acres).
- Bioretention area: upstream area draining into each identified and planned BMP (acres), the remainder as 2% of the “Medium Density Residential” area in each sub-watershed.

Basis for BMP Efficiency Coefficients

Implementation BMP	**Efficiency Coefficients**			
	N	**P**	**Sed**	**Source**
Riparian forest buffer	0.57	0.70	0.70	1
Livestock exclusion	0.75	0.75	0.75	1
Constructed wetlands	0.45	0.50	0.50	2
Vegetative buffer	0.43	0.53	0.53	1
Livestock exclusion + alternative water system + Riparian forest buffer	0.89	0.93	0.93	1
Stream channel restoration	0.90	0.90	0.90	5
Loafing lot management + diversion	1.00	1.00	0.00	2
Infiltration practices	0.50	0.70	0.90	2
Level spreader	0.30	0.30	0.60	3
Bioretention areas	0.43	0.81	0.75	3
Sanitary sewer overflow prevention	1.00	1.00	1.00	
Street sweeping	0.58	0.28	0.79	4
Hydrodynamic separator	0.65	0.32	0.75	6
Increased E&S inspections	0.33	0.50	0.50	2

1 - DCR 2002NPS Watershed Assessment
2 - CBP Phase 4.3
3 - MdDER, Prince Georges County, BMPmodel
4 - Montgomery Co, MD. DEP, February 2002
5 - Based on local estimates of stream channel erosion
6 - NJ DEP and Rinker testing summaries

Basis for BMP Costs

- Riparian forest buffer: $547/acre cited by DCR (2003). This was also an intermediate estimate of $87/acre for softwood species and $825/acre using hardwood species (personal communication with Chris Barbour, Skyline SWCD).
- Livestock exclusion: $2.41/lin.ft. cost based on woven wire fence (personal communication with Chris Barbour).
- Constructed wetlands: $859/acre cost from DCR IP Guidance Manual (DCR, 2003). EPA cites a range of costs on a per cubic foot basis ($0.60 - $1.25/cu.ft.).

- Vegetative buffer: $99/acre cost from DCR IP Guidance Manual (DCR, 2003).
- Limited access crossing: $22/lin.ft. cost basis (personal communication with Chris Barbour).
- Stream channel restoration: $155/lin.ft. cost based on estimates from NC experience as follows (NCEEP, 2006):

  Current average stream fee: $205/lin. ft.

  Rural streams (2002): $94.40 - $146.85 (avg.= $111.78)
  Rural streams (2004): $80.16 - $234.39 (avg.= $133.00)

  Urban streams (2002): $130.96 - $232.11 (avg.= $135.00) n=16
  Urban streams (2004): $106.01 - $315.14 (avg.= $160.00) n=40

  Assuming rural stream conditions projected into 2006: $154.22
  Rounded upward: $155.00

- Loafing lot management: To Be Determined.
- Infiltration practices: $17.50/cu.ft. cost provided by David Dent, VT S&I. A value of $6.89/cu.ft. was used in the WQIF grant application (T. Wynn et al., 2005). EPA cites a value of $4.00/cu.ft. (EPA, 1999), which was used for the additional 2% of the Medium Density Residential areas.
- Sanitary sewer upgrades: $550,000, estimate from David Dent, VT S&I.
- Street sweeping: $218/curb mi / yr based on use of a vacuum-assisted sweeper run monthly (EPA, 1999).
- Hydrodynamic separator: $50,000/system cost provided by David Dent, VT S&I.
- Increase E&S program efficiency: $50,000/inspector cost estimate.
- Level spreader: TBD
- Bioretention areas: $6.89/cu.ft. used in WQIF grant application (T. Wynn et al., 2005). EPA cites a value of $5.30/cu.ft. (EPA, 1999), which was used for the additional 2% of the Medium Density Residential areas..

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