Virginia State University

MS-4 Permit: VAR040119

Chesapeake Bay TMDL Action Plan

Prepared for
Virginia State University
Capital Outlay & Facilities Management
PO Box 9414
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June 30, 2015

Revised December 28, 2015

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1.0 Introduction

Virginia State University (VSU) has developed this Chesapeake Bay TMDL Action Plan (Action Plan) pursuant to the Special Condition for the Chesapeake Bay TMDL (General Permit Section I.C) as required by VSU's Municipal Separate Storm Sewer System (MS-4) Permit. To assist with the development of the Action Plan, VSU has utilized both the General VPDES Permit for Discharges of Stormwater from Small Municipal Separate Storm Sewer Systems, which became effective July 1, 2013 and the Department of Environmental Quality's (DEQ) Chesapeake Bay TMDL Special Condition Guidance Document (Guidance Memo No. 15-2005). VSU utilized the Virginia Geographic Information Network (VGIN), and Virginia Environmental Geographic Information Systems (VEGIS) coupled with campus GIS data to meet the technical requirements of the Action Plan.

The focus of the Action Plan is driven by the Chesapeake Bay Total Maximum Daily Load (TMDL), which was approved by the US Environmental Protection Agency (EPA) in December of 2010. Nitrogen, Phosphorous, and Sediment are the Pollutants of Concern (POC) driving the need for required pollutant reductions in the Chesapeake Bay watershed, in which the entire VSU campus is included. Three permit cycles have been adopted to address the percent pollutant reduction required by a Municipal Separate Storm Sewer System (MS4) in Virginia. A 5% POC load reduction is required by the end of the first permit cycle on June 30, 2018, followed by a 35%, and 60% reduction in the following 2 cycles, respectively. For the purposes of this Action Plan, the primary focus will be on Permit Cycle 1 and the associated 5% reduction requirements, although the loadings and reductions have been provided for the 35% and 60% cycles for reference. Projects implemented as part of this Action Plan that exceed the required 5% reductions will be tracked to meet future cycle requirements and referenced in the Permit Cycle 2 Action Plan. VSU may modify the Action Plan during the permit cycle to include new opportunities for reductions or address projects that are deemed infeasible. Any updates will be submitted to DEQ in accordance with the Program Plan Modification section of the permit (GP Section II.F.1). This Action Plan includes the following components as required by the General Permit:

- ***Current Program and Existing Legal Authority*** - Permit Section I.C.2.a.(1)
- ***New or Modified Legal Authority*** – Permit Section I.C.2.a.(2)
- ***Means and Methods to Address Discharges from New Sources*** – Permit Section I.C.2.a.(3)
- ***Estimated Existing Source Loads and Calculated Total (POC) Required Reductions*** – Permit Section I.C.2.a.(4) and I.C.2.a.(5)
- ***Means and Methods to Meet the Required Reductions and Schedule*** – Permit Section 1.C.2.a.(6)
- ***Means and Methods to Offset Increased Loads from New Sources Initiating Construction between July 1, 2009 and June 30, 2014*** – Permit Section 1.C.2.a.(7)
- ***Means and Methods to Offset Increased Loads from Grandfathered Projects that begin Construction after July 1, 2014*** – Permit Section 1.C.2.a.(8)
- ***A List of Future Projects, and Associated Acreage that Qualifies as Grandfathered*** – Permit Section 1.C.2.a.(10)

2.0 Current MS4 Program and Existing Legal Authority

VSU has performed a review of its current MS4 Program Plan and existing legal authorities in order to evaluate its ability to comply with the Special Condition for the Chesapeake Bay TMDL (Section I.C) in the MS4 Permit. The following is a list of VSU's relevant existing legal authorities and policies that were reviewed to prepare this Action Plan:

- MS4 Program Plan
- Illicit Discharge Detection and Elimination Policy
- Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management
- Stormwater Master Plan

3.0 New or Modified Legal Authority

Based on the review of items listed above, VSU has no new or modified legal authorities such as ordinances, state and other permits, orders, specific contract language and/or inter-jurisdictional agreements implemented or needing to be implemented to meet the requirements of this special condition.

VSU intends to continue coordinating with Chesterfield County (adjacent MS4) to clarify inter-jurisdictional responsibilities for POC loads and subsequent required POC load reductions.

4.0 Means and Methods to Address Discharges from New Sources

All new sources developed or redeveloped after July 1, 2009 on the VSU campus meet an average impervious land cover condition of 16% for the design of post developed stormwater management facilities. As such, no additional offsets are required under this permit's Special Conditions beyond those for existing development.

5.0 Estimated Existing Source Loads and Calculated Total POC Required Reductions

VSU's Existing Sources Land Cover Type is summarized in Table 5-1. The table shows the estimated existing (2009 baseline cover area) impervious, pervious, forested, and open water cover types and areas for the VSU Campus.

Table 5-1: Existing Sources Land Cover Type

Land Cover Type	Area (AC)
Pervious	135.77
Forested	39.68
Open Water	0.78
Impervious	85.79
Total	**262.02**

Land cover types were delineated using VSU GIS data and 2009 VGIN aerial photography. Open waters were considered unregulated area and were excluded from the load calculations. Forested lands were observed to meet the tree density requirements of Guidance Memo 15-2005, Appendix V.H, were undeveloped, and met a minimum area of 900m^2.

Figure 1 shows VSU's regulated MS4 area and the 2009 baseline land cover within the regulated area.

