REDUCING SEDIMENT IN STROUBLES CREEK, BLACKSBURG, VA

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Abstract

Upstream urbanization, stream channelization, and livestock access have resulted in significant sediment loading to Stroubles Creek, resulting in a benthic macroinvertebrate community impairment. Developed in 2006, the Stroubles Creek TMDL Implementation Plan identified the need for additional agricultural, stream channel, and stormwater management best management practices (BMPs) to address the aquatic life impairment in Stroubles Creek. Numerous groups have installed BMPs throughout the watershed over the years; however, sediment is still a major issue. We assembled the Stroubles Creek Improvement Partnership (SCIP) to continue reducing sediment loading to Stroubles Creek, which includes the Virginia Tech (VT) Biological Systems Engineering department (BSE), VT Office of Site & Infrastructure Development (SID), the Town of Blacksburg, and the Stroubles Creek Restoration Initiative (SCRI). We implemented the following BMPs as part of Virginia Department of Environmental Quality (VADEQ) grant #15946:

- Agricultural: One stream exclusion fencing with grazing land management, which included 1200 feet of fencing, one livestock watering system, and 4.5-ac of riparian buffer plantings (485 hardwood trees and shrubs);
- Stream Channel: Two riparian buffer plantings; one with 65 container trees and shrubs planted along Holtan Branch in an apartment complex, and one 900 feet long with 440 hardwood trees within a 3-ac riparian zone; and
- Stormwater Management: Three bioretention cells treating runoff from two roofs and one parking lot at an apartment complex.

We developed education and outreach programming that included a InfoGraphic about Stroubles Creek for the general public, a high school science module about Stroubles Creek and the importance of stream in general, an online self-guided tour of stormwater management and other important features within the Stroubles Creek watershed, and a SCIP website. Additionally, we created educational signage for the installed BMPs and worked with several student groups to add sections of Stroubles Creek to the VDCR Adopt-A-Stream program.

Acknowledgements

The SCIP members involved in the project included:

- **VT-BSE:** W. Cully Hession (Professor), Erin Ling (Water Quality Extension Associate), Brian Benham (Professor), Durelle Scott (Assoc. Professor), Gene Yagow (Sr. Research Scientist), Teneil Sivells (MEng Student), and many more graduate and undergraduate student volunteers.
- **VT-SID:** Chuck Dietz (Stormwater Compliance Manager), Lauren Keim (Water Resources Engineer), and Katelyn Kast.
- **Town of Blacksburg:** Kafi Howard (Town Engineer).
- **SCRI:** Tom Saxton, Maria Saxton, and many student volunteers.
- **Foxridge Apartments (HHHunt Corp.):** Terry Poff (Operations Manager), Donna Gresh (Regional Property Manager), and Josh Sharitz (Hethwood Foundation Director).
- **Blacksburg High School Science Teachers**: Teresa Grisso, Shannon St. Germain, and Adam Rotche.

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Introduction to Stroubles Creek

Project Need

The Virginia DEQ list Stroubles Creek (Fig. 1) in the 1998-303(d) list for a benthic impairment along a 4.98-mile segment (VAW-N22R_STE04A00) between the VT Duck Pond and the downstream confluence with Wall Branch. A 2003 TMDL study identified sediment as the primary stressor. Additional, lesser stressors included organic matter and nutrients (VADEQ & VADCR, 2003). The TMDL cited construction and streambank erosion as major sources of sediment within the watershed. USEPA approved the Stroubles Creek Benthic Impairment TMDL in January 2004 and the Stroubles Creek Implementation Plan (VADEQ & VADCR, 2006) was completed in 2006. Stroubles Creek was also listed on the 2002 303(d) list for violations of the bacteria standard, but a bacterial TMDL has yet to be developed. Stroubles Creek is a tributary to the New River (VAW-N22R, HUC 05050001), an American Heritage River. Improved land use management within the New River Watershed is crucial for the protection and preservation of this important national resource.

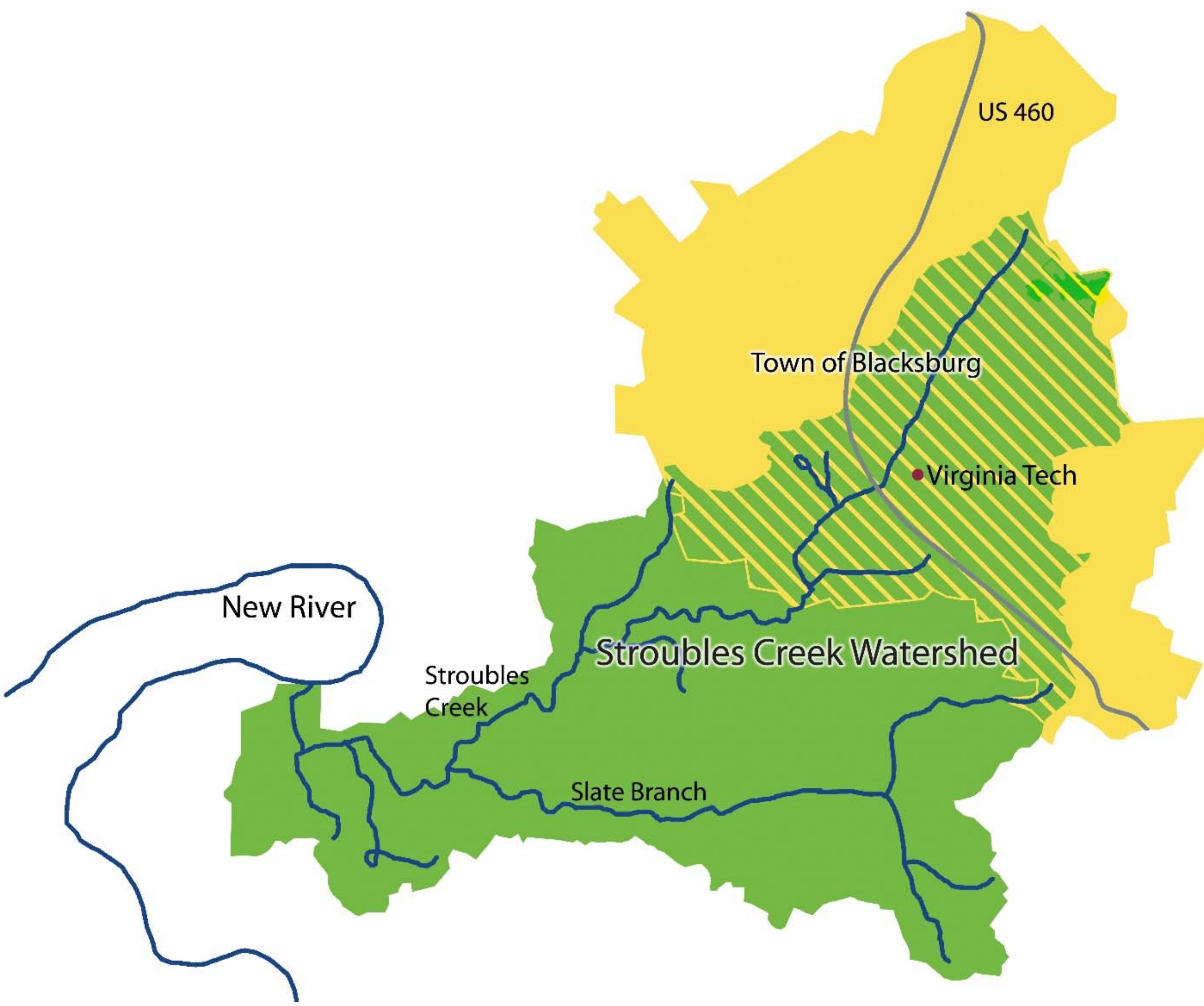

Figure 1. Stroubles Creek Watershed showing area of Town of Blacksburg and Virginia Tech.

Introduction to Stroubles Creek and the Project

Stroubles Creek is nearly 12-mi long with a total drainage area of more than 22 mi^2. The creek begins its journey in the town of Blacksburg, Virginia, flows through the Virginia Tech campus to the New River, the Kanawha River, the Ohio River, the Mississippi River, and then finally, the Gulf of Mexico. The impaired segment of the creek drains the 6,119-ac upper Stroubles Creek watershed in Montgomery County and includes major portions of the Town of Blacksburg and the Virginia Tech (VT) campus. The two named tributaries (Webb Branch and Central Branch) flow into the Duck Pond on the VT campus, with the main Stroubles Creek channel beginning at the pond outfall.

Starting with the Tutelo/Monacan people and continuing with European settlers in the 1740s, the area has been inhabited by humans for almost 400 years due to the many springs that create the headwaters of Stroubles Creek. In fact, the town of Blacksburg was originally planned as "Sixteen Squares" (or blocks) based on the location of the springs, ensuring access to drinking water. Until the early 1900s, the stream was used as the drinking water supply for Blacksburg, with no system of sanitary sewers. The combination of drinking water from a spring-fed stream with nearby privies, cesspools, and outhouses resulted in an outbreak of typhoid fever in 1911 when the Virginia State Commissioner of Health recommended a centralized water supply and sewage system for the town and Virginia Tech (Williams, 1911).

The main land use in the Stroubles Creek watershed is urban/residential comprising 46% of the total area. Forest, pasture, and cropland account for the remaining 28%, 21%, and 5% of the watershed area, respectively. Extensive streambank erosion was prevalent in the downstream sections of Stroubles Creek resulting from increased flows due to urbanization in the headwaters, stream channelization, and unrestricted cattle access on the former Heth Farm. However, since the completion of the implementation plan, there was much activity in the Stroubles Creek watershed before the initiation of this project:

1) the Town of Blacksburg has installed numerous retrofit low impact development (LID) BMPs;
2) the VT SID has implemented numerous innovative urban stormwater BMPs (bioretention cells, pervious pavement, and green roofs) for both existing and new development; and
3) BSE has led the restoration of 1.3 miles of Stroubles Creek and Docs Branch (a previously unnamed tributary at the Heth Farm (DCR-WQIF #2007-WQIF-42), as well as installation of two urban stormwater BMPs at a highly visible site on town property (DCR-WQIF #WQIA-2006-42).

We implemented the following BMPs as part of Virginia Department of Environmental Quality (VADEQ) grant #15946: 1) One stream exclusion fencing with grazing land management, which included 1200 feet of fencing, one livestock watering system, and 4.5-ac of riparian buffer plantings (485 hardwood trees and shrubs); 2) Two riparian buffer plantings; one with 65 container trees and shrubs planted along Holtan Branch in an apartment complex, and one 900 feet long with 440 hardwood trees within a 3-ac riparian zone; and 3) Three bioretention cells treating runoff from two roofs and one parking lot at an apartment complex. We also developed education and outreach programming that included a InfoGraphic about Stroubles Creek for the general public, a high school science module about Stroubles Creek and the importance of stream in general, an online self-guided tour of stormwater management and other important features within the Stroubles Creek watershed, and a SCIP website. Additionally, we created educational signage for the installed BMPs and worked with several student groups to add sections of Stroubles Creek to the VDCR Adopt-A-Stream program.

