Benthic TMDL Development Stressor Analysis Report

Cunningham Creek

Fluvanna County, Virginia

Submitted by:

Virginia Department of Environmental Quality

Prepared by:

Department of Biological Systems Engineering; Virginia Tech

Draft: March 21, 2016

VT-BSE Document No. 2016-0001

Project Personnel

Virginia Tech, Department of Biological Systems Engineering

Gene Yagow, Senior Research Scientist: Project Manager
Brian Benham, Professor and Extension Specialist: Project Director

Virginia Department of Environmental Quality (DEQ)

Tara Sieber, Regional TMDL Coordinator, Valley Regional Office, Harrisonburg
Nesha McRae, Regional Nonpoint Source Coordinator
Don Kain, Water Permitting Program Manager, Valley Regional Office, Harrisonburg
Liz McKercher, Watershed Programs Manager, Central Office

For additional information, please contact:

Virginia Department of Environmental Quality

Water Quality Assessment Office, Richmond: Liz McKercher, (804) 698-4291
Valley Region Office, Harrisonburg: Tara Seiber, (540) 574-7870

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1.0 Defining the Cause of Impairment

Basis for Impairment

A biological impairment in Virginia is based on the biological monitoring and assessment of benthic macroinvertebrate inventories and a related habitat evaluation. Biomonitoring allows the Virginia Department of Environmental Quality (DEQ) to assess the overall ecological condition of streams and rivers by evaluating stream condition with respect to suitability for support of aquatic communities. In Virginia, benthic macroinvertebrate communities are used as indicators of ecological condition and are one way to determine support for the aquatic life designated use. A multimetric macroinvertebrate index, the Virginia Stream Condition Index (VSCI), is used to assess the aquatic life use status of wadeable freshwater streams and rivers in non-coastal areas of the state. The VSCI combines a series of biological metrics that are regionally calibrated to an appropriate reference condition (VDEQ, 2006a), and combines them into a single value that is sensitive to a wide range of stressors. Streams with VSCI values less than 60 are deemed to be impaired, while those with VSCI values equal to or greater than 60 are considered to be healthy. The stream segments described below are Piedmont Zones Class III Non-Tidal Waters (9VAC25-260-50)

Stream Segment VAV-H32R_CNM02A04: This stream segment consists of the (Upper) Middle Fork Cunningham Creek and a tributary from the headwaters downstream to its confluence with an unnamed tributary originating near Antioch. The Virginia Department of Environmental Quality (DEQ) has identified this impairment as Cause Group Code H32R-01-BEN. The DEQ Draft 2014 Impaired Waters Fact Sheets for Category 5 Waters (VDEQ, 2014) state that this 4.02-mile segment was originally listed as impaired due to water quality exceedances of the general aquatic life (benthic) standard in the 2004 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report. This segment had been fully supporting for VSCI benthic assessment during the 2010 cycle. The source of this benthic impairment has been determined to be natural conditions (drought). The segment remains listed as “impaired”, since two consecutive non-impaired benthic assessments are required to delist. The 2004 impairment assessment was apparently based on observations at stations 2-CNM003.82. The suspected source of impairment is listed as natural conditions.

Stream Segment VAV-H32R_CNM01A00: This stream segment constitutes (Lower) Middle Fork Cunningham Creek from its confluence with an unnamed tributary originating near Antioch, downstream to its confluence with Cunningham Creek. The Virginia Department of Environmental Quality (DEQ) has identified this impairment as Cause Group Code H32R-02-BEN. The DEQ Draft 2014 Impaired Waters Fact Sheets for Category 5 Waters (VDEQ, 2014) state that this 3.46-mile segment was originally listed as impaired due to water quality exceedances of the general aquatic life (benthic) standard in the 2010 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report and that the impairment assessment was based on observations at stations 2-CNM001.75, 2-CNM002.25, 2-CNM05-SW, and 2-CNM07-SW. The suspected source of impairment is listed as non-point sources.

Stream Segment VAV-H32R_XCF01A10: This stream segment constitutes an unnamed tributary to North Fork Cunningham Creek from the headwaters, downstream to its confluence with the North Fork Cunningham Creek. The Virginia Department of Environmental Quality

(DEQ) has identified this impairment as Cause Group Code H32R-04-BEN. The DEQ Draft 2014 Impaired Waters Fact Sheets for Category 5 Waters (VDEQ, 2014) state that this 0.59-mile segment was originally listed as impaired due to water quality exceedances of the general aquatic life (benthic) standard in the 2010 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report and that the impairment assessment was based on observations at station 2-XCF01-SW. Suspected sources of impairment are listed as municipal (urbanized high density area) and non-point sources.

Stream Segment VAV-H32R_CFK01A00: This stream segment constitutes North Fork Cunningham Creek from the Fluvanna Ruritan Lake outfall, downstream to its confluence with Cunningham Creek. The Virginia Department of Environmental Quality (DEQ) has identified this impairment as Cause Group Code H32R-05-BEN. The DEQ Draft 2014 Impaired Waters Fact Sheets for Category 5 Waters (VDEQ, 2014) state that this 4.18-mile segment was originally listed as impaired due to water quality exceedances of the general aquatic life (benthic) standard in the 2012 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report and that the impairment assessment was based on observations at stations 2-CFK001.31. The suspected source of impairment is listed as non-point sources.

Stream Segment VAV-H32R_CXB01A00: This stream segment constitutes Cunningham Creek from the confluence of the Middle/South Fork Cunningham Creek downstream to its confluence with the Rivanna River. The Virginia Department of Environmental Quality (DEQ) has identified this impairment as Cause Group Code H32R-06-BEN. The DEQ Draft 2014 Impaired Waters Fact Sheets for Category 5 Waters (VDEQ, 2014) state that this 5.56-mile segment was originally listed as impaired due to water quality exceedances of the general aquatic life (benthic) standard in the 2012 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report and that the impairment assessment was based on observations at stations 2-CXB000.86 and 2-CXB02-SW. The suspected source of impairment is listed as non-point sources.

All stream segments within these watersheds are Piedmont Zones Class III Non-Tidal Waters (9VAC25-260-50).

The DEQ, Stream Watch (SW), and Save Our Streams (SOS) biological monitoring stations are shown in Figure 1-1. Additional DEQ ambient monitoring stations are also shown in the figure. The correspondence between impaired segments, monitoring sites and modeling sub-watersheds are further clarified in Table 1-1.