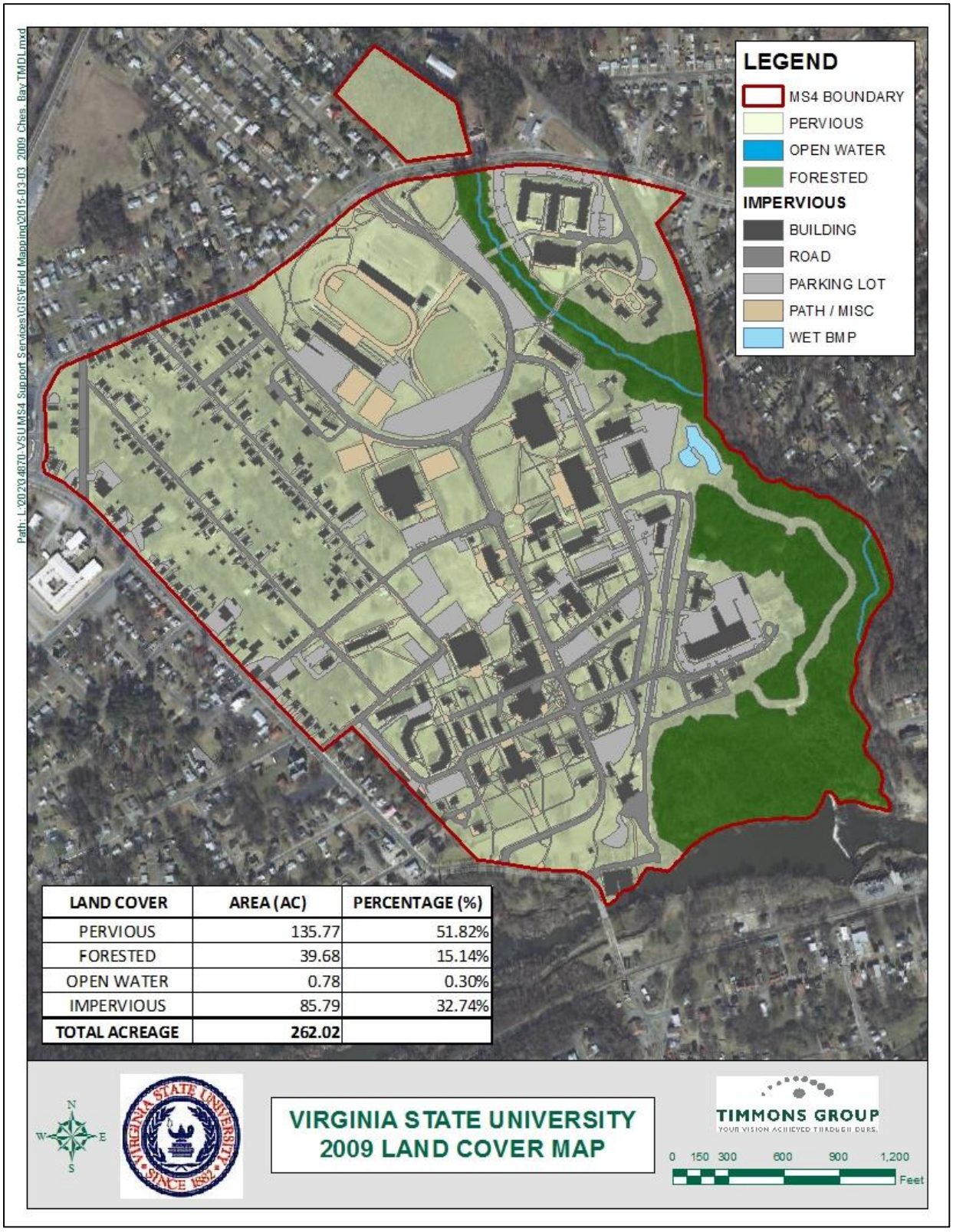

Figure 5-1: Regulated MS4 Area and 2009 Baseline Land Cover

5.1. Existing Source Loads

Table 5-2 and Table 5-3 provide the baseline existing source loads and required pollutant reductions based on VSU's 2009 baseline cover area.

Table 5-2: Calculation for Estimate Existing Source Loads

*Based on Chesapeake Bay Program Watershed Model Phase 5.3.2 for the James River Basin

Subsource	Pollutant	Total Existing Acres Served by MS4 (06/30/09)	2009 EOS Loading Rate (lbs/acre/yr)	Estimated Total POC Load based on 2009 Progress Run (lbs/yr)
Regulated Urban Impervious	Nitrogen	85.79	9.39	805.57
Regulated Urban Pervious		135.77	6.99	949.03
Regulated Urban Impervious	Phosphorus	85.79	1.76	150.99
Regulated Urban Pervious		135.77	0.5	67.89
Regulated Urban Impervious	Total Suspended Solids	85.79	676.94	58,074.68
Regulated Urban Pervious		135.77	101.08	13,723.63

5.2. Existing POC Required Reductions

Table 5-3: Calculation for Determining Total POC Reduction Required

*Based on Chesapeake Bay Program Watershed Model Phase 5.3.2 for the James River Basin