BMP Implementation

Agricultural

Our sole agricultural BMP was a Stream Exclusion with Grazing Land Management practice at the VT Beef Farm (Fig. 2). The pasture is adjacent to Stroubles Creek and includes Holtan Branch, a previously unnamed tributary to the creek. While the main stem of Stroubles Creek was fenced off in 1995, cattle were still directly affecting approximately 1,300 feet of Holtan Branch. We fenced one side of this stream (left bank looking downstream), connecting to existing fencing on the upstream and right bank (Fig. 3). The fence length is approximately 1,200 feet and resulted in nearly 4.5 acres of protected riparian area that we planted in a mix of hardwood and wetland plants (Fig. 4 and Fig. 5). We also extended existing water lines and added a new watering system to serve this large pasture area (Fig. 6).

Figure 2. Stream exclusion with watering system and riparian buffer (~4.5 ac) at the Virginia Tech Beef Farm along Holtan Branch.

Figure 3. Livestock exclusion fencing along Holtan Branch looking downstream.

Figure 4. Conservation Services, Inc. planting hardwood trees and shrubs along Holtan Branch (April 2016).

Figure 5. Volunteers from the Stroubles Creek Restoration Initiative (SCRI) planting at downstream end of Holtan Creek just above confluence with Stroubles Creek.

Figure 6. New watering system in pasture at the Virginia Tech Beef Farm.

Stream Channel/Riparian Buffers

We installed two riparian forest buffers along Stroubles Creek and its tributaries. The first was a 900-ft section along Stroubles Creek included planting of 440 hardwood trees to create 3-acre riparian forest buffer at the downstream end of the VT Stream Lab (Fig. 7). These native hardwood seedlings were planted with oak stakes, tree shelters, bird nests, and shade cloth were installed by Conservation Services, Inc.

Figure 7. Riparian forest buffer planted near downstream end of the VT StREAM Lab.

We installed the second riparian forest buffer using volunteer labor along a 300-foot section of Holtan Branch just above the Foxridge Apartment's pond, creating a 0.35 ac riparian buffer. Here we planted 65 container trees and shrubs purchased from New Leaf Farms, Inc. in Bedford, VA. We completed planting of this riparian buffer during March of 2017, continue to water, and maintain the plantings as of this report writing. Selection of plants and a planting plan (Fig. 8) were coordinated with the Stroubles Creek Restoration Initiative, Foxridge Apartments, and the Hethwood Foundation.

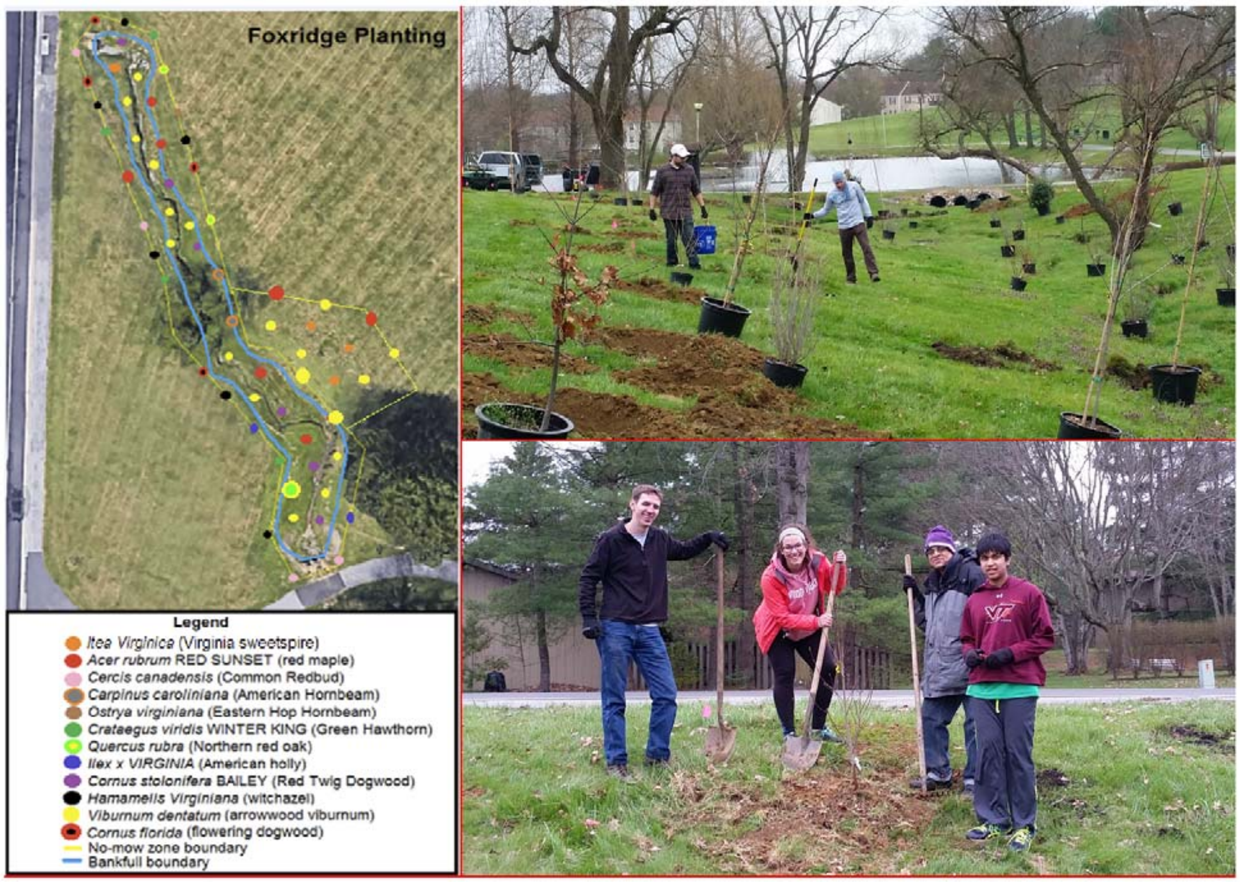

Figure 8. Planting riparian buffer just upstream of Foxridge Apartments pond along Holtan Branch, a tributary to Stroubles Creek. Planting plan shown on left and volunteers shown planting containerized native trees/shrubs on right.

Stormwater Management

We installed three bioretention cells within the Foxridge Apartment complex to treat runoff from several roofs and one parking lot (Fig. 9). These were all designed as part of VT Biological Systems Engineering (BSE) department senior design projects and were installed by volunteers, BSE staff and students, and Foxridge Apartment/HHHunt Corporation personnel in 2015. The two smaller bioretention cells were installed to treat about a tenth of an acre of impervious rooftop each and are four feet deep with an area of 120 ft^2 (Fig. 10). The larger bioretention treats nearly 0.5 acre of impervious roof and parking lot, is 5-6 feet deep, and has an area of 1,050 ft^2 (Fig. 11).

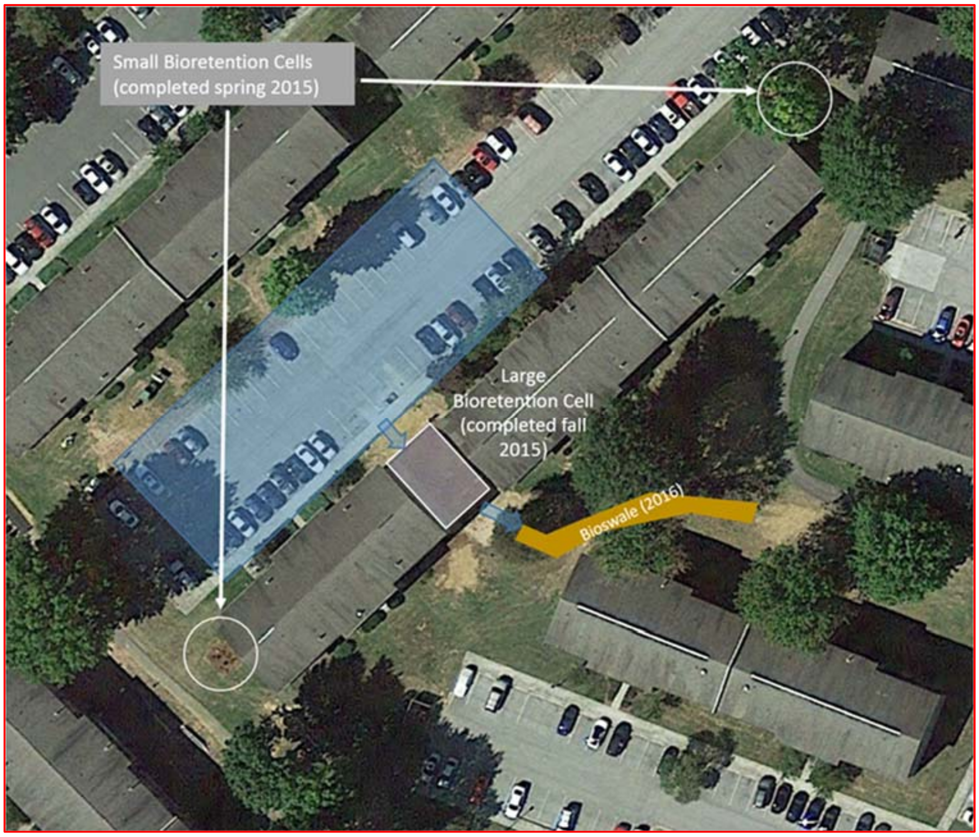

Figure 9. Section of Foxridge Apartment complex showing the locations of three bioretention cells.

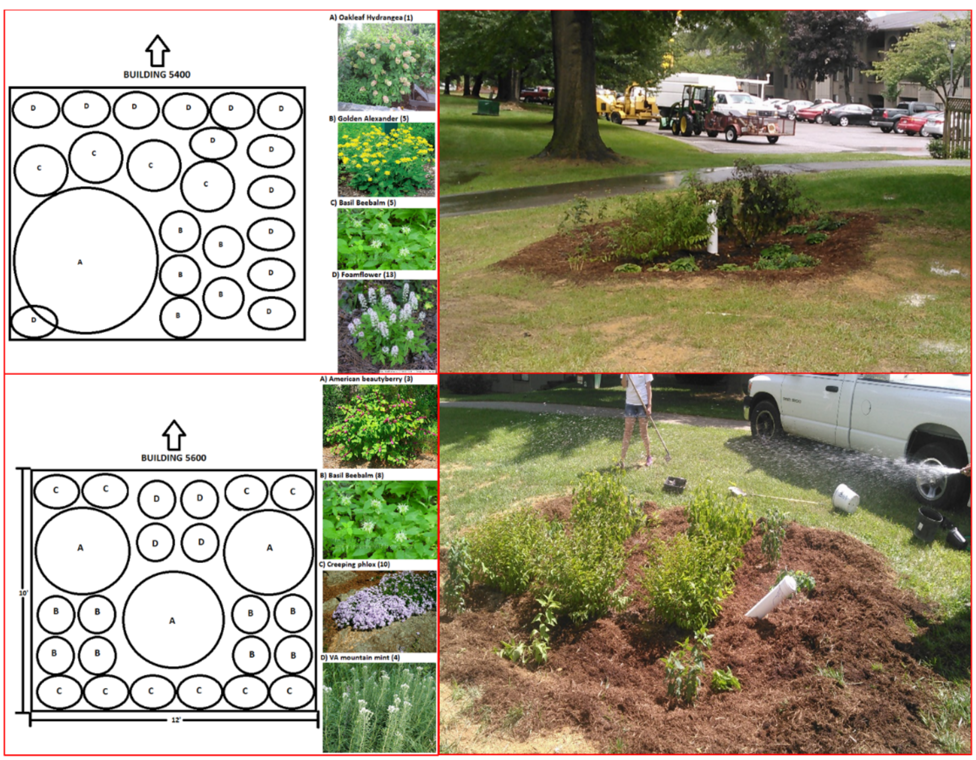

Figure 10. Two small bioretention cells installed at Foxridge Apartments to treat roof runoff.