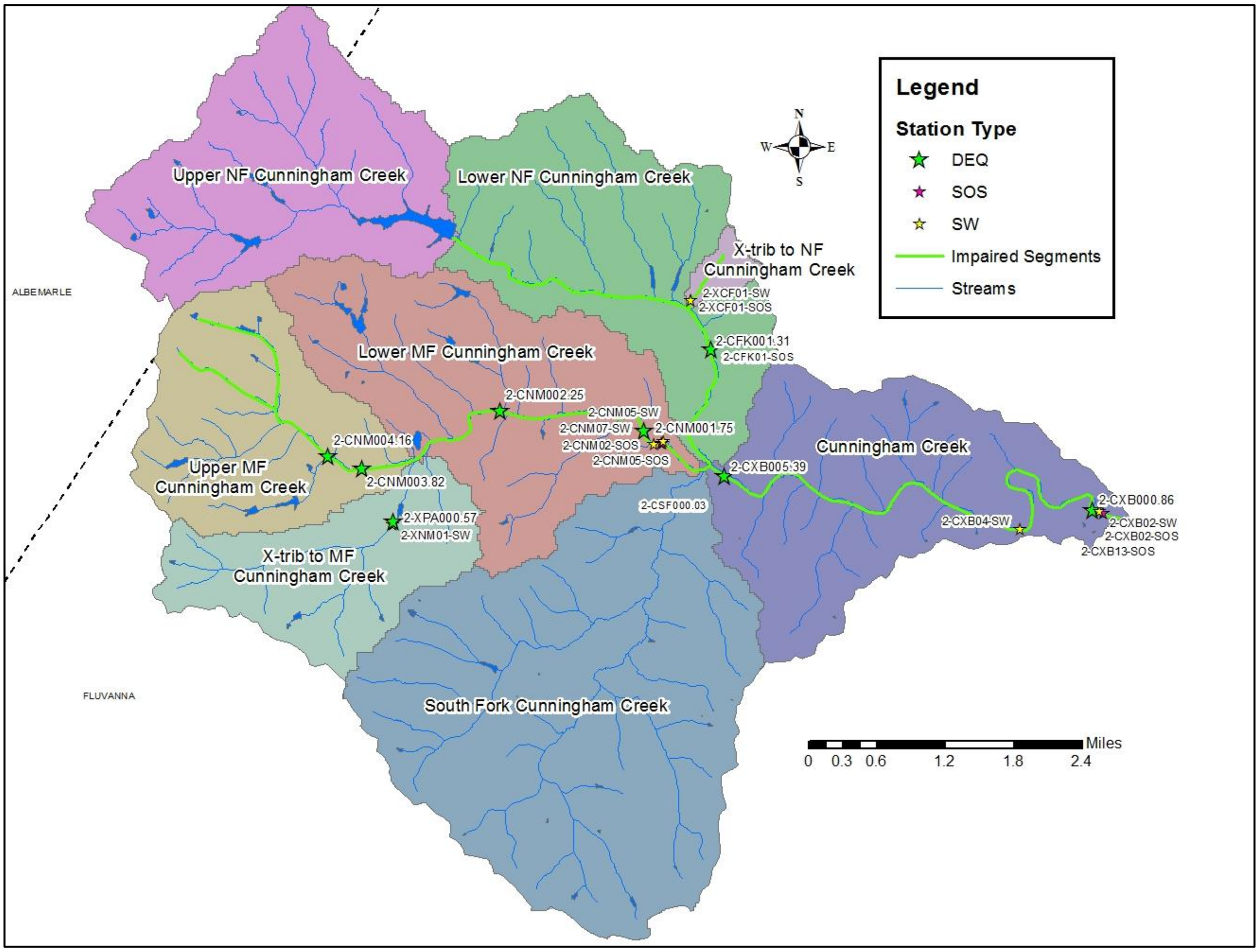

Figure 1-1. DEQ and Other Monitoring Sites in the Cunningham Creek Watershed

Table 1-1. Correspondence between Impaired Segments, Monitoring Stations, and Sub-Watersheds

SubWS ID	Sub-Watershed	Impaired Segment	Biological Monitoring Station ID			Other DEQ Station ID	Other Type*
			DEQ	SW	SOS		
1	Cunningham Creek	**CXB01A00**	2-CXB000.86	2-CXB02-SW 2-CXB04-SW	2-CXB13-SOS 2-CXB02-SOS	2-CXB000.86 2-CXB005.39	Amb, Phab; Amb
2	Lower NF Cunningham Creek	**CFK01A00**	2-CFK001.31		2-CFK01-SOS	2-CFK001.31	Amb, Phab
3	X-trib to NF Cunningham Creek	**XCF01A10**		2-XCF01-SW	2-XCF01-SOS		
4	Upper NF Cunningham Creek						
5	South Fork Cunningham Creek					2-CSF000.03	Phab
6	Lower MF Cunningham Creek	**CNM01A00**	2-CNM001.75 2-CNM002.25	2-CNM05-SW 2-CNM07-SW	2-CNM02-SOS 2-CNM05-SOS	2-CNM001.75 2-CNM002.25	Amb, Phab; Amb
7	X-trib to MF Cunningham Creek			2-XNM01-SW	2-CNM01-SOS	2-XPA000.57	Amb
8	Upper MF Cunningham Creek	**CNM02A04**	2-CNM003.82			2-CNM004.16	Amb

Note: Monitoring stations listed as being along the same impaired segment are not necessarily co-located.

* Amb = DEQ ambient monitoring station; Phab = Physical Habitat monitoring station.

1.1. DEQ Biological Data

The benthic macroinvertebrate data collected by DEQ in Upper Middle Fork Cunningham Creek, Lower Middle Fork Cunningham Creek, North Fork Cunningham Creek, and Cunningham Creek and an unnamed tributary are summarized, respectively, in Table 1-2 through Table 1-8. These tables include inventories of individual taxa and miscellaneous metrics for each sample. Biological monitoring data were obtained from the Valley Regional Office of DEQ and their

EDAS database, available at: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/ProbabilisticMonitoring/ProbMonDataSources.aspx.

Table 1-2. Taxa Inventory for Upper Middle Fork Cunningham Creek (2-CNM003.82)

Family	Functional Family Group	Tolerance Value	04/29/02	03/26/03
Leuctridae	Shredder	0	18	
Rhyacophilidae	Predator	0		1
Gomphidae	Predator	1	1	
Athericidae	Predator	2	1	
Leptophlebiidae	Collector	2	4	
Nemouridae	Shredder	2	2	41
Perlodidae	Predator	2		3
Taeniopterygidae	Shredder	2	2	
Tipulidae	Shredder	3	2	2
Baetidae	Collector	4	4	
Elmidae	Scraper	4	2	11
Ephemerellidae	Collector	4		16
Heptageniidae	Scraper	4		1
Cambaridae	Shredder	5		2
Corydalidae	Predator	5		1
Dryopidae	Shredder	5		1
Chironomidae (A)	Collector	6	91	14
Gammaridae	Collector	6		1
Simuliidae	Filterer	6	2	1
Lumbriculidae	Collector	8	1	
Sphaeriidae	Filterer	8	1	1
Tubificidae	Collector	10	1	
VSCI			**37.7**	**62.9**
Scraper/Filter-Collector Ratio			0.02	0.36
%Filterer-Collector			78.8%	34.4%
%Haptobenthos			3.0%	36.5%
%Shredders			18.2%	47.9%

[shaded box] - Dominant 2 species in each sample.

VSCI: Optimal > 60; suboptimal < 50.