Subsource	Pollutant	Total Existing Acres Served by MS4 (06/30/09)	First Permit Cycle Required Reduction in Loading Rate (lbs/acre/yr)	5% Total Reduction Required First Permit Cycle (lbs/yr)[1]	35% Total Reduction Required Second Permit Cycle (lbs/yr)[2]	60% Total Reduction Required Third Permit Cycle (lbs/yr)[2]	Total Reduction (lbs/yr)
Regulated Urban Impervious	Nitrogen	85.79	0.04	3.43	25.38	43.50	**72.31**
Regulated Urban Pervious		135.77	0.02	2.72	19.93	34.17	**56.82**
			Total:	6.15	45.31	77.67	**129.13**
Regulated Urban Impervious	Phosphorus	85.79	0.01	0.86	8.46	14.50	**23.82**
Regulated Urban Pervious		135.77	0.002	0.27	1.72	2.95	**4.94**
			Total:	1.13	10.18	17.45	**28.76**
Regulated Urban Impervious	Total Suspended Solids	85.79	6.67	572.22	4,065.23	6,968.96	**11,606.41**
Regulated Urban Pervious		135.77	0.44	59.74	420.29	720.49	**1,200.52**
			Total:	631.96	4,485.52	7,689.45	**12,806.93**

1. Calculated based on the MS4 General Permit
2. Calculated based on the 2009 Level 2 Watershed Implementation Plan (Virginia)

6.0 Means and Methods to Meet the Required Reductions and Schedule

VSU intends to meet the required reductions and schedule by implementing two stream restoration projects on campus. Stream restoration appears to be the most cost effective compliance strategy to date based on DEQ's current guidance information. The proposed strategy for long term compliance through the 100% reduction requirement meets milestone goals at 5% of total reductions and 35% of total reductions. The following two stream restoration projects on campus have been identified:

1. Restore approximately 220 linear feet of existing unnamed tributary behind Lockett Hall

2. Restore approximately 2,000 linear feet of Fleet's Branch from River Road to the old railroad bed

Both streams discharge to the Appomattox River. Figure 6-1 shows the location and extent of the proposed restoration projects.

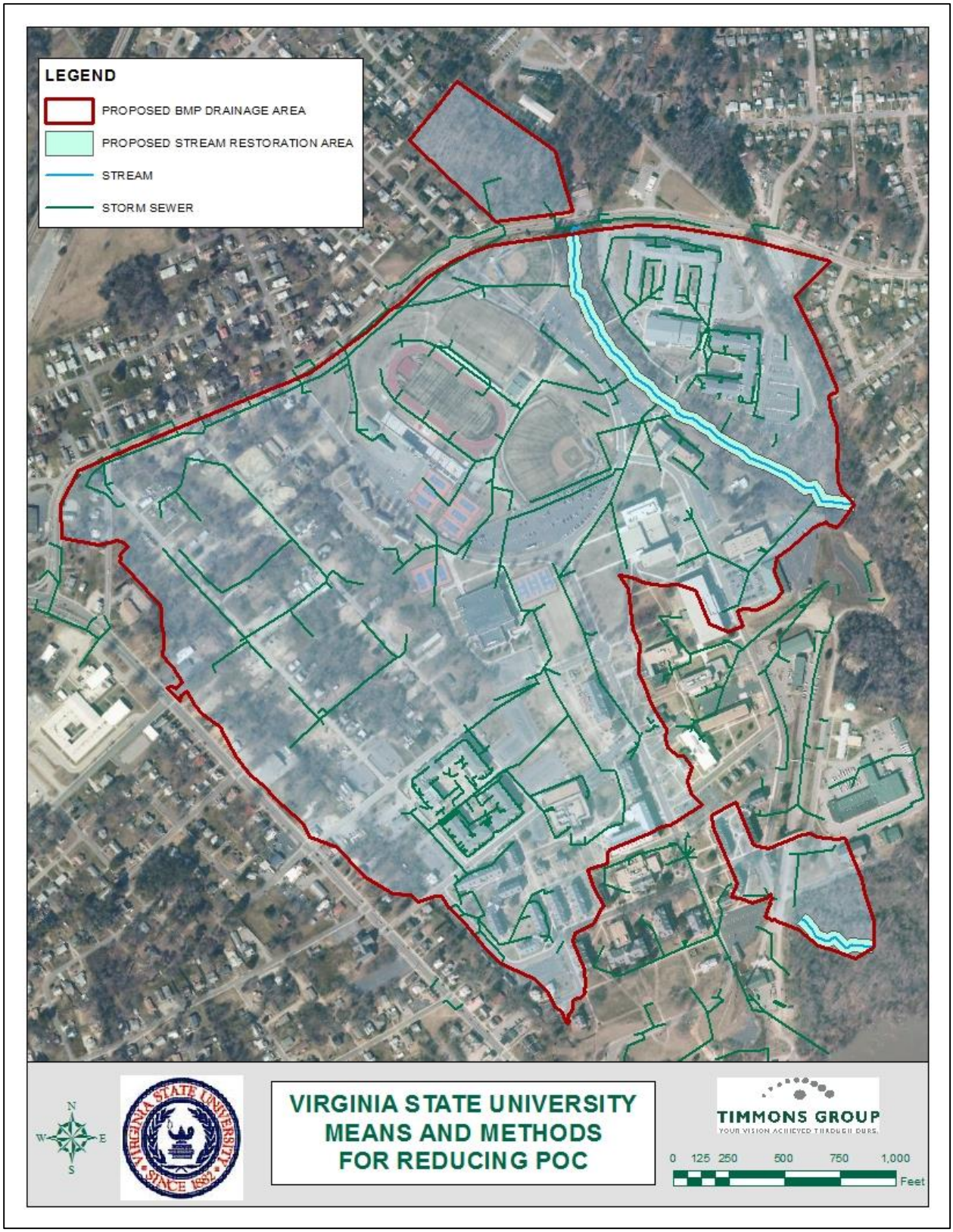

Figure 6-1: Proposed Stream Restoration Projects

An assessment dated June 11, 2014 was conducted by Timmons Group to predict the amount of pollution reduction anticipated from each proposed stream restoration project. The assessment utilized the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model, the results of which are summarized in Table 6-1. The BANCS assessment has been provided in Appendix A for reference.