Figure 11. Installation of large bioretention cell at Foxridge Apartments in 2015. Images show before, during and after construction.

Due to some problems with clogging, we modified the upstream and downstream ends of the bioretention cell in 2016 (Fig. 12). We also extended the outlet to a storm drain at the bottom of the hill via underground pipe at the request of Foxridge Apartments. We excavated the upper and lower sections of bioretention cell and replaced fill with riprap so the inlet pipes from parking lot and roof downspouts could flow freely into the cell (Fig. 13). This more porous material also provide for more storage of water within the cell during storm events.

Initially we planned to install a grasses swale to guide water from the outlet of the bioretention cell down the hill toward a stormwater inlet. However, due to some flooding issues around an apartment down the hill (not entirely due to our bioretention cell outlet, but also do to overall drainage issues of the site), Foxridge Apartments asked us to bury our outlet pipe the entire distance (approximately 200 feet). This required hand digging for much of the distance due buried utilities, installation of flexible drainpipe, installation of PVC pipe, and, finally, backfilling with gravel to provide for drainage of surrounding surface water to the storm drain.

The final retrofitted bioretention cell is shown in Fig. 14. We have purchased topsoil to spread around the cell to allow for planting of grass during the spring of 2017.

Figure 12. Excavation of bioretention cell and installation of riprap improve flow into BMP.

Figure 13. Retrofit of bioretention cell outlet using buried pipe and gravel.

Figure 14. Final retrofitted bioretention cell. We will incorporate topsoil and grass during the spring of 1017.

Education and Outreach

Our target audience for education and outreach included all citizens that live and/or work in the Stroubles Creek watershed, as well as students at Virginia Tech. Our overall goal was 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" as stated in the original implementation plan (VADEQ & VADCR, 2006). In 2012, one of our NSF-REU teams conducted a survey in the Stroubles Creek watershed and found that more than half those surveyed did not know the name of the creek that flows thru Blacksburg, and 75% did not know where their stormwater goes (https://sites.google.com/site/communitysurveystroubles/home/). To improve the water quality in Stroubles Creek, we must make all Stroubles Creek stakeholders aware how they influence the creek with their day-to-day activities. To increase awareness about Stroubles Creek, we completed the following activities.

Fact Sheet/InfoGraphic

We developed a Stroubles Creek factsheet for online (http://bit.ly/2oYpUb2) and as handouts (Appendix A) targeted to community members and schoolchildren in Blacksburg, VA. The Stroubles Creek factsheet will complement our existing educational/outreach resources and we have made 500 hardcopies of the brochure to share with science teachers and to distribute at various educational events. For example, Dr. Hession presented an update about the Stroubles Creek Improvement Partnership activities at the Blacksburg Library "Beyond Earth Day" event on April 24, 2017. This fact sheet will also be used by high school science teachers as part of the teaching module developed as part of our grant (see below for more information).

Online Tour of Stroubles Creek and BMPs

We created an online map of the Stroubles Creek watershed that highlights the location of stormwater BMPs (http://arcg.is/2oXZfsK). We created this using the ESRI Story Map application that allows for integrated maps and photos/information about the BMPs (Fig. 15). In addition to BMPs, the story includes the headwater springs that initiate Stroubles Creek, several sections within town where the stream is actually above ground, as well as the location of frog statues installed as part of the Town of Blacksburg's Freshwater Heritage project (Fig. 16).

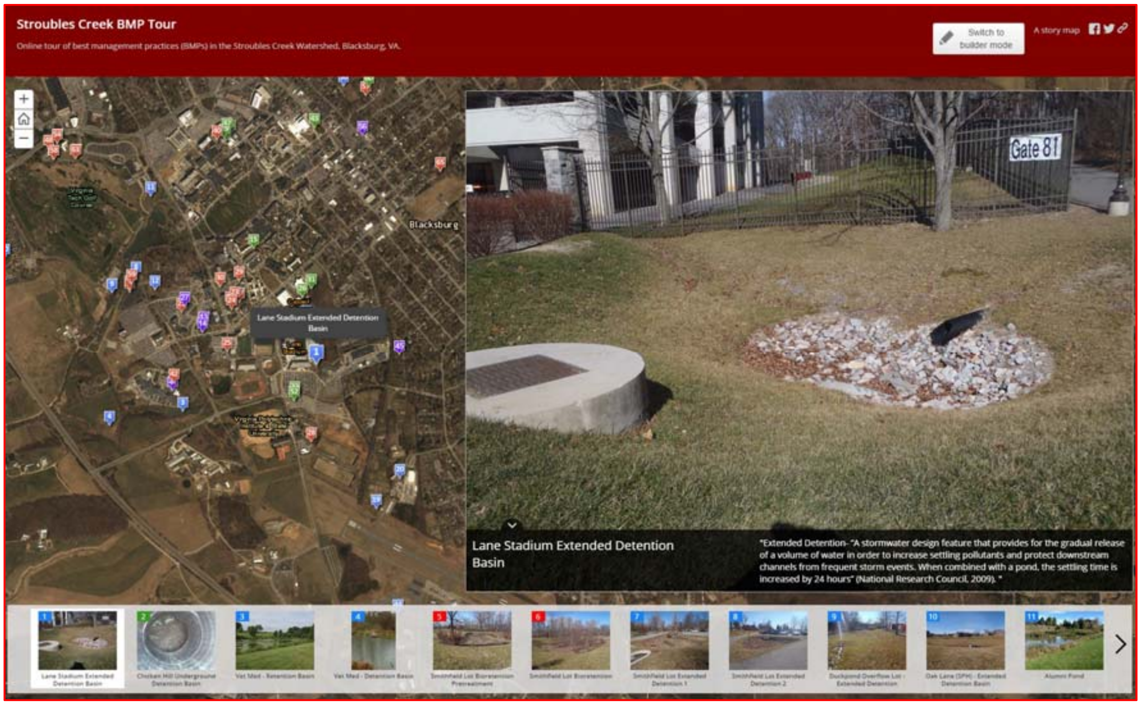

Figure 15. Screen capture of the online Stroubles Creek BMP Tour story map.

Figure 16. Frog statue installed at stormwater drain as part of Town of Blacksburg's Freshwater Heritage project.

Teaching Module

Dr. Hession and Erin Ling worked with Blacksburg High School science teachers (Teresa Grisso, Shannon St. Germain, and Adam Rotche) to create a 9th-grade teaching module about the Stroubles Creek Watershed (Appendix B). They will implement the module during the fall of 2017 for the first time. The module will utilize the InfoGraphic and online BMP Story Map (described above) and include hands-on activities.

The module fits within Standard of Learning ES.9. The students will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts included in the standard are: a) processes of soil development; b) development of karst topography; c) identification of groundwater zones including the water table, zone of saturation, and zone of aeration; d) identification of other sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle; e) dependence on freshwater resources and the effects of human usage on water quality; and f) identification of the major watershed systems in Virginia including the Chesapeake Bay and its tributaries.

SCIP Website

We created a website to share information about our project, as well as a place to share information created by our project. The website: http://stroubles.weebly.com/. The website provides information and links to more information about the partners, a summary of BMP projects installed as part of our grant, educational information about Stroubles Creek issues (including our InfoGraphic), and historical information concerning the important linkages between Stroubles Creek and the Town of Blacksburg and Virginia Tech.

Figure 17. SCIP website.

Educational Signage

We will install five interpretive signs at installed BMPs. These include two signs for the livestock exclusion, one for the Foxridge Apartment bioretention cells, one for the Foxridge riparian forest planting, and one general Stroubles Creek sign. We will not install a sign at the riparian buffer site at the StREAM Lab since it is not accessible to the public. The signs are still being developed with the help of TechExpress in TechExpress in Christiansburg, VA, but will be installed by the end of May 2017. The signs will be 2' by 3' and mounted similar to a previous sign installed as part of DCR-WQIF #2007-WQIF-42 (Fig. 18). We also helped pay for and install the SCRI student group signs that are located adjacent to the Holtan Creek livestock exclusion and riparian buffer plantings (Fig. 19). This is a series of seven signs that describe Stroubles Creek and the importance of riparian forests.

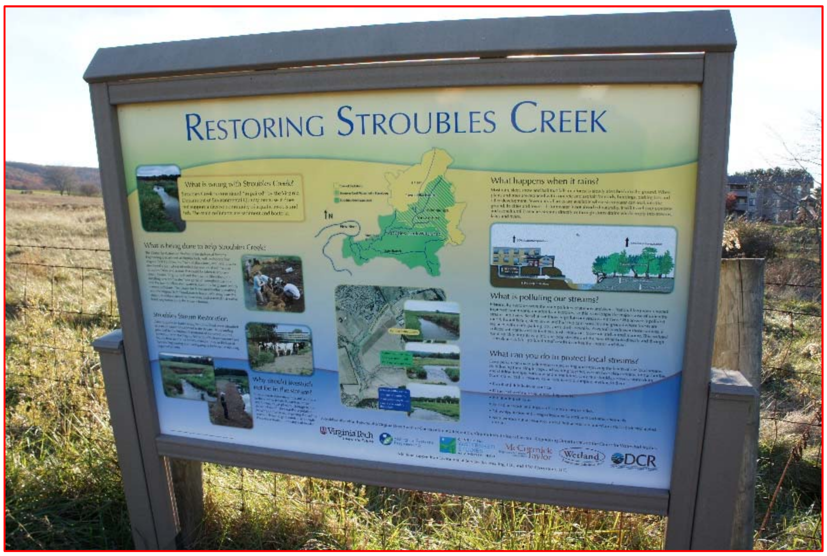

Figure 18. Previous sign installed as part of stream restoration project in 2010.

Figure 19. Maria Saxton (SCRI) installing sign along bike trail adjacent to Stroubles Creek. Beef Farm pasture in background where we installed fencing and watering system.