Table 1-3. Taxa Inventory for Lower Middle Fork Cunningham Creek (2-CNM001.75)

Family	Functional Family Group	Tolerance Value	04/10/08	10/29/08	04/26/10	11/01/10	03/30/11	11/02/11	04/09/15	10/20/15
Glossosomatidae	Scraper	0	3							
Capniidae	Shredder	1		7				2		
Chloroperlidae	Predator	1			4		2			
Gomphidae	Predator	1		1						3
Haploperla		1							2	
Leptophlebiidae	Collector	1								3
Perlidae	Predator	1	1		15				2	
Stenelmis	Scraper	1							2	
Tipulidae	Predator	1								4
Ephemerella	Collector	2							15	
Isonychiidae	Filterer	2						1		2
Isoperla	Predator	2							2	
Leptophlebiidae		2						2		
Nemouridae	Shredder	2	26		1		3			
Perlodidae	Predator	2					4			
Taeniopterygidae	Shredder	2		17		2		9		
Chimarra	Filterer	3							3	
Philopotamidae	Collector	3		1		2	1	2		
Philopotamidae	Filterer	3								2
Simuliidae	Filterer	3								2
Simulium	Filterer	3							8	
Tipulidae	Shredder	3			1	1				
Baetidae	Collector	4	14		17					
Caenidae	Collector	4		1				1		
Elmidae	Scraper	4	10	7	18	69	22	56		62
Elmidae		4								12
Elmidae	Collector	4							9	
Ephemerellidae	Collector	4	4		4		26			
Heptageniidae	Scraper	4		1	1			17		
Heptageniidae		4								5
Optioservus	Scraper	4							12	
Oulimnius		4							9	
Plauditus		5							2	
Ceratopogonidae	Predator	6		1	1	1		1		2
Chironomidae (A)	Collector	6	4	5	30	3	7	4		
Chironomidae (A)		6							30	3
Hydropsychidae		6	2	58	2	33	2	10		6
Simuliidae		6	2	2	3		39	4		
Lymnaeidae	Scraper	7	11			1				
Planorbidae	Scraper	7	2	1			1			
Corbiculidae	Filterer	8	35			2	1			
Leuctra	Shredder	(blank)							3	
VSCI			61.6	**51.1**	60.5	46.1	**56.2**	66.0	64.5	**57.8**
Scraper/Filter-Collector Ratio			0.46	1.29	0.37	10.00	0.66	9.13	0.40	6.89
%Filterer-Collector			50.0%	6.9%	52.6%	6.1%	32.4%	7.3%	35.4%	8.5%
%Haptobenthos			19.3%	67.6%	48.5%	91.2%	88.9%	81.7%	11.1%	84.0%
%Shredders			22.8%	23.5%	2.1%	2.6%	2.8%	10.1%	3.0%	0.0%

[shaded box] - Dominant 2 species in each sample.

* An additional number of taxa (40) were identified with only 1 organism in all samples.

VSCI: Optimal > 60; suboptimal < 50.

Table 1-4. Taxa Inventory for Lower Middle Fork Cunningham Creek (2-CNM002.25)

Family	Functional Family Group	Tolerance Value	04/29/02	03/26/03	04/21/04	10/27/04	05/11/07
Leuctridae	Shredder	0	7				
Capniidae	Shredder	1		1		12	
Perlidae	Predator	1	1		13		
Isonychiidae	Filterer	2			1		2
Leptophlebiidae	Collector	2	3				
Nemouridae	Shredder	2	10	10	5		2
Perlodidae	Predator	2		1	1		1
Taeniopterygidae	Shredder	2				11	
Philopotamidae	Collector	3	2	4	3	2	
Tipulidae	Shredder	3	5	2		1	
Baetidae	Collector	4	2		16	5	11
Elmidae	Scraper	4	15		4	3	1
Ephemerellidae	Collector	4			4	1	1
Heptageniidae	Scraper	4	3		2	12	
Ceratopogonidae	Predator	6		2			
Chironomidae (A)	Collector	6	72	13	29	13	14
Empididae	Predator	6	1	2	3	1	
Hydropsychidae	Filterer	6			2	10	3
Simuliidae	Filterer	6	7	1	5	39	71
Chaoboridae	Predator	7		2			
Asellidae	Collector	8		4	1	4	
Lumbriculidae	Collector	8	2	46			
Naididae	Collector	8	1	3	8		
Sphaeriidae	Filterer	8	4	17	15		
Tubificidae	Collector	10	2	4	11	1	
VSCI			**48.9**	**45.8**	**63.4**	**65.7**	**38.4**
Scraper/Filter-Collector Ratio			0.19	0.00	0.06	0.20	0.01
%Filterer-Collector			69.3%	82.1%	77.2%	65.2%	96.2%
%Haptobenthos			20.4%	5.4%	27.6%	58.3%	72.6%
%Shredders			16.1%	11.6%	4.1%	20.9%	1.9%

- Dominant 2 species in each sample.

* An additional number of taxa (9) were identified with only 1 organism in all samples.

VSCI: Optimal > 60; suboptimal < 50.

Table 1-5.Taxa Inventory for North Fork Cunningham Creek (2-CFK001.31)

Family	Functional Family Group	Tolerance Value	04/26/10	11/02/11	04/19/12	10/22/12	04/09/15	10/20/15
Leuctridae	Shredder	0	6		2			
Gomphidae	Predator	1			2			
Perlidae	Predator	1	10	1	11		1	
Amphinemura	Shredder	2					11	
Ephemerella	Collector	2					7	
Leptophlebiidae		2		1		1		
Nemouridae	Shredder	2			16			
Nigronia	Predator	2					2	
Peltoperlidae	Shredder	2	3					
Taeniopterygidae	Shredder	2		12		3		2
Hydropsychidae	Filterer	3						2
Perlidae		3						3
Philopotamidae	Collector	3		7		9		
Simulium	Filterer	3					7	
Tipulidae	Shredder	3		1	1	1		
Baetidae	Collector	4	4		1	1		
Elmidae		4	8	56	24	31		31
Elmidae		4						11
Elmidae	Collector	4					7	4
Ephemerellidae	Collector	4	11	1	7	1		
Heptageniidae	Scraper	4		78	2	32		
Heptageniidae		4						21
Optioservus	Scraper	4					15	
Oulimnius		4					9	
Hydracarina (unknown)	Predator	5		4				
Ceratopogonidae	Predator	6		5				1
Chironomidae (A)	Collector	6	31	15	30	3		
Chironomidae (A)		6					39	14
Corbiculidae	Filterer	6						2
Hydropsychidae		6	2	26	5	26		8
Simuliidae		6	22	8	7			
Lumbriculidae	Collector	8		1				1
Naididae	Collector	8	5					
Sphaeriidae	Filterer	8						2
Tubificidae	Collector	9					2	
Tubificidae		10		2				
Maccaffertium		(blank)					4	
VSCI			**51.1**	**65.4**	**63.4**	**69.2**	**55.2**	**63.5**
Scraper/Filter-Collector Ratio			0.00	3.25	0.05	2.29	0.65	0.00
%Filterer-Collector			50.0%	11.0%	35.2%	13.0%	22.1%	10.8%
%Haptobenthos			54.9%	81.2%	51.9%	91.7%	7.7%	78.4%
%Shredders			8.8%	6.0%	17.6%	3.7%	10.6%	2.0%

[shaded box] - Dominant 2 species in each sample.

* An additional number of taxa (20) were identified with only 1 organism in all samples.

VSCI: Optimal > 60; suboptimal < 50.