Table 6-1: BANCS Assessment Reductions

Project	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Suspended Solids (lbs/yr)
Appomattox Tributary Restoration	60	28	52,000
Fleet's Branch Restoration	424	196	372,000

GIS data was used to determine the acreage of urban impervious, urban pervious, and forested land covers draining to each stream. Those acreages were then used to adjust the predicted reductions from the BANCS assessment based on the ratio of each land cover draining to each stream, shown in Table 6-2.

Table 6-2: Adjusted Reductions

Project	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Suspended Solids (lbs/yr)
Appomattox Tributary Restoration	42.03	19.61	36,425.96
Fleet's Branch Restoration	365.86	169.12	320,988.18

Detailed calculations for each stream restoration segment are provided in Appendix B.

VSU plans to complete the 1st permit cycle reduction requirement of 5.0%, through the Appomattox Tributary Restoration project. Implementation of this project will allow VSU to significantly exceed the required POC reduction for the 1st permit cycle, as illustrated in Table 6-3.

VSU plans to complete the 2nd and 3rd permit cycle reduction requirements of 35% and 60% through the Fleet's Branch stream restoration project. Implementation of this project will significantly exceed the required POC reduction for the 2nd and 3rd permit cycles, as illustrated in Table 6-3.

Table 6-3: Pollutant Reduction Requirements and Credits			
	Total Nitrogen (lbs/yr)	**Total Phosphorus (lbs/yr)**	**Total Suspended Solids (lbs/yr)**
First Permit Term			
Appomattox Tributary Restoration Credits (Adjusted)	42.03	19.61	36,425.96
Required 1st Term Reduction	6.15	1.13	631.96
Remaining Credits (at end of 1st Term)	35.88	18.48	35,794.00
Second Permit Term			
Rollover Credits (from 1st Term)	35.88	18.48	35,794.00
Fleet's Branch Restoration Credits (Adjusted)	365.86	169.12	320,988.18
Total 2nd Term Credits	401.74	187.60	356,782.18
Required 2nd Term Reduction	45.31	10.18	4,485.52
Remaining Credits (at end of 2nd Term)	356.43	177.42	352,296.66
Third Permit Term			
Rollover Credits (from 2nd Term)	356.43	177.42	352,296.66
Required 3rd Term Reduction	77.67	17.45	7,689.45
Remaining Credits*	278.76	159.97	344,607.21

***Remaining credits after the third permit term are surplus beyond the total reduction requirement for all three permit terms**

At the completion of both stream restoration projects and after VSU has officially certified all credits required for TMDL compliance, VSU reserves the right to share the remaining credits and implementation costs of the project with adjacent MS4s. VSU also reserves the right to revise this Action Plan as needed as the implementation process continues.

7.0 Means and Methods to Offset Increased Loads from New Sources Initiating Construction between July 1, 2009 and June 30, 2014

VSU has no increased loads from new sources initiating construction between July 1, 2009 and June 30, 2014. All new sources developed or redeveloped on the VSU campus after July 1, 2009 meet an average impervious land cover condition of 16% for the design of post developed stormwater management facilities. No further offsets are required under the Special Condition beyond those for existing development.

8.0 Means and Methods to Offset Increased Loads from Grandfathered Projects that Began Construction After July 1, 2014

VSU has no increased loads from grandfathered projects that began construction after July 1, 2014. All grandfathered projects constructed after July 1, 2014 meet an average impervious land cover condition of 16% for the design of post developed stormwater management facilities.

No further offsets are required under the Special Condition beyond those for existing development.

9.0 List of Future Projects, and Associated Acreage that Qualify as Grandfathered

VSU has no future projects that would qualify as grandfathered projects. The University obtained initial 2009 Construction General Permit coverage for the MS4 boundary encompassing the main campus area in order to implement its architectural master plan in accordance with its stormwater master plan. As such, projects completed within the MS4 boundary limits of the main campus are considered to meet the time limits on applicability of approved design criteria per 9VAC25-870-47 and are eligible to use the technical criteria from Part II B or Part IIC. All such projects will be designed to meet an average impervious land cover condition of 16% for the design of post developed stormwater management facilities designed to meet Part IIC technical criteria.

10.0 Estimate of Expected Cost to Implement Necessary Reductions

The estimated expected cost to perform the two stream restoration projects on campus is provided in Table 10-1. This is not based on a detailed cost estimate derived from design plans, and is subject to change upon implementation.

Table 10-1: Stream Restoration Budgetary Cost

	Appomattox Tributary Restoration	Fleet's Branch Restoration
Design Cost	$53,945	$121,470
Construction Cost	$77,000	$700,000
Total Cost	$130,945	$821,470
Combined Total Cost	$952,415	

11.0 Public Comments on Draft Action Plan

A draft of the Action Plan was posted to the University website for at least 30 days in order to receive comments and feedback from the public. No comments or feedback were received by the public during the comment period.

Appendix A

TIMMONS GROUP
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June 19, 2014

Jonathan Taylor
Virginia State University
Director, Capital Outlay and Maintenance Reserve
P.O. Box 9414
Petersburg, VA 23806

VIA EMAIL: jtaylor@vsu.edu

Re: Defining Pollutant Reductions for Fleets Branch and a Tributary to the Appomattox Petersburg, Virginia

Dear Mr. Taylor:

Timmons Group was contracted to analyze the applicability of three of the four (Protocols 1-3), as well as the interim rate from the *Recommended Protocols for Defining Pollutant Reductions Achieved by Individual Stream Restoration Projects*[1]. The following is a summary of our analysis.