Other Education/Outreach Activities

We utilized the VADCR's Adopt-A-Stream program to increase the community's awareness of and promote the stewardship of Stroubles Creek. Through this program, two student groups adopted a section of Stroubles Creek from Foxridge Apartments bike trail down to Merrimack Road (Fig. 20). We submitted an application for the Stroubles Creek Restoration Initiative (SCRI) to adopt Holtan Branch (previously unnamed) that starts in the Foxridge Apartment complex where we installed a riparian buffer just above the pond, down to where the branch meets Stroubles Creek on the VT Beef Farm where we install livestock exclusion practice. Unfortunately, VADEQ has yet to respond to our application (http://www.dcr.virginia.gov/stormwater_management/adopt.shtml. The signs installed as part of Adopt-A-Stream will aid in making the public more aware of Stroubles Creek, where it is, and how intertwined it is with Blacksburg and VT. Numerous classes have toured our BMP installations during and after construction (Fig. 21). All three bioretention cells and the livestock exclusion project were designed as part of VT-BSE Senior Design projects.

Figure 20. Students for ASABE installing Adopt-A-Stream sign.

Figure 21. . Classes visiting the large bioretention cell at Foxridge Apartments and taking soil cores for analysis.

Water Quality Monitoring

Our monitoring activities focused on assessing the impact of livestock exclusion on flow, sediment, and nutrient loadings. We monitored the small stream (Holtan Branch) targeted for a livestock exclusion BMP, as well as a nearby tributary (Docs Branch) at the StREAM Lab that has not been impacted by cattle since 1995 (Fig. 22). We monitored both tributaries for one year prior to installing fencing at the livestock exclusion site, and one year post-fencing. We installed H-flumes on each tributary at locations with similar contributing watershed areas (Fig. 23). We measured stage continuously in the flumes using pressure transducers. We sampled each tributary monthly using grab samples (Fig. 24), and for nine storm events using our ISCO automatic samplers (Fig. 25).

We analyzed sample for the following nutrients and anions: total nitrogen (TN), total phosphorus (TP), nitrate (NO_3^-), ammonia (NH_4^+), dissolved phosphorus (P), and chloride (Cl^-). We measured precipitation at the StREAM Lab weather station, which is located equidistant from the two small watersheds (about 3,000 feet from the two H-flumes). Sample plan details are shown in Table 1 (detailed sample IDs and times for all monthly and storm samples are provided in Table C1, C2, and C3).

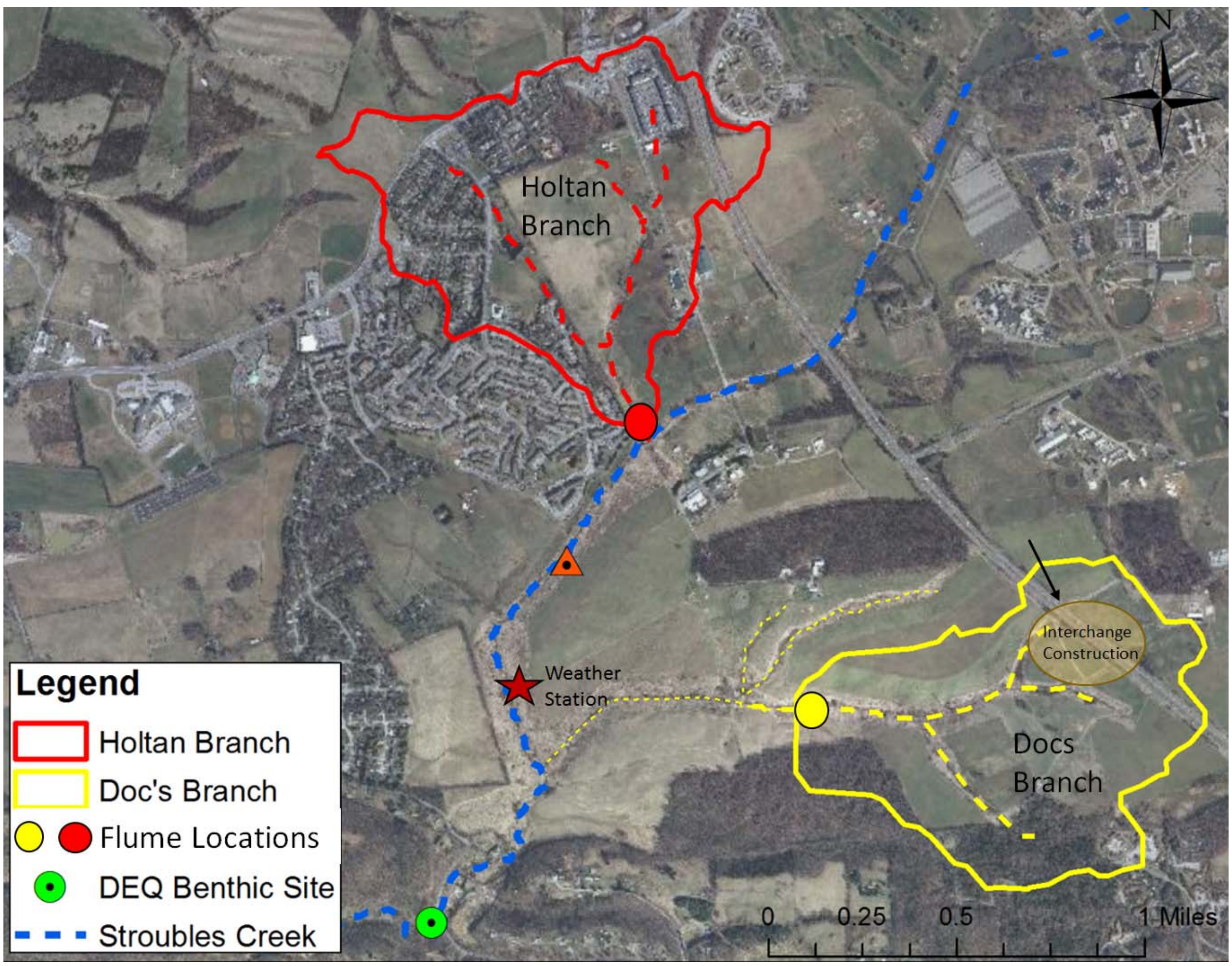

Figure 22. Location of two watersheds monitored before and after fencing of Holtan Creek. Note the StREAM Lab weather station and the area where construction was activity after in Docs Branch headwaters (our "control") starting approximately eight months into our study and continuing until the end.

The paired stream/watershed (Fig. 22) approach works under the assumption that the paired water quality remains the same over time (weather changes, etc.) except for the influence of BMP implementation. In general, the idea is to develop a relationship between the paired observations during a “calibration” period (in this case only one year). These relationships could be simple linear regressions between the paired observations of flow, sediment (concentration, load), and nutrient (concentration, load).

Figure 23. H-flume being installed at Docs Branch as part of class project. Before (left) and after (right).

Figure 24. Teneil Sivells taking grab sample at Holtan Branch.

Figure 25. ISCO Automatic Sampler used for sampling storm events. Hut constructed to house the sampler shown on right.

Table 1. Sampling design for monitoring program-highlighting number of samples. Note that we actually captured nine storm events.

Sampling Design			
Parameter		Sampling	Number of Samples
Physical	Precipitation	Continuous	--
	Stage	Continuous	--
	Flow Rate	Continuous	--
Chemical	Suspended Sediment Concentration	Monthly Storm	1 Sample/ Month x 2 Years = 24 4 Events/Year x 2 Years x 5 Samples/Event = 40
	Total Nitrogen	Monthly Storm	24 40
	Total Phosphorus	Monthly Storm	24 40
	Nitrate	Monthly Storm	24 40
	Ammonia	Monthly Storm	24 40
	Dissolved Phosphorus	Monthly Storm	24 40
	Conductivity	Monthly Storm	24 40

Actual dates of monthly samples and storm samples are shown in Fig. 26. Note that we obtained an additional storm sample and monthly grab sample during January 2017. Unfortunately, in June of 2015, construction began on a new interchange connecting Route 460 to Virginia Tech campus (Fig. 27). This construction is in the headwaters of Docs Branch and required filling in of wetlands. As you can see in Fig. 27, the erosion and sediment control for this construction activity has been abysmal. Therefore, our attempt to use Docs Branch as a control became nearly impossible.

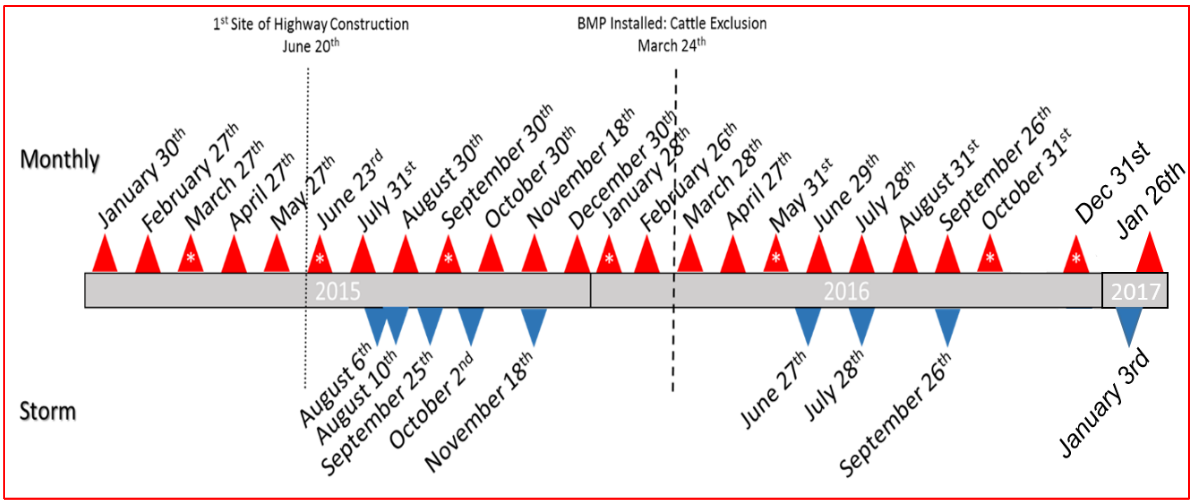

Figure 26. Timeline of sampling events, construction, and BMP installation. Note that we actually capture one more storm event on January 3, 2017 and a final monthly sample at the end of January 2017 (not shown on graphic).