Table 1-6. Taxa Inventory for Cunningham Creek (2-CXB000.86)

Family	Functional Family Group	Tolerance Value	04/10/08	10/22/08	04/26/10	11/01/10	11/02/11	04/19/12	04/09/15	10/20/15
Capniidae	Shredder	1		3		6	5			2
Chloroperlidae	Predator	1						1	2	
Ephemerellidae	Collector	1							3	
Goera		1							2	
Gomphidae	Predator	1					2			
Perlidae	Predator	1	1		1			6		
Stenelmis	Scraper	1							2	
Amphinemura	Shredder	2							3	
Ephemerella	Collector	2							3	
Isonychiidae	Filterer	2	2	2	2		2			1
Leptophlebiidae	Collector	2		1	2					1
Nemouridae	Shredder	2	22		3			6		
Perlodidae	Predator	2	1							1
Taeniopterygidae	Shredder	2		27		43	33	1		17
Chimarra	Filterer	3							4	
Hydropsychidae	Filterer	3								3
Philopotamidae	Collector	3	2	51		2	2			4
Philopotamidae	Filterer	3							1	1
Simuliidae	Filterer	3								21
Simulium	Filterer	3							5	
Baetidae	Collector	4	26		17		2	16	1	
Caenidae	Collector	4				1	3			
Elmidae	Scraper	4		5	5	21	19	3		17
Ephemerellidae		4	4		4		1	1		
Heptageniidae	Scraper	4	1	6	1	1	21	12		1
Heptageniidae		4								15
Optioservus	Scraper	4							2	
Oulimnius		4							4	
Pleuroceridae	Scraper	4	1			2	1			
Corydalidae	Predator	5	1	1		3				1
Plauditus		5							4	
Pleuroceridae		5							2	
Cheumatopsyche	Filterer	6							2	
Chironomidae (A)	Collector	6	23	5	23	6	6	51		
Chironomidae (A)		6							56	14
Hydropsychidae		6	3	15	1	9		5		4
Simuliidae		6	5	3	53	3	4	7		
Lymnaeidae	Scraper	7				3				
Asellidae	Collector	8	1			1				
Corbiculidae	Filterer	8	2				2			
Naididae	Collector	8			1			1		
Physidae	Scraper	8				3				
Sphaeriidae	Filterer	8		1		2			1	
Coenagrionidae	Predator	9					2			
Naididae		9							2	
Tubificidae	Collector	9								2
Sparganophilidae	Collector	10					2			1
Tubificidae		10			1		1			
Maccaffertium		(blank)							2	
VSCI			66.8	61.4	**51.2**	65.9	82.2	**52.3**	**56.4**	71.5
Scraper/Filter-Collector Ratio			0.04	0.18	0.13	2.50	2.16	0.22	0.20	0.53
%Filterer-Collector			58.9%	50.0%	39.5%	11.3%	17.6%	61.8%	19.8%	32.1%
%Haptobenthos			20.0%	67.5%	57.0%	38.7%	44.4%	31.8%	7.9%	64.2%
%Shredders			23.2%	25.0%	2.6%	46.2%	35.2%	6.4%	3.0%	17.9%

- Dominant 2 species in each sample.

* An additional number of taxa (19) were identified with only 1 organism in all samples.

VSCI: Optimal > 60; suboptimal < 50.

Table 1-7 and Table 1-8 include the VSCI metric scores and overall ratings. The Middle Fork Cunningham Creek stations are included in Table 1-7, and those for North Fork and Cunningham Creek in Table 1-8. Table 1-9 includes a description of the individual metrics that comprise the VSCI. Graphs of individual sample VSCI scores are shown for Middle Fork Cunningham Creek in Figure 1-2, and for the North Fork and main stem Cunningham Creek in Figure 1-3.

The primary biological effects were assessed as those individual VSCI metrics with scores less than 20. The primary biological effects at all Cunningham Creek sites were low percentages of the sensitive ephemeroptera, plecoptera, and tricoptera (EPT) families, and low percentages of scrapers.

Table 1-7. DEQ Virginia Stream Condition (VSCI) Metric Scores – Middle Fork Cunningham Creek

StationID	2-CNM001.75								2-CNM002.25					2-CNM003.82	
StreamName	Middle Fork Cunningham Creek														
CollDate	04/10/08	10/29/08	04/26/10	11/01/10	03/30/11	11/02/11	04/09/15	10/20/15	04/29/02	03/26/03	04/21/04	10/27/04	05/11/07	04/29/02	03/26/03
RepNum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
VSCI Metric Values															
Total Taxa	13	12	13	9	13	13	19	14	17	17	19	18	9	14	14
EPT Taxa	6	6	7	3	6	8	10	6	7	5	10	9	6	5	5
%Ephemeroptera	15.7	2.0	22.4	0.0	23.6	19.1	16.4	10.0	5.8	0.0	18.4	15.1	13.2	6.1	17.7
%PT - Hydropsychidae	26.1	24.5	20.4	3.5	9.1	11.8	13.6	1.8	14.5	14.9	18.4	22.7	2.8	16.7	46.9
%Scrapers	22.6	8.8	19.4	61.4	21.8	66.4	30.0	71.8	13.0	0.0	6.4	13.4	0.9	1.5	12.5
%Chironomidae Score	3.5	4.9	30.6	2.6	6.4	3.6	27.3	2.7	52.2	11.4	23.2	10.9	13.2	68.9	14.6
%2Dominant	53.0	73.5	49.0	89.5	59.1	66.4	56.4	73.6	63.0	55.3	36.0	43.7	80.2	82.6	59.4
HBI	5.1	4.7	4.1	4.7	4.8	4.1	4.6	4.0	5.0	6.7	5.5	4.7	5.6	4.8	3.4
VSCI Metric Scores															
Total Taxa Score	59.1	54.5	59.1	40.9	59.1	59.1	86.4	63.6	77.3	77.3	86.4	81.8	40.9	63.6	63.6
EPT Score	54.5	54.5	63.6	27.3	54.5	72.7	90.9	54.5	63.6	45.5	90.9	81.8	54.5	45.5	45.5
%Ephem Score	25.5	3.2	36.6	0.0	38.6	31.1	26.7	16.3	9.5	0.0	30.0	24.7	21.5	9.9	28.9
%PT-H Score	73.3	68.8	57.3	9.9	25.5	33.2	38.3	5.1	40.7	41.9	51.7	63.7	7.9	46.8	100.0
%Scraper Score	43.8	17.1	37.6	100.0	42.3	100.0	58.1	100.0	25.3	0.0	12.4	26.1	1.8	2.9	24.2
%Chironomidae Score	96.5	95.1	69.4	97.4	93.6	96.4	72.7	97.3	47.8	88.6	76.8	89.1	86.8	31.1	85.4
%2Dominant Score	67.9	38.3	73.7	15.2	59.1	48.6	63.1	38.1	53.4	64.6	92.5	81.4	28.6	25.2	58.7
%HBI Score	72.0	77.3	86.3	78.2	76.5	86.9	79.8	87.7	73.6	48.4	66.4	77.2	65.2	76.5	96.5
VSCI	**61.6**	**51.1**	**60.5**	**46.1**	**56.2**	**66.0**	**64.50**	**57.8**	**48.9**	**45.8**	**63.4**	**65.7**	**38.4**	**37.7**	**62.9**
VSCI Rating	**Good**	**Stressed**	**Good**	**Stressed**	**Stressed**	**Good**	**Good**	**Stressed**	**Stressed**	**Stressed**	**Good**	**Good**	**Severe Stress**	**Severe Stress**	**Good**

- Primary biological effects.