Protocol 1: Credit for Prevented Sediment during Storm Flow

"This protocol provides an annual mass nutrient and sediment reduction credit for qualifying stream restoration practices that prevent channel or bank erosion that would otherwise be delivered downstream from an actively enlarging or incising urban stream," (Schueler and Stack 2013). Timmons Group followed the outlined three step process to compute a mass reduction credit for prevented sediment, as follows:

Step 1. The stream sediment erosion rates and annual sediment loadings were estimated utilizing the Bank and Nonpoint Source Consequences of Sediment (BANCS) Method developed by Rosgen (2001). On February 25, 2014, Timmons Group assessed the existing channel by performing a series of field data collection exercises including the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) assessments for each stream bank within the study area. This assessment summary can be found on the enclosed Worksheet 3-13. Summary form of annual stream bank erosion estimates for various study reaches. Sample reaches were then assigned one of four (4) corresponding erosion rate categories ranging from "Low" to "Extreme," as illustrated on the enclosed BANCS Assessment Map. Based on this analysis, the existing Fleets Branch can be classified as having a high erosion rate (calculated unit erosion rate = 0.18 tons/yr/ft). Extrapolated along the existing restoration length, the overall sediment load is predicted to be 372 ton/yr. The existing Tributary to the Appomattox River can also be classified as having a high erosion rate (calculated unit erosion rate = 0.12 tons/yr/ft). Extrapolated along the existing restoration length, the overall sediment load is predicted to be 52 ton/yr.

Step 2. The erosion rates calculated using the BANCS method were converted to nitrogen and phosphorus loadings. Based on the published values presented in the guidance document for both phosphorus and nitrogen concentrations in stream bank sediments (1.05 pounds P/ton of sediment and

[1] Provided as Section 5 in *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects* prepared by Tom Schueler, Chesapeake Stormwater Network and Bill Stack, Center for Watershed Protection. The Water Quality Goal Implementation Team issued their final approval of this document on May 13, 2013.

2.28 pounds N/ton of sediment), the predicted nutrient load resulting from erosion of the stream banks for Fleets Branch are 391 lb/yr of phosphorus and 848 lb/yr of nitrogen. For the Tributary to the Appomattox River the nutrient results are 55 lb/yr of phosphorus and 119 lb/yr of nitrogen.

Step 3. The protocol calls for a 50% effective reduction in the nutrient loading unless there is a representative "natural" condition from which the low BEHI and NBS scores can be estimated from, however the 50% effective reduction was used in this analysis. The following sediment and nutrient credits were determined for Protocol 1:

Fleets Branch	Tributary to Appomattox
Total Phosphorus = 196 lb/yr	Total Phosphorus = 28 lb/yr
Total Nitrogen = 424 lb/yr	Total Nitrogen = 60 lb/yr
Sediment = 186 ton/yr	Sediment = 26 ton/yr

Protocol 2: Credit for In-stream and Riparian Nutrient Processing during Base Flow

"This protocol provides an annual mass nitrogen reduction credit for qualifying projects that include design features to promote denitrification during base flow," (Schueler and Stack 2013). To qualify for credit under Protocol 2, the bank height ratio is required to be 1.0 or less in order to promote hyporheic exchange between the stream channel and the floodplain rooting zone. The hyporheic box is calculated as the width of the channel plus five feet on either side of the stream bank, extending to a maximum depth of five feet, excluding areas of bedrock outcropping or confining clay layers. The box extends the length of the restored channel.

This project has the potential to be designed with a bank height ratio of 1.0 or less, thereby qualifying for the denitrification credit. Final calculations can only be made after a final design has been submitted.

Protocol 3: Credit for Floodplain Reconnection Volume

"This protocol provides an annual mass sediment and nutrient reduction credit for qualifying projects that reconnect stream channels to their floodplain over a wide range of storm events… A wetland-like treatment is used to compute the load reduction attributable to floodplain deposition, plant uptake, denitrification and other biological and physical processes," (Schueler and Stack 2013). Protocol 3 cannot be used in conjunction with Protocol 2; if a project qualifies for Protocol 3, then according to the guidance, Protocol 2 no longer applies.

It appears the intent of Protocol 3 is to provide increased sediment and nutrient credit for restoration projects that include the design of wetlands within the project floodplain that are actively engaged during smaller storm events, specifically those less than the 1.5 year storm event. The result is a reduction in sediment and nutrient concentrations of the stormwater runoff from the contributing watershed by means of hydraulic detention and nutrient processing occurring in the floodplain wetlands. Therefore, the project should result in a minimum watershed to floodplain ratio of one percent to ensure adequate hydraulic detention time for flows in the floodplain. Further, the floodplains should be specifically designed to act as wetlands, and designers are afforded more credit for designs that engage the floodplain during smaller storm events (e.g., 0.25 or 0.5 inches).

Protocol 3 can only be used if the project incorporates a floodplain wetland that is at least 1% of the contributing watershed area. Unfortunately, constructing the required wetland area for both of these reaches is unlikely and therefore these projects would not qualify for Protocol 3.

Interim Rate

"Local watershed planners will often need to compare many different BMP options within their community." While the interim removal rates can only be applied to historic projects or projects that cannot conform to recommended reporting requirements, it is another tool to estimate and compare removal rates for these two streams.