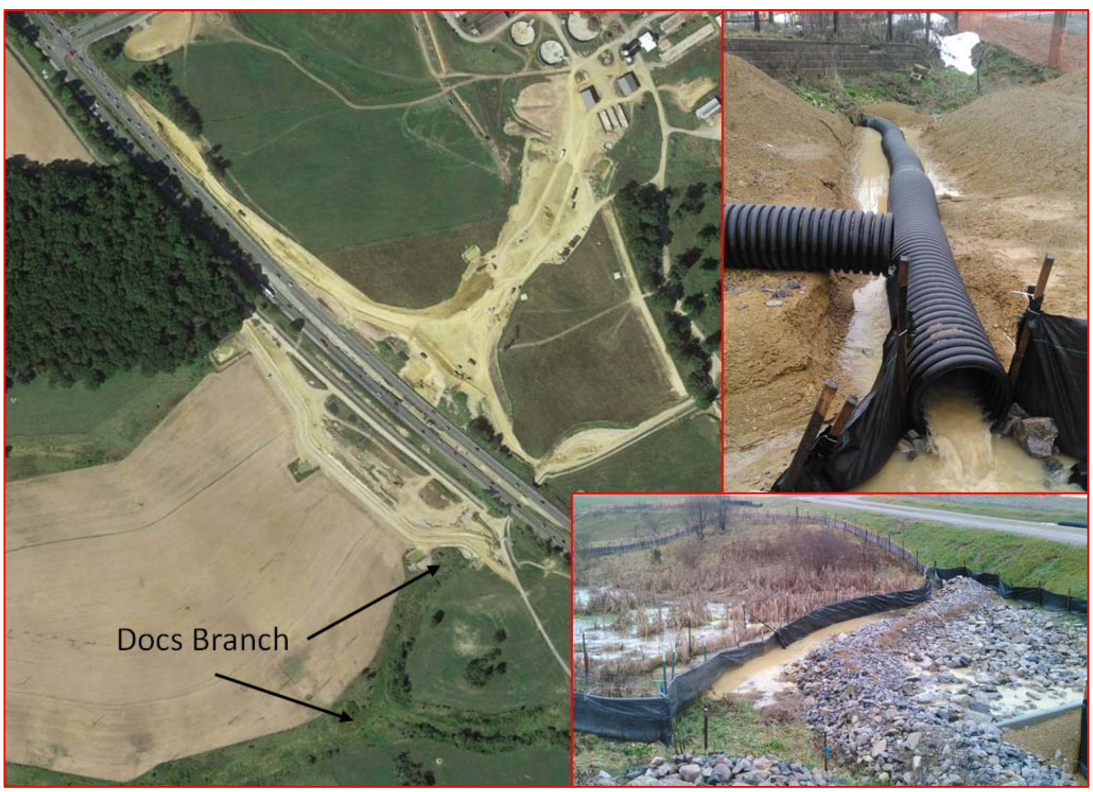

Figure 27. Construction in headwaters of Docs Branch showing impacted area and terrible E&S controls.

A comparison of continuous discharge hydrographs are shown in Fig. 28 for the first and second year. For each year, we have plotted Doc Branch and Holtan Branch together. While we realize the scale of these plots makes it difficult to compare, we have looked closely at these data and the main differences are due to locations and tracking of storms. Even though these two watersheds are close to each other, the track of storms has an immense impact on the flow in these small streams. There are no obvious differences between year 1 (pre BMP) and year 2 (post BMP), but additional analyses are in the works.

We compare TN concentrations for both years to compare Docs Branch (control) and Holtan Branch (livestock exclusion installed at end of Year 1) in Fig. 29. Based on these monthly grab samples, Holtan Branch always has a higher TN concentration than Docs Branch. There are no obvious changes after we installed livestock fencing, likely because much of the upper reaches of Holtan Branch still have high-density livestock in and around the stream (sheep and horses). Since these concentrations are based on monthly grab samples obtained during near base-flows, TN is really the only parameter we would expect to be different since SSC and TP are mostly influenced by storm flows.

In Fig. 30 we compare the range of TN concentrations across both years and within Year 1 and Year 2 separately. Again, in all cases, Holtan Branch has a higher mean concentration and there are no obvious changes before and after fencing.

In Fig. 31 we compare the range of TP concentrations across both years and within Year 1 and Year 2 separately. Again, in all cases, Holtan Branch has a higher mean concentration and there are no obvious changes before and after fencing.

We are finalizing analyses of the nine storm events captured. However, herein we do compare TN concentrations across all storm events in Fig. 32 and 33 representing before and after livestock fencing installation, respectively. Again, Holtan Branch TN concentrations are on average always higher than Docs Branch, even during storm events. In addition, there are no obvious differences between pre- and post-BMP installation.

Storm hydrographs, TP concentrations during storm events, SSC concentration from grab samples and storm events, and Bacteria results are not included in this report. They are being worked up as part of a Masters in Engineering (MEng) project report and have yet to be submitted. Once that report is completed, we will submit to VADEQ.

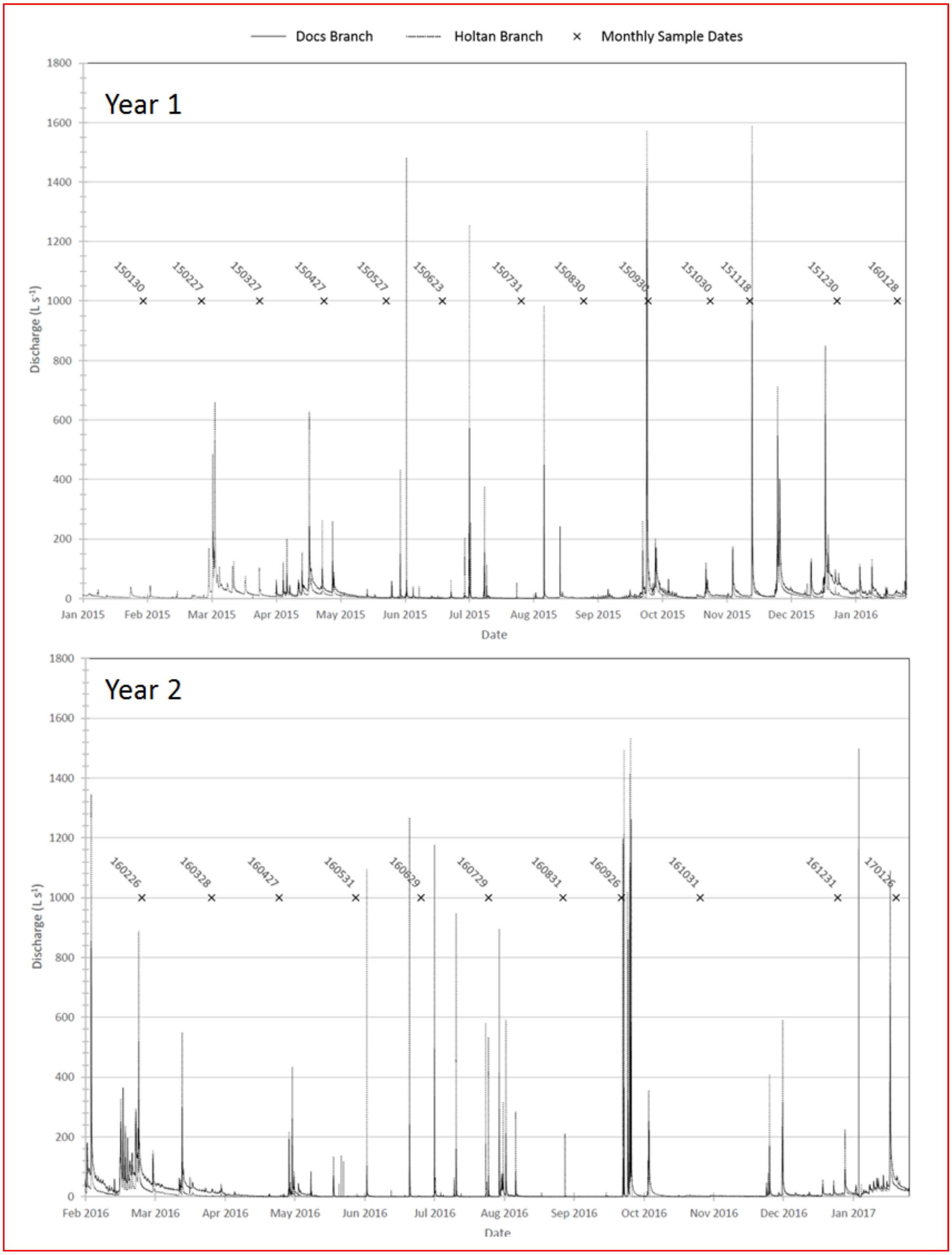

Figure 28. Discharge comparison between Docs and Holtan Branch. Year 1 is from January 1, 2015 to January 31, 2016 and represents pre-BMP installation period (top). Year 2 is from February 1, 2016 to January 31, 2017 and represents the post-BMP period (bottom).

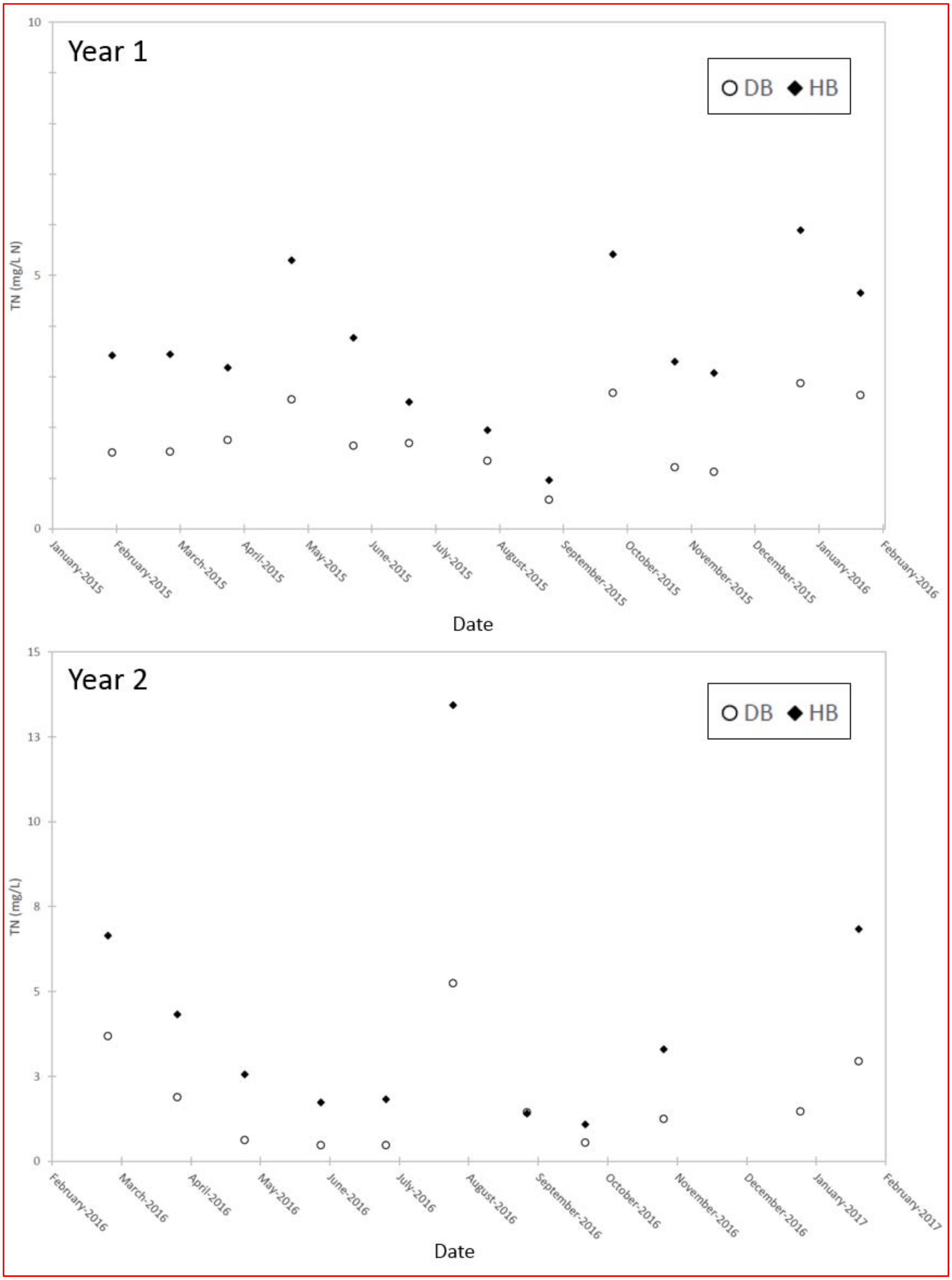

Figure 29. Comparison of Docs and Holtan Branch total nitrogen (TN) concentrations from monthly samples in Year 1 (top) and Year 2 (bottom).