Table 1-8. DEQ Virginia Stream Condition (VSCI) Metric Scores – North Fork and Main Stem, Cunningham Creek

StationID	2-CFK001.31							2-CXB000.86							
StreamName	North Fork Cunningham Creek							Cunningham Creek							
CollDate	04/26/10	11/02/11	11/02/11	04/19/12	10/22/12	04/09/15	10/20/15	04/10/08	10/22/08	04/26/10	11/01/10	11/02/11	04/19/12	04/09/15	10/20/15
RepNum	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
VSCI Metric Values															
Total Taxa	10	14	11	14	12	15	16	16	12	15	15	19	12	20	17
EPT Taxa	6	5	6	8	8	7	7	10	7	9	6	10	8	10	9
%Ephemeroptera	14.7	31.8	40.9	9.1	32.7	10.0	20.9	34.4	7.5	22.4	1.9	27.3	26.4	13.6	17.3
%PT - Hydropsychidae	18.6	7.3	10.9	27.3	10.9	12.7	5.5	28.1	67.5	4.3	47.7	37.3	12.7	13.6	22.7
%Scrapers	7.8	56.4	65.5	23.6	57.3	32.7	62.7	2.1	9.2	6.0	29.0	38.2	13.6	13.6	30.9
%Chironomidae Score	30.4	10.9	2.7	27.3	2.7	35.5	12.7	24.0	4.2	19.8	5.6	5.5	46.4	50.9	12.7
%2Dominant	52.0	56.4	65.5	49.1	57.3	63.6	62.7	51.0	65.0	65.5	59.8	49.1	60.9	58.2	35.5
HBI	4.7	4.6	4.3	4.0	4.4	4.8	4.5	4.2	3.4	5.3	3.7	3.6	4.9	5.0	4.5
VSCI Metric Scores															
Total Taxa Score	45.5	63.6	50.0	63.6	54.5	68.2	72.7	72.7	54.5	68.2	68.2	86.4	54.5	90.9	77.3
EPT Score	54.5	45.5	54.5	72.7	72.7	63.6	63.6	90.9	63.6	81.8	54.5	90.9	72.7	90.9	81.8
%Ephem Score	24.0	51.9	66.7	14.8	53.4	16.3	34.1	56.1	12.2	36.6	3.0	44.5	43.0	22.2	28.2
%PT-H Score	52.3	20.4	30.6	76.6	30.6	35.8	15.3	79.0	100.0	12.1	100.0	100.0	35.8	38.3	63.8
%Scraper Score	15.2	100.0	100.0	45.8	100.0	63.4	100.0	4.0	17.8	11.7	56.1	74.0	26.4	26.4	59.9
%Chironomidae Score	69.6	89.1	97.3	72.7	97.3	64.5	87.3	76.0	95.8	80.2	94.4	94.5	53.6	49.1	87.3
%2Dominant Score	69.4	63.1	49.9	73.6	61.7	52.5	53.9	70.7	50.6	49.8	58.1	73.6	56.5	60.4	93.3
%HBI Score	78.1	78.7	84.2	87.6	82.9	76.9	80.7	85.2	96.7	69.6	93.0	93.4	75.5	73.1	80.3
VSCI	**51.1**	**64.0**	**66.7**	**63.4**	**69.2**	**55.2**	**63.5**	**66.8**	**61.4**	**51.2**	**65.9**	**82.2**	**52.3**	**56.4**	**71.5**
VSCI Rating	**Stressed**	**Good**	**Good**	**Good**	**Good**	**Stressed**	**Good**	**Good**	**Good**	**Stressed**	**Good**	**Excellent**	**Stressed**	**Stressed**	**Good**

(shaded) - Primary biological effects.

Table 1-9. Component Metrics of the Virginia Stream Condition Index (VSCI)

Metric	Description	Measures…	Response to Pollution
Total Taxa	Number of distinct taxa	overall variety of macroinvertebrate assemblage	Decrease
EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera taxa	prevalence of pollutant-sensitive mayflies, stoneflies, and caddis flies	Decrease
%Ephemeroptera	Percent of individuals Ephemeroptera	pollutant-sensitive mayflies	Decrease
%PT - Hydropsychidae	Percent individuals of Plecoptera, and Trichoptera, excluding Hydropsychidae	pollutant-sensitive stoneflies and caddis flies without counting pollution-insensitive net-spinning caddis flies	Decrease
%Scrapers	Percent individuals from scraper functional feeding group	macroinvertebrates which graze on substrate- or periphyton-attached algae	Decrease
%Chironomidae	Percent of individuals Chironomidae	pollution-tolerant midge larvae	Increase
%2Dominant	Percent of individuals from two most dominant taxa	diversity of benthic community	Increase
HBI	Family-level Hilsenhoff Biotic Index	average tolerance to pollution of benthic community, weighted by abundance	Increase