For general watershed planning purposes the removal rates based on the interim rate for Fleets Branch and the Tributary to the Appomattox River are:

Fleets Branch
- Total Phosphorus = 138 lb/yr
- Total Nitrogen = 152 lb/yr
- Sediment = 251 ton/yr

Tributary to Appomattox
- Total Phosphorus = 29 lb/yr
- Total Nitrogen = 32 lb/yr
- Sediment = 53 ton/yr

Summary

Sediment and nutrient credits were computed for the Fleets Branch and the Tributary to the Appomattox River, as follows:

Fleets Branch

Protocol	Phosphorous Credit (lbs/yr)	Nitrogen Credit (lbs/yr)	Sediment Removal Credit (ton/yr)
1	196	424	186
2	N/A	TBD	N/A
3	N/A	N/A	N/A
Interim Rate	138	152	251

Tributary to the Appomattox River

Protocol	Phosphorous Credit (lbs/yr)	Nitrogen Credit (lbs/yr)	Sediment Removal Credit (ton/yr)
1	28	60	26
2	N/A	TBD	N/A
3	N/A	N/A	N/A
Interim Rate	29	32	53

Timmons Group thanks you for the opportunity to work on this project and assess the potential sediment and nutrient reduction credits associated with compliance with the Chesapeake Bay TMDL. We would be happy to meet with you to review our findings and to discuss our assumptions, the guidance documents, and the Protocols in-depth, as related to this and future projects for Virginia State University. Please contact us at your convenience to discuss the subject further.

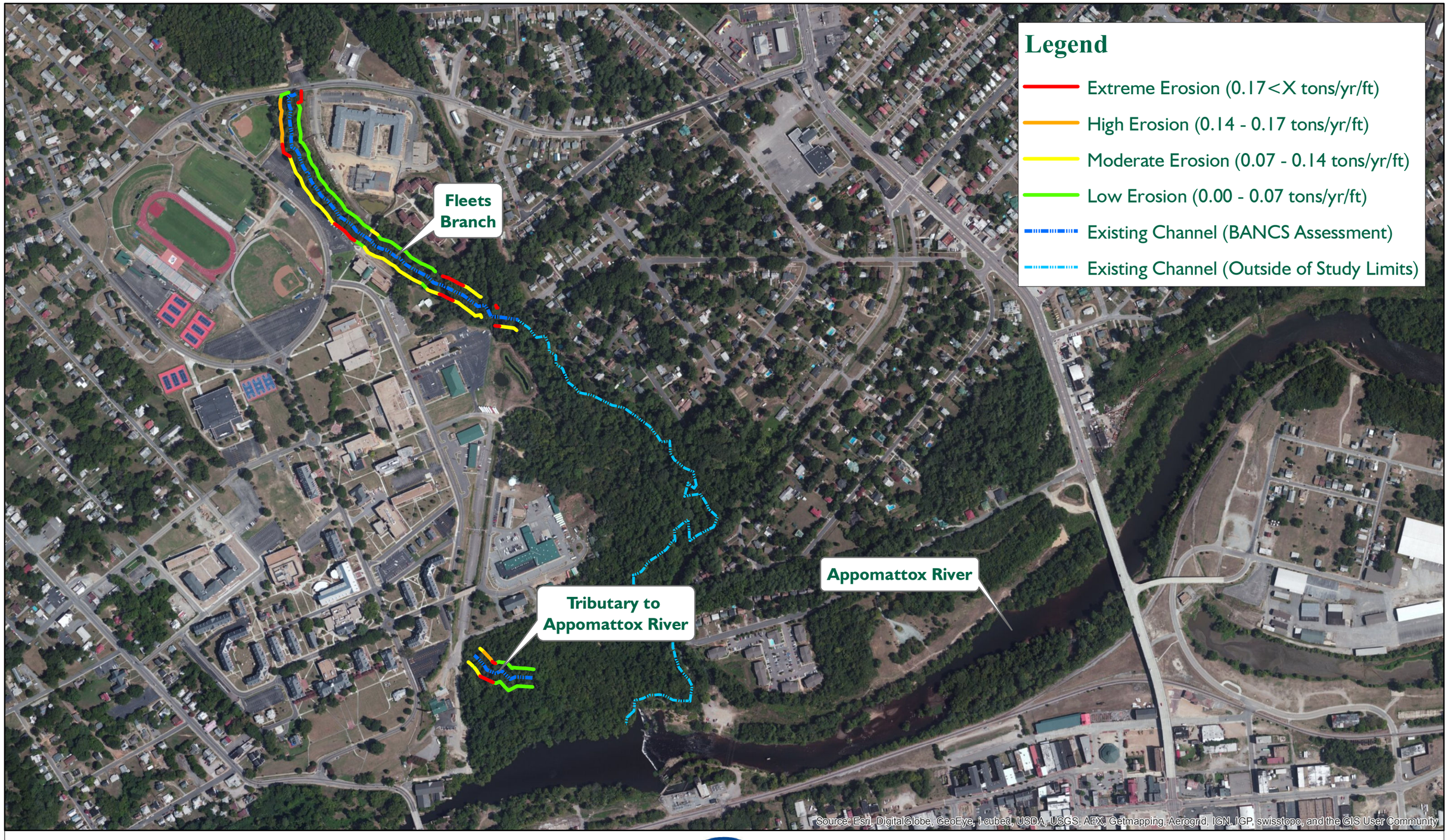
Sincerely,

Timmons Group

Rebecca Napier, PE
Environmental Project Manager

Enclosures:

- Worksheets 3-13. Summary form of annual streambank erosion estimates for various study reaches. (Trib to Appomattox and Fleets Branch)
- BANCS Assessment Map



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BANCS Assessment Map

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0 130 260 520 780 1,040
Feet

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	**Existing, Reach - Fleets Branch**			Location: **VSU, Petersburg, VA**			
Graph Used:	**Colorado**	Total Stream Length (ft): **2027**				Date: **6/11/2014**	
Observers:	**JB**		Valley Type: **VIII**			Stream Type: **G5**	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 3-11) (adjective)**	**NBS rating (Worksheet 3-12) (adjective)**	**Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **LEFT 0+00 TO 0+36**	**Moderate**	**Extreme**	**1.156**	**36.0**	**5.0**	**208.08**	**0.27830**
2. **LEFT 0+36 TO 0+73**	**Low**	**Low**	**0.036**	**37.0**	**3.5**	**4.62**	**0.00600**
3. **LEFT 0+73 TO 4+32**	**Moderate**	**Low**	**0.153**	**359.0**	**5.0**	**274.64**	**0.03680**
4. **LEFT 4+32 TO 7+80**	**Low**	**Low**	**0.003**	**348.0**	**5.0**	**5.22**	**0.00070**
5. **LEFT 7+80 TO 9+50**	**Low**	**Low**	**0.036**	**170.0**	**4.0**	**24.28**	**0.00690**
6. **LEFT 9+50 TO 10+16**	**Low**	**Low**	**0.036**	**66.0**	**6.0**	**14.14**	**0.01030**
7. **LEFT 10+16 TO 10+42**	**Moderate**	**Low**	**0.153**	**26.0**	**15.0**	**59.67**	**0.11050**
8. **LEFT 10+42 TO 12+40**	**Low**	**Low**	**0.036**	**198.0**	**6.0**	**42.41**	**0.01030**
9. **LEFT 12+40 TO 14+49**	**Moderate**	**Low**	**0.153**	**209.0**	**8.0**	**255.82**	**0.05890**
10. **LEFT 15+00 TO 16+25**	**High**	**High**	**0.575**	**125.0**	**8.0**	**575.00**	**0.22150**
11. **LEFT 16+25 TO 17+64**	**Moderate**	**High**	**0.420**	**139.0**	**5.0**	**291.90**	**0.10110**
12. **LEFT 18+06 TO 18+40**	**High**	**High**	**0.575**	**34.0**	**7.0**	**136.85**	**0.19380**
13. **LEFT 18+40 TO 18+75**	**Low**	**Moderate**	**0.073**	**35.0**	**2.5**	**6.35**	**0.00870**
14. **RIGHT 0+36 TO 0+73**	**Moderate**	**Low**	**0.153**	**37.0**	**8.0**	**45.29**	**0.05890**
15. **RIGHT 0+73 TO 3+18**	**Moderate**	**Moderate**	**0.253**	**245.0**	**12.0**	**743.82**	**0.14620**
16 **RIGHT 3+18 TO 3+80**	**High**	**High**	**0.575**	**62.0**	**12.0**	**427.80**	**0.33220**
17 **RIGHT 3+80 TO 6+55**	**Moderate**	**Low**	**0.153**	**275.0**	**15.0**	**631.13**	**0.11050**
18 **RIGHT 6+55 TO 8+15**	**Moderate**	**Low**	**0.153**	**160.0**	**15.0**	**367.20**	**0.11050**
19 **RIGHT 8+15 TO 9+50**	**Very High**	**Low**	**0.250**	**135.0**	**15.0**	**506.25**	**0.18060**
20 **RIGHT 9+50 TO 10+42**	**Low**	**Low**	**0.036**	**92.0**	**20.0**	**65.69**	**0.03440**
21 **RIGHT 10+42 TO 12+00**	**Moderate**	**Low**	**0.153**	**158.0**	**15.0**	**362.61**	**0.11050**

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream: **Existing, Reach - Fleets Branch** Location: **VSU, Petersburg, VA**

Graph Used: **Colorado** Total Stream Length (ft): **2027** Date: **6/11/2014**

Observers: **JB** Valley Type: **VIII** Stream Type: **G5**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Station (ft)	**BEHI rating (Worksheet 3-11) (adjective)**	**NBS rating (Worksheet 3-12) (adjective)**	**Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
22	**RIGHT 12+00 TO 13+85**	**High**	**Low**	**0.250**	**185.0**	**10.0**	**462.50**	**0.12040**
23	**RIGHT 13+85 TO 14+46**	**Low**	**Low**	**0.036**	**61.0**	**10.0**	**21.78**	**0.01720**
24	**RIGHT 14+46 TO 15+00**	**Moderate**	**Low**	**0.153**	**54.0**	**10.0**	**82.62**	**0.07370**
25	**RIGHT 15+00 TO 15+90**	**High**	**Very High**	**0.872**	**90.0**	**8.0**	**627.84**	**0.33590**
26	**RIGHT 15+90 TO 17+45**	**Moderate**	**High**	**0.420**	**155.0**	**6.0**	**390.60**	**0.12130**
27	**RIGHT 17+45 TO 18+06**	**Moderate**	**Moderate**	**0.253**	**61.0**	**8.0**	**123.46**	**0.09750**
28	**RIGHT 18+74 TO 19+00**	**High**	**Extreme**	**1.322**	**26.0**	**18.0**	**618.70**	**1.14570**
29	**RIGHT 19+00 TO 19+79**	**Moderate**	**Low**	**0.153**	**79.0**	**18.0**	**217.57**	**0.13260**
30	**RIGHT 19+79 TO 20+27**	**Moderate**	**Low**	**0.153**	**48.0**	**18.0**	**132.19**	**0.13260**
31								
32								
33								
34								
35								
36								
	Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**7726.00**	
	Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**286.15**	
	Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**371.99**	
	Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Unit Erosion Rate (tons/yr/ft)**	**0.1835**	