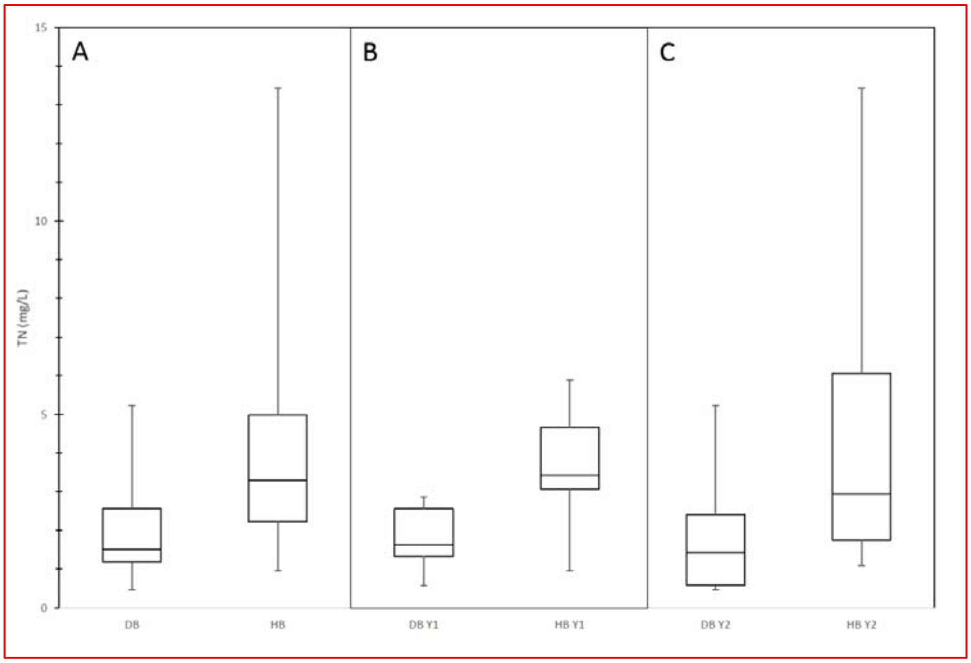

Figure 30. Percentile distribution comparison of TN concentrations from monthly grab samples at Docs Branch (DB) and Holtan Branch (HB). Middle line of box represents the median or 50th percentile, the top and bottom of box represent the 75th and 25th percentiles, respectively, and the whiskers represent to 95th and 5th percentiles. A) Comparison across the entire two years; B) comparison of Year 1 values only; and C) comparison of Year 2 values only.

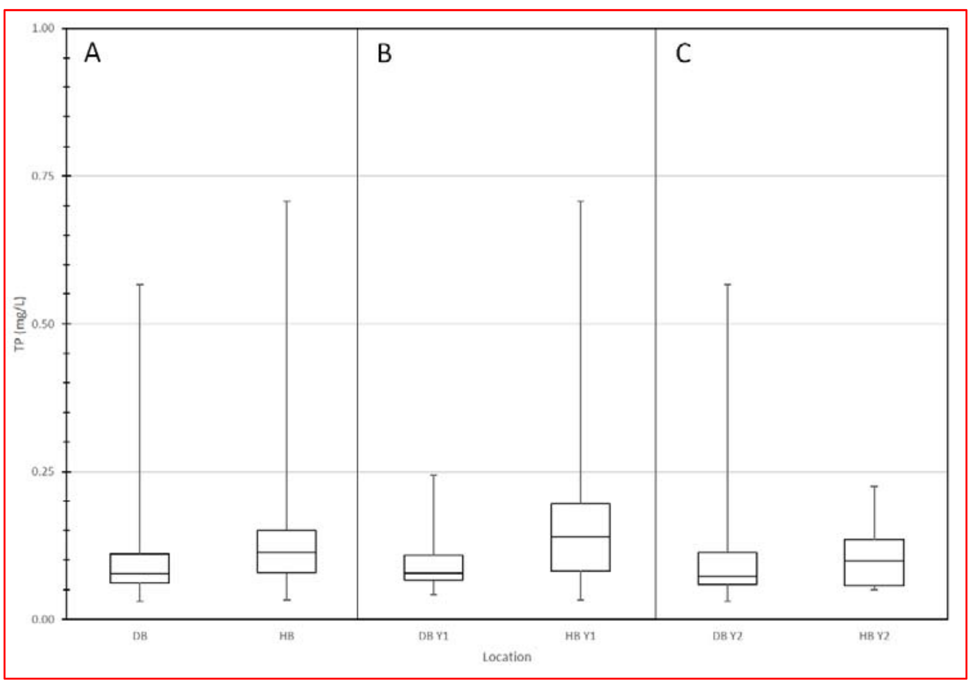

Figure 31. Percentile distribution comparison of TP concentrations from monthly grab samples at Docs Branch (DB) and Holtan Branch (HB).

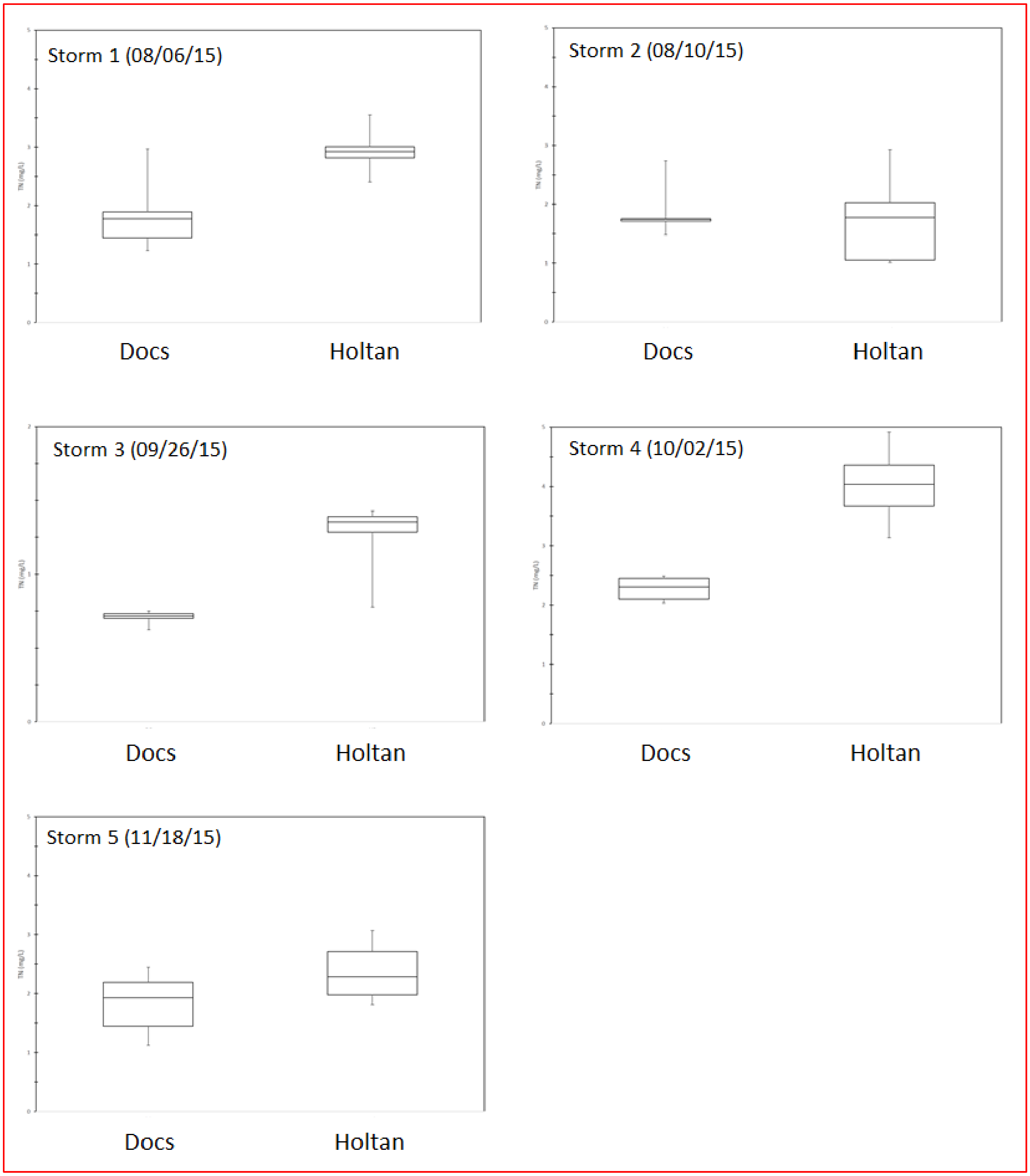

Figure 32. TN concentrations during storm events in Year 1, before livestock exclusion fencing installation on Holtan Branch.