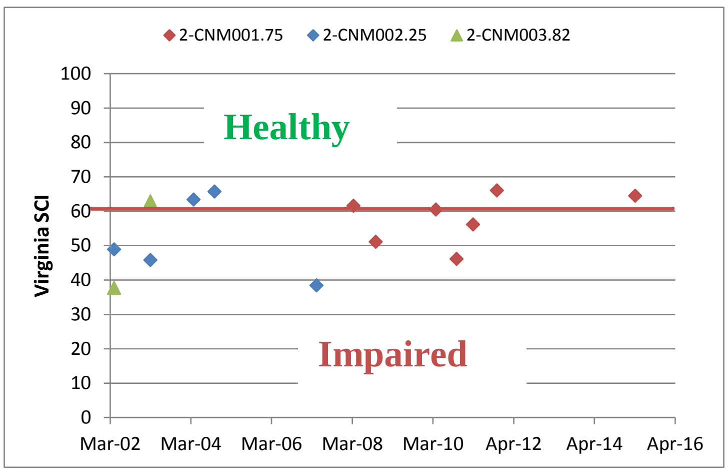

Figure 1-2. DEQ VSCI Scores for Middle Fork Cunningham Creek

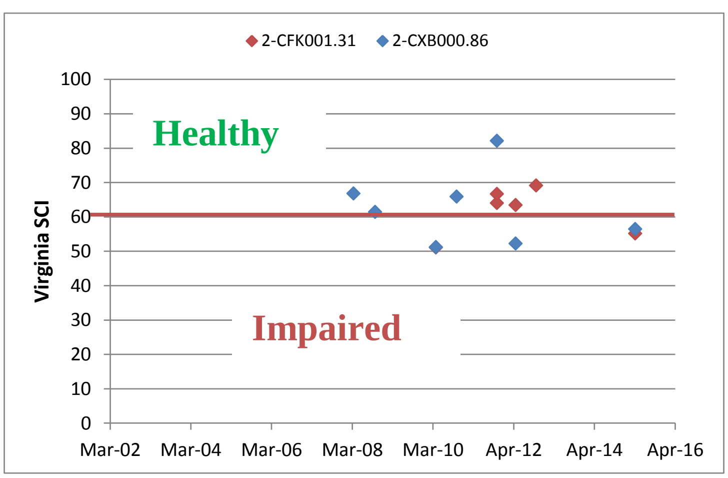

Figure 1-3. DEQ VSCI Scores for North Fork and Main Stem, Cunningham Creek

1.2. DEQ Habitat Data

The habitat assessment data for Middle Fork Cunningham Creek stations are shown in Table 1-11 for North Fork Cunningham Creek in Table 1-11, and for the main stem Cunningham Creek in Table 1-12. Habitat data collected as part of the biological monitoring were also obtained from the Valley Regional Office of DEQ. The 10-metric total possible score is 200; scores less than 120 are considered sub-optimal, and those greater than 150 as optimal. For the Middle Fork Cunningham Creek, the “bank stability”, “vegetative protection”, “riparian vegetative zone width” and “sediment deposition” metrics often received “marginal” or “poor” scores at the downstream site (2-CNM001.75), while fewer “poor” ratings were given to the upstream sites. At the North Fork Cunningham Creek site, the “sediment deposition” and “epifaunal substrate” metrics often received “marginal” or “poor” scores. The main stem Cunningham Creek also shows “marginal” or “poor” scores for “sediment deposition” and “epifaunal substrate” metrics, as well as “bank stability” with decreasing scores since 2011. The missing metric values on 04/19/12 at 2-CFK001.31 and on 04/08/10 at 2-CXB000.86 were the result of sampling errors.

Table 1-10. DEQ Habitat Evaluation Summary for the Middle Fork Cunningham Creek

StationID	2-CNM001.75								2-CNM002.25					2-CNM003.82	
Collection Date	04/10/08	10/29/08	04/26/10	11/01/10	03/30/11	11/02/11	04/09/15		04/29/02	03/26/03	04/21/04	10/27/04	05/11/07	04/29/02	03/26/03
Channel Alteration	15	18	18	18	19	18	18		19	20	18	18	18	15	15
Bank Stability[1]	16	14	14	10	14	14	12		12	8	8	10	8	12	6
Vegetative Protection[1]	15	13	16	16	17	16	18		14	17	4	6	12	20	18
Embeddedness	10	12	12	9	7	10	14		13	12	4	10	10	13	8
Channel Flow Status	16	13	17	15	17	18	17		17	16	9	11	17	12	18
Frequency of riffles (or bends)	16	13	17	16	17	18	16		17	14	19	18	12	18	12
Riparian Vegetative Zone Width[1]	15	7	7	8	7	8	9		4	2	2	2	4	20	20
Sediment Deposition	10	8	8	8	3	5	2		11	13	6	11	12	16	6
Epifaunal Substrate / Available Cover	10	8	9	11	10	8	3		14	11	5	5	5	15	10
Velocity / Depth Regime	16	15	16	16	16	16	16		14	20	14	14	14	13	17
10-Metric Total Habitat Score[2]	**139**	**121**	**134**	**127**	**127**	**131**	**125**		**135**	**133**	**89**	**105**	**112**	**154**	**130**

- Marginal or Poor habitat metric rating.

[1] Metric is the sum of scores for both the left and right banks.

[2] Total Habitat Score: optimal > 150; suboptimal < 120.

Table 1-11. DEQ Habitat Evaluation Summary for the North Fork Cunningham Creek

StationID	2-CFK001.31					
Collection Date	04/26/10	11/02/11	04/19/12	10/22/12	04/09/15	
Channel Alteration	17	18		18	18	
Bank Stability[1]	12	15	12	16	14	
Vegetative Protection[1]	13	18	18	15	16	
Embeddedness	12	10	11	12	13	
Channel Flow Status	18	17		11	17	
Frequency of riffles (or bends)	16	17		15	14	
Riparian Vegetative Zone Width[1]	15	16	16	16	14	
Sediment Deposition	9	6	6	15	7	
Epifaunal Substrate / Available Cover	9	11	10	10	13	
Velocity / Depth Regime	16	15	16	13	15	
10-Metric Total Habitat Score[2]	**137**	**143**	**89**	**141**	**141**	

- Marginal or Poor habitat metric rating.

[1] Metric is the sum of scores for both the left and right banks.

[2] Total Habitat Score: optimal > 150; suboptimal < 120.

Table 1-12. DEQ Habitat Evaluation Summary for the main stem, Cunningham Creek

StationID	2-CXB000.86							
Collection Date	04/10/08	10/22/08	04/26/10	11/01/10	11/02/11	04/19/12	04/09/15	
Channel Alteration	13	14	13	15	15	15	13	
Bank Stability[1]	14	14	11	11	11	10	10	
Vegetative Protection[1]	10	13	13	16	13	12	16	
Embeddedness		17	11	11	10	11	12	
Channel Flow Status	18	13	18	15	16	18	18	
Frequency of riffles (or bends)	17	16	16	16	17	17	17	
Riparian Vegetative Zone Width[1]	17	11	18	18	18	17	16	
Sediment Deposition	13	15	11	11	7	5	7	
Epifaunal Substrate / Available Cover		17	12	11	9	8	6	
Velocity / Depth Regime	16	17	18	18	18	18	17	
10-Metric Total Habitat Score[2]	**118**	**147**	**141**	**142**	**134**	**131**	**132**	

- Marginal or Poor habitat metric rating.

[1] Metric is the sum of scores for both the left and right banks.

[2] Total Habitat Score: optimal > 150; suboptimal < 120.

1.3. Stream Watch (SW) Biological and Habitat Data

Stream Watch monitoring data were provided by the Valley Regional Office. The Stream Watch organization has been monitoring stream health since 2004 and is recognized by DEQ as a Level III data provider, suitable for use in assessments. Benthic taxa inventories enumerated by SW are shown for the Middle Fork Cunningham Creek in Table 1-13, and for an Unnamed Tributary to NF Cunningham Creek and Cunningham Creek in Table 1-14.