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream: **Existing, Reach - Trib to Appomattox**			Location: **VSU, Petersburg, VA**				
Graph Used: **Colorado**		Total Stream Length (ft): **430**				Date: **6/11/2014**	
Observers: **JB, MA**			Valley Type: **VIII**			Stream Type: **G5**	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 3-11) (adjective)**	**NBS rating (Worksheet 3-12) (adjective)**	**Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **LEFT 0+00 TO 0+30**	**Very High**	**High**	**0.575**	**30.0**	**5.0**	**86.25**	**0.13840**
2. **LEFT 0+30 TO 1+00**	**High**	**High**	**0.575**	**70.0**	**6.0**	**241.50**	**0.16610**
3. **LEFT 1+00 TO 1+48**	**High**	**High**	**0.575**	**48.0**	**7.0**	**193.20**	**0.19380**
4. **LEFT 1+48 TO 2+57**	**High**	**Low**	**0.250**	**109.0**	**3.0**	**81.75**	**0.03610**
5. **LEFT 2+57 TO 4+30**	**Low**	**Moderate**	**0.073**	**173.0**	**0.7**	**8.15**	**0.00230**
6. **RIGHT 0+00 TO 0+30**	**High**	**High**	**0.575**	**30.0**	**5.0**	**86.25**	**0.13840**
7. **RIGHT 0+30 TO 0+47**	**High**	**High**	**0.575**	**17.0**	**1.0**	**9.77**	**0.02770**
8. **RIGHT 0+47 TO 1+00**	**High**	**High**	**0.575**	**53.0**	**4.0**	**121.90**	**0.11070**
9. **RIGHT 1+00 TO 1+48**	**High**	**High**	**0.575**	**48.0**	**7.0**	**193.20**	**0.19380**
10. **RIGHT 1+48 TO 2+57**	**Moderate**	**Low**	**0.153**	**109.0**	**3.0**	**50.03**	**0.02210**
11. **RIGHT 2+57 TO 4+30**	**Low**	**Moderate**	**0.073**	**173.0**	**0.7**	**8.15**	**0.00230**
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**1080.16**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**40.01**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**52.01**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Unit Erosion Rate (tons/yr/ft)**	**0.1209**	

Appendix B

Name: Appomattox Tributary Stream Restoration

Linear Feet of Restoration: 220

POC Reductions Per BANCS Assessment		
TN	TP	TSS
60	28	52,000

Acres Draining Stream Restoration Project					
	Urban Impervious Acres	Urban Pervious Acres	Total Urban Acres	Forested Acres	
Regulated Land	2.51	1.7	4.21	1.8	
Unregulated Land	0	0	0	0	Total
		Total	4.21	1.8	6.01

Total Reductions for Regulated and Unregulated Urban Lands				
	Ratios	TN Credit	TP Credit	TSS Credit
Regulated Acres	0.70	42.03	19.61	36,425.96
Unregulated Acres	0.00	0.00	0.00	0.00
Forested Acres	0.30			

Total Baseline Unregulated Land Reductions Adjustment						
		Loading rate (Table 3a)	x 20	x Unregulated Acres	Total Reduction	Subtract from Credit
Regulated Urban Impervious	TN	0.04	0.8	0	0	0.00
Regulated Urban Pervious		0.02	0.4	0		
Regulated Urban Impervious	TP	0.01	0.2	0	0	0.00
Regulated Urban Pervious		0.002	0.04	0		
Regulated Urban Impervious	TSS	6.67	133.4	0	0	0.00
Regulated Urban Pervious		0.44	8.8	0		

Total Adjusted Reductions	
TN Credit	**42.03**
TP Credit	**19.61**
TSS Credit	**36,425.96**

Name: Fleet's Branch Stream Restoration

Linear Feet of Restoration: 2,000

POC Reductions from BANCS Assessment		
TN	TP	TSS
424	196	372,000

Acres Draining Stream Restoration Project					
	Urban Impervious Acres	Urban Pervious Acres	Total Urban Acres	Forested Acres	
Regulated Land	97.1	316.69	413.79	65.76	
Unregulated Land	0	0	0	0	Total
		Total	413.79	65.76	479.55

Total Reductions for Regulated and Unregulated Urban Lands				
	Ratios	TN Credit	TP Credit	TSS Credit
Regulated Acres	0.86	365.86	169.12	320,988.18
Unregulated Acres	0.00	0.00	0.00	0.00
Forested Acres	0.14			

Total Baseline Unregulated Land Reductions Adjustment						
		Loading rate (Table 3a)	x 20	x Unregulated Acres	Total Reduction	Subtract from Credit
Regulated Urban Impervious	TN	0.04	0.8	0	0	0.00
Regulated Urban Pervious		0.02	0.4	0		
Regulated Urban Impervious	TP	0.01	0.2	0	0	0.00
Regulated Urban Pervious		0.002	0.04	0		
Regulated Urban Impervious	TSS	6.67	133.4	0	0	0.00
Regulated Urban Pervious		0.44	8.8	0		

Total Adjusted Reductions	
TN Credit	**365.86**
TP Credit	**169.12**
TSS Credit	**320,988.18**