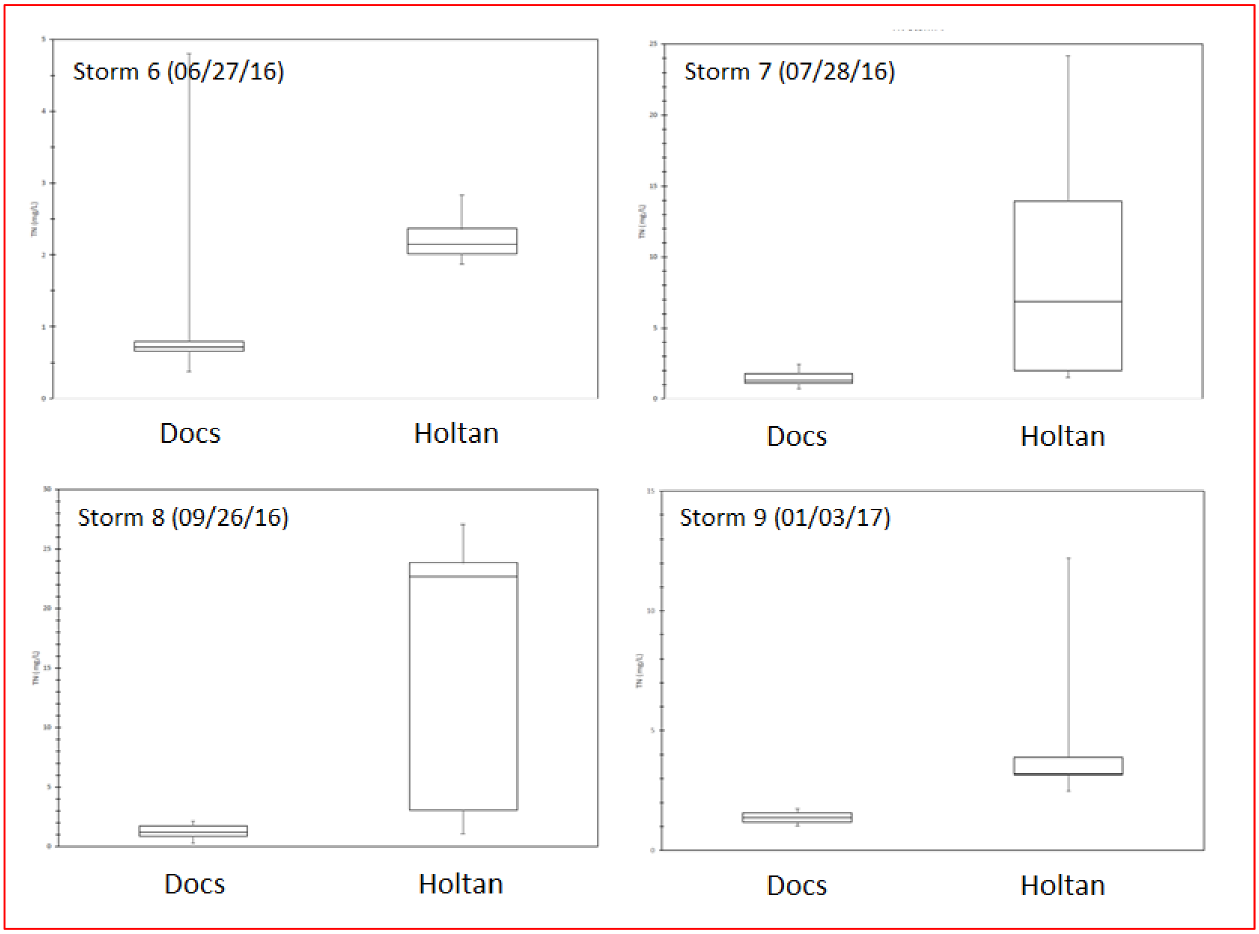

Figure 33. TN concentrations for storm events during Year 2 (after livestock fencing installation at Holtan Branch).

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Appendices

Appendix A – Stroubles Creek InfoGraphics

Appendix B – Stroubles Creek High School Science Module

Appendix C – Additional Monitoring Information

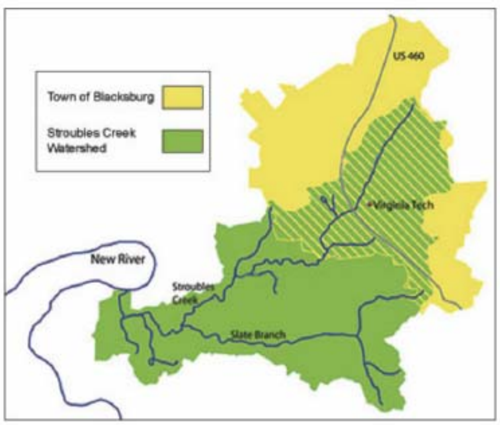
Appendix A – Stroubles Creek InfoGraphic (http://bit.ly/2oYpUb2)

Improving Stroubles Creek

Help us protect and restore Stroubles Creek in Blacksburg, VA

Biological Systems Engineering | Town of Blacksburg, a special place | DEQ Virginia Department of Environmental Quality | VirginiaTech Invent the Future

Stroubles Creek Watershed



Map of Stroubles Creek Watershed

Stroubles Creek is nearly 12 miles long with a drainage area of more than 22 square miles. The creek begins its journey in the town of Blacksburg, Virginia, flows through the Virginia Tech campus to the New River, the Kanawha River, the Ohio River, the Mississippi River, and the Gulf of Mexico.

Originally settled by the Tutelo/Monacan people, followed by European settlers in the 1740s, the area has been inhabited by humans for over 400 years because of the many springs that are the headwaters of Stroubles Creek. In fact, the town of Blacksburg was originally planned as "Sixteen Squares" (or blocks) based on the location of the springs, ensuring access to drinking water. Until the early 1900s, the stream was used as the drinking water supply for Blacksburg, with no system of sanitary sewers. Using the spring-fed stream for drinking water while surrounding it with privies, cesspools, and outhouses resulted in an outbreak of typhoid fever in 1911, prompting the Virginia commissioner of health to recommend a centralized water supply and sewage system for the town and Virginia Tech.

Where did the stream go?

Today most sections of Stroubles Creek that flow through Blacksburg and Virginia Tech are underground, so they are "out of sight, out of mind" for many local residents. The stream was buried near the War Memorial Gym and under Virginia Tech's Drillfield in about 1937 (right).

The Duck Pond

Those who live in Blacksburg or attend Virginia Tech recognize the Duck Pond as a prominent feature in our community (left). The pond is at the confluence of several spring-fed branches of Stroubles Creek.

The upper pond was constructed as an "ice pond" in the early 1880s, and the lower pond was constructed in the 1930s. While not designed for stormwater management, the pond does slow water down and remove sediments before moving downstream.

Why our local stream is impaired

Benthic Impairment

Upstream urbanization and construction in Blacksburg and Virginia Tech, stream channelization, and livestock stream access have resulted in significant sediment loading to Stroubles Creek. Sediments "impair" the small animals, such as insects, crustaceans, mollusks, and worms that inhabit the stream bottom. These benthic macroinvertebrates are important for stream ecosystems and the survival of larger animals, such as fish.

A Plan: Total Maximum Daily Load

Stroubles Creek is listed as "impaired" by Virginia due to excess sediment. Environmental scientists evaluated the condition of the stream and used a computer model to determine the amount of sediment that can enter the stream without harming water quality and stream ecology. This is called a Total Maximum Daily Load (TMDL). Most commonly, streams are considered impaired due to excess sediment, nutrients, or bacteria entering the water.

Best Management Practices

In 2006, a TMDL implementation plan identified the need for agricultural, stream channel, and stormwater best management practices (BMPs) to address the benthic impairment in Stroubles Creek. As part of a recent VA DEQ project, we have installed the following BMPs: three bioretention cells; a livestock exclusion fence and watering system; and establishment or improvement of 3,500 feet of riparian forest buffer (planted 1500 trees & shrubs).

Adult mayfly

Heavy sediment due to upstream construction activity

Cattle fenced away from stream

How local residents can learn more and help

Take the BMP tour. Get acquainted with Stroubles Creek and the watershed, and learn about the practices in place to improve water quality using this interactive map, then visit them in person! http://arcg.is/2fAPuwS

16 Frogs Project

Check out the 16 Frogs Freshwater Heritage Project, which seeks to highlight important points in the watershed and along the stream using lifesize bronze frog sculptures: https://www.facebook.com/16Frogs/

Stroubles Creek BMP Tour

Take Action!

- Fertilize lawns and gardens properly
- Pick up and dispose of pet waste
- Properly dispose of household chemicals and trash
- Plant native trees
- Minimize driving; walk or ride a bike
- Practice water conservation

MORE INFO:

Stroubles Creek Improvement Partnership: http://stroubles.weebly.com/

Stroubles Creek Restoration Initiative: https://www.facebook.com/savestroubles/

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Appendix B – Stroubles Creek High School Science Module

BHS 9th grade Earth science module (can be adapted for AP Environmental Science):

Addresses: Standard of Learning ES.9 - The student will investigate and understand how freshwater resources are influenced by geologic processes, and the activities of humans. Key concepts include:

a) processes of soil development;
b) development of karst topography;
c) identification of groundwater zones including the water table, zone of saturation, and zone of aeration;
d) identification of other sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle;
e) dependence on freshwater resources and the effects of human usage on water quality; and
f) identification of the major watershed systems in Virginia including the Chesapeake Bay and its tributaries.

What is a watershed?

- An area of land that drains to a stream, river or other surface water body

What are the major watersheds of Virginia?

In which watershed is Blacksburg High School located? What watershed is your home located in?

- Stroubles→New River →Kanawah River →Ohio River →Mississippi River→ Gulf of Mexico (is this surprising to you? How many students thought we were in the Chesapeake Bay watershed? Point out that a small part of Montgomery County is).
- Look at a map of Stroubles and the larger watershed

How are groundwater and surface water connected? Review the water cycle with regard to surface and groundwater (include infiltration, runoff). Is water a renewable resource? Why or why not?

What about in karst or limestone areas like the Valley and Ridge province?

Think of all the humans and agricultural activities that can affect a watershed. Get specific and local – what do you see when you drive or walk around our community? What are the some of the impacts that these activities can have on a stream or river? Point out that these are a somewhat unavoidable part of us living on the surface of the Earth: using and affecting our natural resources

- Use of fertilizers and manure for agriculture and lawns (nutrient contamination)
- Use of agricultural chemicals such as pesticides and herbicides
- Pet waste (bacteria and nutrient contamination)
- Excavating to build new structures (erosion; sediment contamination
- Paving areas for parking lots or new buildings (creation of impermeable surfaces, which inhibit groundwater infiltration and change the natural flow pathways of surface water; can also lead to increased temperature of water reaching the stream, and trash, fertilizer and other chemicals reaching the stream; note that water that flows into storm drains does NOT go to the water treatment plant to be filtered and treated, but directly to the nearest stream or river)
- Litter/trash
- Septic tanks that aren't functioning properly or sewer overflows (bacteria and nutrients)
- What else?
- Pictures for discussion here: http://stroubles.weebly.com/problems.html

How do each of these groups of contaminants affect the health of the stream and it's ecology?

- Nutrients
- Bacteria
- Sediment
- What about trash? Increased temperature? Other chemicals?

What types of best management practices (BMP's) or changes in behavior can help protect our local streams and rivers, and ultimately, improve downstream/downriver water quality too?