Table 1-13. SW Taxa Inventory for Middle Fork Cunningham Creek

		DEQ_Station_ID:	2-CNM07-SW										XNM01-SW
		Sub-watershed Name:	Lower Middle Fork Cunningham Creek										MF Cunn. Cr. X-trib
Sample Date	Functional Family Group	Tolerance Value	02/08/09	05/13/09	10/20/09	04/30/10	10/29/10	05/24/11	10/25/11	11/08/12	03/15/13	04/01/14	11/18/09
Leuctridae	Shredder	0									1		
Pteronarcyidae	Shredder	0			1								
Rhyacophilidae	Predator	0				5						2	1
Capniidae	Shredder	1	4										7
Chloroperlidae	Predator	1				11					1	1	4
Gomphidae	Predator	1		1	4	3	2	1	6	2	3	2	
Perlidae	Predator	1		7	1	19		12	1		3	5	
Isonychiidae	Filterer	2		1		1		2		3			
Leptophlebiidae	Collector	2							3	2		1	6
Nemouridae	Shredder	2		6		22					6		
Perlodidae	Predator	2	2	1		1			1			2	1
Taeniopterygidae	Shredder	2	94						2	4	13		1
Philopotamidae	Collector	3			4	2	2		11	18			2
Tipulidae	Shredder	3		1		1		5	3			2	4
Uenoidae	Scraper	3									5		8
Baetidae	Collector	4				56					32		
Baetidae	Collector	4										2	
Elmidae	Scraper	4	4	8	47	27	150	34	64	98	231	41	26
Ephemerellidae	Collector	4		10		51		10			1	45	1
Heptageniidae	Scraper	4				6		3	32	14		5	22
Psephenidae	Scraper	4							1	1	1		4
Cambaridae	Shredder	5							1				
Corydalidae	Predator	5			1	1					2		
Dryopidae	Shredder	5								1			
Gyrinidae	Predator	5						1					
Ptilodactylidae	Shredder	5							1				
Pyralidae	Shredder	5			1								
Ceratopogonidae	Predator	6		1	1				3	4			
Chironomidae (A)	Collector	6	4	60		37	1	19	1		18	113	20
Hydropsychidae	Filterer	6	10	8	149	19	45	111	59	78	26	4	4
Oligochaeta	Collector	6									2		
Simuliidae	Filterer	6	129	119	2	1		9	21		1		
Tabanidae	Predator	6							1				
Corbiculidae	Filterer	8			1		5		1		1		
Planariidae	#N/A	#N/A					3						
VSCI			45.89	38.68	39.56	74.92	43.92	45.52	65.05	56.85	64.32	49.99	78.3
Scraper/Filter-Collector Ratio			0.03	0.04	0.30	0.20	2.83	0.25	1.01	1.12	2.93	0.28	1.82
%Filterer-Collector			57.9%	88.8%	73.6%	63.5%	25.5%	72.9%	45.3%	44.9%	23.3%	73.3%	29.7%
%Haptobenthos			58.7%	68.6%	96.7%	54.4%	94.7%	86.5%	90.1%	93.3%	78.1%	46.7%	65.8%
%Shredders			39.7%	3.1%	0.9%	8.7%	0.0%	2.4%	3.3%	2.2%	5.8%	0.9%	10.8%

- Dominant 2 species in each sample.

VSCI: Optimal > 60; suboptimal < 50.

Chironimidae was interpreted as Chironomidae (A) for classification.

Enumerations of taxa prior to 2009 were not available in the data provided by DEQ.

Table 1-14. SW Taxa Inventory for a NF Cunningham Creek Unnamed Tributary and Cunningham Creek

DEQ_Station_ID:			2-CXB02-SW									CXB04-SW	XCF01-SW	
Sub-watershed Name:			Cunningham Creek										NF Cunn. Cr. X-trib	
Sample Date	Functional Family Group	Tolerance Value	04/19/09	04/18/10	10/23/10	05/28/11	10/23/11	05/05/12	10/14/12	09/15/13	05/08/14	11/18/09	02/11/09	04/08/09
Glossosomatidae	Scraper	0	5	2										
Libellulidae/Corduliidae	Predator	0										4		
Capniidae	Shredder	1										1	2	
Chloroperlidae	Predator	1									3			1
Gomphidae	Predator	1	1		2		1		2	1		1		
Perlidae	Predator	1		1		5	1			1	5		1	
Isonychiidae	Filterer	2			4	8	2	7	13	2	4			
Nemouridae	Shredder	2	134	13		1		4			3			
Perlodidae	Predator	2	2	1			20							
Taeniopterygidae	Shredder	2			9		2	13				5		
Aeshnidae	Predator	3								2				
Baetiscidae	Collector	3							14					
Hydrobiidae	Scraper	3		1						1				
Philopotamidae	Collector	3	35	2	6	7	11	1	15	8	5	7		
Tipulidae	Shredder	3	1		4	1		10	1		2		40	13
Uenoidae	Scraper	3										18		3
Baetidae	Collector	4	4	27			1	28	2	15	8			3
Caenidae	Collector	4			4	2			1	1				
Elmidae	Scraper	4	9	17	37	9	15	3	30	38	59	26		
Ephemerellidae	Collector	4	24	9				4			32		1	22
Heptageniidae	Scraper	4		6	4	23	24	30	61	24	24	2		
Limnephilidae	Shredder	4											2	3
Pleuroceridae	Scraper	4		1			1		6	2	2	2		
Psephenidae	Scraper	4				1	1		3	4	2	1		
Cambaridae	Shredder	5			1		2				1			2
Corydalidae	Predator	5	1		22	3	9		15	5	1			
Dryopidae	Shredder	5	1			1	1		1				1	1
Hydrophilidae	Predator	5					1		1					
Ptilodactylidae	Shredder	5							10					
Ancylidae	Scraper	6					2							
Ceratopogonidae	Predator	6							3					
Chironomidae (A)	Collector	6	164	56	58	31	6	117	1	6	11	8	36	224
Gammaridae	Collector	6											3	
Hydropsychidae	Filterer	6	29	3	7	18	6	57	33	74	35	10	6	7
Oligochaeta	Collector	6	1	2	16	8	24		5	2	5		7	14
Simuliidae	Filterer	6	63	168	4	86	28	20		55	10	7	1	
Lymnaeidae	Scraper	7			13									2
Planorbidae	Scraper	7							1			1		
Asellidae	Collector	8				3	1							
Corbiculidae	Filterer	8	1		3	1	4		2	2	4	8		
Coenagrionidae	Predator	9			2		1		1					
Planariidae	#N/A	#N/A					6	2	4				3	
VSCI			**58.4**	**50.1**	**54.5**	**54.6**	**69.1**	**50.0**	**75.2**	**61.3**	**72.0**	**73.0**	**	**40.4**
Scraper/Filter-Collector Ratio			0.04	0.10	0.53	0.20	0.52	0.14	1.17	0.42	0.76	1.25	0.00	0.02
%Filterer-Collector			67.6%	86.4%	52.0%	78.8%	48.8%	79.1%	38.2%	67.9%	52.8%	39.6%	52.4%	91.5%
%Haptobenthos			35.6%	68.0%	40.8%	73.6%	70.0%	38.9%	77.3%	86.8%	82.4%	72.3%	9.7%	11.5%
%Shredders			28.6%	4.2%	7.1%	1.4%	2.9%	9.1%	5.3%	0.0%	2.8%	5.9%	43.7%	6.4%

- Dominant 2 species in each sample.

An additional 7 taxa were reported with only 1 organism in all samples.

VSCI: Optimal > 60; suboptimal < 50.

Chironimidae was interpreted as Chironomidae (A) for classification.

Enumerations of taxa prior to 2009 were not available in the data provided by DEQ.

** = Invalid sample.

Metric scores for the various VSCI metrics, as enumerated by SW and as available for samples prior to 2009, are shown in Table 1-15 and Table 1-16 for the Middle Fork Cunningham Creek, and for an Unnamed Tributary to the NF Cunningham Creek and Cunningham Creek, respectively. Virginia Stream Condition Index (VSCI) scores for SW benthic samples collected along the Middle Fork Cunningham Creek and an unnamed tributary are shown in Figure 1-4, while those for the main stem Cunningham Creek and an unnamed tributary to the North Fork are shown in Figure 1-5.