- Stroubles BMP tour: http://arcg.is/2fAPuwS
- Bioretention – stormwater is collected in a basin and filtered out with constructed layers of vegetation, sand, organic matter. Slows water down and allows it to be cleaned up before moving into the stream or groundwater
- Riparian buffers – various plants and grasses are planted along stream and river banks to slow down and filter water before it reaches the stream
- Livestock exclusion – fencing livestock out of the stream to prevent them from trampling banks and stream bottoms, and keep excess manure and sediment out of the stream
- Pet waste stations
- Education! Who can we educate and what behaviors might that change?
    - Homeowners
        - Lawn care – fertilizing properly
        - Pet waste
        - Proper disposal of chemicals
        - Planting trees
    - Citizens
        - Not littering
        - Being aware of the stream and how our actions affect it (e.g. that water that travels off parking lots is not filtered)
        - Minimize driving
        - Water conservation
        - Volunteering to pick up litter, plant trees
    - What about kids? What can you do?

Activity:

- Visit: http://arcg.is/2fAPuwS
- What types of BMPs are installed? How are they helping Stroubles Creek?
- Extra credit: take a tour of the 16 Frogs with your family using the same site. What observations can you make about the stream in different locations? What BMP's did you visit? What did you learn about your watershed that you didn't know before?

What else can you do? Encourage students to take a walk, participate in tree planting, water trees, pick up trash, etc. - https://www.facebook.com/savestroubles/videos/vb.871399246223496/997448310285255/?type=2&theater

Worksheet Example

Stroubles Creek Watershed- Blacksburg Area

Best Management Practice (BMP) are effective actions taken to prevent or decrease non point pollution of water sources (groundwater, streams, lakes, etc)

What is non -point pollution? Give 2 examples.	

An impermeable surface that decreases infiltration, like a parking lot, would increase what process in the hydrological cycle? (runoff or infiltration)	

What could raise the water table?	

What could lower the water table?	

Click on the link below and answer the questions that are in this lab by looking at the pictures and/ or reading the information

http://arcg.is/2fAPuwS

Exploring BMPs around Virginia Tech campus

Click on **picture 1** and answer the following:

What is an extended detention?	
Looking at this picture describe the extended detention in this area?	

Click on **picture 10** and answer the questions-

A extended detention is shown in this picture. How does it protect downstream resources?	
Click on photo 10 of oak lane and 11 of alum	

pond. How do you think a changing water table influence these two extended detention?	

Click on **picture 13** and answer the following questions related to it-

What is an green roof?	
What do you see in this photo and what could be a benefit of having a 'green roof'?	

Click on **picture 26** and answer the following questions?

What is an Underground Water Quality unit (WQU)?	
What is a disadvantage of this system?	

Click on **picture 27** and answer the following questions?

What is a rain garden?	
What do you think happens to this area during the different season?	

Click on **picture 29** and answer the following questions?

What is a bioretention filter?	
Compare picture 29 with picture 26. What is different about them?	

Appendix C - Additional Monitoring Information

Table C1. Summary of monthly sample collection.

Docs Branch		Holtan Branch	
Sample ID	**Date and Time**	**Sample ID**	**Date and Time**
150130-D-M	1/30/2015 13:30	150130-H-M	1/30/2015 13:50
150227-D-M	2/27/2015 14:30	150227-H-M	2/27/2015 15:50
150327-D-MT	3/27/2015 11:30	150327-H-MT	3/27/2015 12:10
150427-D-M	4/27/2015 14:40	150427-H-M	4/27/2015 14:10
150528-D-M	5/28/2015 10:30	150528-H-M	5/28/2015 11:50
150623-D-MT	6/23/2015 10:50	150623-H-MT	6/23/2015 10:30
150731-D-M	7/31/2015 11:00	150731-H-M	7/31/2015 11:20
150830-D-M	8/30/2015 15:00	150830-H-M	8/30/2015 13:50
150930-D-MT	9/30/2015 12:00	150930-H-MT	9/30/2015 10:10
151030-D-M	10/30/2015 13:50	151030-H-M	10/30/2015 14:10
151118-D-M	11/18/2015 9:50	151118-H-M	11/18/2015 10:40
151230-D-M	12/30/2015 11:10	151230-H-M	12/30/2015 11:30
160128-D-MT	1/28/2016 14:10	160128-H-MT	1/28/2016 12:50
160226-D-M	2/26/2016 15:00	160226-H-M	2/26/2016 15:20
160328-D-M	3/28/2016 7:20	160328-H-M	3/28/2016 7:50
160427-D-M	4/27/2016 11:40	160427-H-M	4/27/2016 10:50
160531-D-MT	5/31/2016 13:50	160531-H-MT	5/31/2016 14:30
160629-D-M	6/29/2016 11:40	160629-H-M	6/29/2016 11:00
160729-D-M	7/29/2016 13:50	160729-H-M	7/29/2016 14:00
160831-D-M	8/31/2016 13:00	160831-H-M	8/31/2016 13:50
160926-D-M	9/26/2016 13:40	160926-H-M	9/26/2016 13:20
161031-D-MT	10/31/2016 17:20	161031-H-MT	10/31/2016 17:40
161231-D-M	12/31/2016 12:20	161231-H-M	12/31/2016 12:50
170126-D-MT	1/26/2017 14:00	170126-H-MT	1/26/2017 13:20

Table C2. Summary of pre-BMP storm samples.

Summary of Storm 1 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
150806-D10-S	8/6/15 18:00	150806-H10-S	8/6/15 18:00
150806-D11-S	8/6/15 18:30	150806-H12-S	8/6/15 19:00
150806-D15-S	8/6/15 20:30	150806-H15-S	8/6/15 20:30
150806-D20-S	8/6/15 23:00	150806-H18-S	8/6/15 22:00
150806-D24-S	8/7/15 1:00	150806-H24-S	8/7/15 1:00

Summary of Storm 2 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
150810-D13-S	8/10/2015 20:30	150810-H13-S	8/10/2015 20:30
150810-D15-S	8/10/2015 21:30	150810-H15-S	8/10/2015 21:30
150810-D18-S	8/10/2015 23:00	150810-H21-S	8/11/2015 0:30
150810-D21-S	8/11/2015 0:30		
150810-D24-S	8/11/2015 2:00		

Summary of Storm 3 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
150925-D14-S	9/25/2015 22:30	150925-H14-S	9/25/2015 22:30
150925-D18-S	9/26/2015 0:30	150925-H18-S	9/26/2015 0:30
150925-D19-S	9/26/2015 1:00	150925-H19-S	9/26/2015 1:00
150925-D22-S	9/26/2015 2:30	150925-H22-S	9/26/2015 2:30
150925-D24-S	9/26/2015 3:30	150925-H24-S	9/26/2015 3:30

Summary of Storm 4 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
151002-D3-S	10/2/2015 15:00	151002-H2-S	10/2/2015 13:00
151002-D10-S	10/3/2015 5:00	151002-H10-S	10/3/2015 5:00
151002-D14-S	10/3/2015 13:00	151002-H14-S	10/3/2015 13:00
151002-D17-S	10/3/2015 19:00	151002-H17-S	10/3/2015 19:00
151002-D19-S	10/3/2015 23:00	151002-H19-S	10/3/2015 23:00
151002-D22-S	10/4/2015 5:00	151002-H21-S	10/4/2015 3:00
151002-D24-S	10/4/2015 9:00	151002-H24-S	10/4/2015 9:00

Summary of Storm 5 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
151118-D-M	11/18/2015 9:50	151118-H-M	11/18/2015 10:40
151118-D3-S	11/18/2015 20:00	151118-H11-S	11/19/2015 0:00
151118-D10-S	11/18/2015 23:30	151118-H20-S	11/19/2015 4:30
151118-D14-S	11/19/2015 1:30	151118-H24-S	11/19/2015 6:30
151118-D16-S	11/19/2015 2:30		
151118-D19-S	11/19/2015 4:00		
151118-D20-S	11/19/2015 4:30		

Table C3. Summary of post-BMP storm samples.

Summary of Storm 6 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
160627-D9-S	6/27/2016 17:00	160627-H10-S	6/27/2016 17:30
160627-D15-S	6/27/2016 20:00	160627-H15-S	6/27/2016 20:00
160627-D18-S	6/27/2016 21:30	160627-H18-S	6/27/2016 21:30
160627-D21-S	6/27/2016 23:00	160627-H20-S	6/27/2016 22:30
160627-D24-S	6/28/2016 0:30	160627-H24-S	6/28/2016 0:30
160629-D-M	6/29/2016 11:40	160629-H-M	6/29/2016 11:00

Summary of Storm 7 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
160728-D7-S	7/28/2016 18:00	160728-H10-S	7/28/2016 19:30
160728-D9-S	7/28/2016 19:00	160728-H13-S	7/28/2016 21:00
160728-D12-S	7/28/2016 20:30	160728-H14-S	7/28/2016 21:30
160728-D14-S	7/28/2016 21:30	160728-H15-S	7/28/2016 22:00
160728-D16-S	7/28/2016 22:30	160728-H17-S	7/28/2016 23:00
160728-D17-S	7/28/2016 23:00	160728-H19-S	7/29/2016 0:00
160728-D18-S	7/28/2016 23:30	160728-H24-S	7/29/2016 2:30
160728-D20-S	7/29/2016 0:30	160729-H-M	7/29/2016 14:00
160728-D24-S	7/29/2016 2:30		
160729-D-M	7/29/2016 13:50		

Summary of Storm 8 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
160926-D-M	9/26/2016 13:40	160926-H-M	9/26/2016 13:20
160926-D1-S	9/26/2016 16:00	160926-H1-S	9/26/2016 16:00
160926-D4-S	9/26/2016 17:30	160926-H2-S	9/26/2016 16:30
160926-D6-S	9/26/2016 18:30	160926-H3-S	9/26/2016 17:00
160926-D9-S	9/26/2016 20:00	160926-H4-S	9/26/2016 17:30
160926-D11-S	9/26/2016 21:00	160926-H5-S	9/26/2016 18:00
160926-D14-S	9/26/2016 22:30	160926-H6-S	9/26/2016 18:30
160926-D19-S	9/27/2016 1:00	160926-H7-S	9/26/2016 19:00
160927-D-S	9/27/2016 14:40	160926-H8-S	9/26/2016 19:30
		160926-H9-S	9/26/2016 20:00
		160926-H11-S	9/26/2016 21:00
		160926-H17-S	9/27/2016 0:00
		160927-H-S	9/27/2016 14:20

Summary of Storm 9 Sample Collection

Doc's Branch Sample ID	Date and Time	Holtan Branch Sample ID	Date and Time
170102-D10-S	1/3/2017 2:30	170102-H10-S	1/3/2017 2:30
170102-D13-S	1/3/2017 4:00	170102-H12-S	1/3/2017 3:30
170102-D16-S	1/3/2017 5:30	170102-H14-S	1/3/2017 4:30
170102-D18-S	1/3/2017 6:30	170102-H16-S	1/3/2017 5:30
170102-D20-S	1/3/2017 7:30	170102-H18-S	1/3/2017 6:30
170102-D22-S	1/3/2017 8:30	170102-H21-S	1/3/2017 8:00
170102-D24-S	1/3/2017 9:30	170102-H22-S	1/3/2017 8:30
170103-D-S	1/3/2017 14:20	170102-H24-S	1/3/2017 9:30
		170103-H-S	1/3/2017 15:00