Table 1-15. SW Metric Scores for the VSCI – Middle Fork Cunningham Creek

Station ID	2-CNM05-SW									2-CNM07-SW			
Sample Date	02/15/04	04/18/04	10/31/04	02/06/05	04/17/05	10/31/05	05/06/06	08/05/06	11/15/06	05/04/07	11/02/07	04/10/08	10/15/08
VSCI Metric Scores													
NumTaxa	72.7	77.3	72.7	90.9	54.5	72.7	63.6	77.3	100.0	50	45.5	45.5	63.6
NumEPT	81.8	90.9	72.7	72.7	72.7	72.7	45.5	72.7	72.7	54.5	18.2	36.4	45.5
PctEphem	5.9	93.0	79.2	12.0	100.0	6.6	24.0	98.8	21.8	100	0	20.2	2.6
PctPT-Hyd	100.0	26.3	3.3	100.0	8.9	3.8	5.0	2.2	24.7	35.6	0.6	100	4.5
PctChironomidae	95.4	84.1	79.9	92.3	91.5	86.5	21.5	94.4	98.9	83.4	100	91	87.4
Pct2Dominant	24.5	66.2	48.3	51.2	46.6	42.8	19.2	60.0	77.8	41.6	15.1	52.2	29.8
HBI	100.0	82.3	78.4	100.0	86.7	78.7	64.9	79.7	70.9	87.95	52.06	75.74	61.68
PctScrapers	8.9	20.8	100.0	20.0	50.2	86.0	3.5	18.8	56.2	2.8	64.6	57.6	14.9
VSCI	**61.2**	**67.6**	**66.8**	**67.4**	**63.9**	**56.2**	**30.9**	**63.0**	**65.4**	**57.0**	**37.0**	**59.8**	**38.8**

- Primary biological effects.

Metric values and scores were not enumerated in the data provided by DEQ for samples after 2008.

Metric values were not enumerated in the data provided by DEQ for any samples.

Table 1-16. SW Metric Scores for the VSCI – NF Cunningham Creek Unnamed Tributary and Cunningham Creek

Station ID	2-CXB02-SW														2-XCF01-SW				
Sample Date	01/22/04	02/14/04	02/14/04	05/05/04	10/27/04	02/12/05	04/17/05	10/29/05	04/30/06	10/25/06	04/22/07	11/03/07	03/01/08	11/01/08	06/20/07	11/08/07	01/24/08	05/06/08	11/06/08
VSCI Metric Scores																			
NumTaxa	63.6	68.2	50.0	72.7	63.6	81.8	77.3	63.6	59.1	77.3	72.7	77.3	77.3	77.3	50.0	40.9	72.7	81.8	54.5
NumEPT	63.6	63.6	54.5	100.0	63.6	63.6	63.6	36.4	72.7	54.5	81.8	54.5	63.6	72.7	36.4	18.2	45.5	100.0	27.3
PctEphem	6.1	2.8	4.1	20.0	33.3	29.1	58.0	23.3	53.3	14.0	66.2	4.2	4.9	3.0	1.4	0.0	2.9	47.5	0.0
PctPT-Hyd	52.9	78.2	100.0	78.2	75.2	100.0	10.5	12.5	10.4	20.2	70.5	100.0	100.0	100.0	3.6	4.0	73.2	36.5	12.5
PctChironomidae	54.5	63.9	70.6	60.8	78.5	95.3	68.5	100.0	42.4	53.1	85.8	100.0	80.1	97.5	61.9	91.5	85.0	48.0	88.1
Pct2Dominant	39.0	56.1	53.4	62.2	84.0	78.0	55.7	65.8	38.9	49.8	74.4	56.2	72.3	47.8	32.5	42.0	70.2	46.7	32.2
HBI	71.4	75.1	84.0	77.6	81.2	91.1	73.1	60.1	73.8	71.8	80.7	82.7	87.7	80.6	64.2	62.3	82.0	81.4	91.8
PctScrapers	13.5	10.7	14.7	4.9	35.5	51.9	62.4	60.6	10.4	45.4	9.7	29.0	31.3	16.2	3.4	5.5	2.1	4.6	4.8
VSCI	**45.6**	**52.3**	**53.9**	**59.5**	**64.4**	**73.9**	**58.7**	**52.8**	**45.1**	**48.3**	**67.7**	**63.0**	**64.6**	**61.9**	**31.7**	**33.0**	**54.2**	**55.8**	**38.9**

- Primary biological effects.

Metric values and scores were not enumerated in the data provided by DEQ for samples after 2008.

Metric values were not enumerated in the data provided by DEQ for any samples.

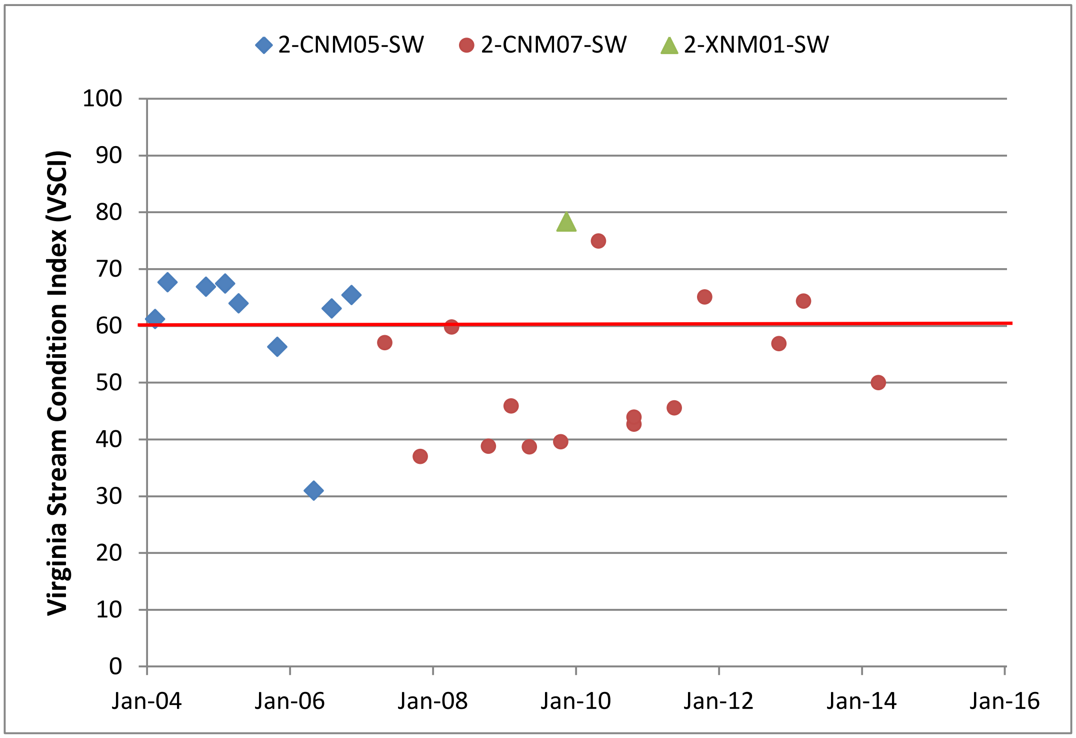

Figure 1-4. Stream Watch VSCI Summary for Middle Fork Cunningham Creek and Unnamed Tributary

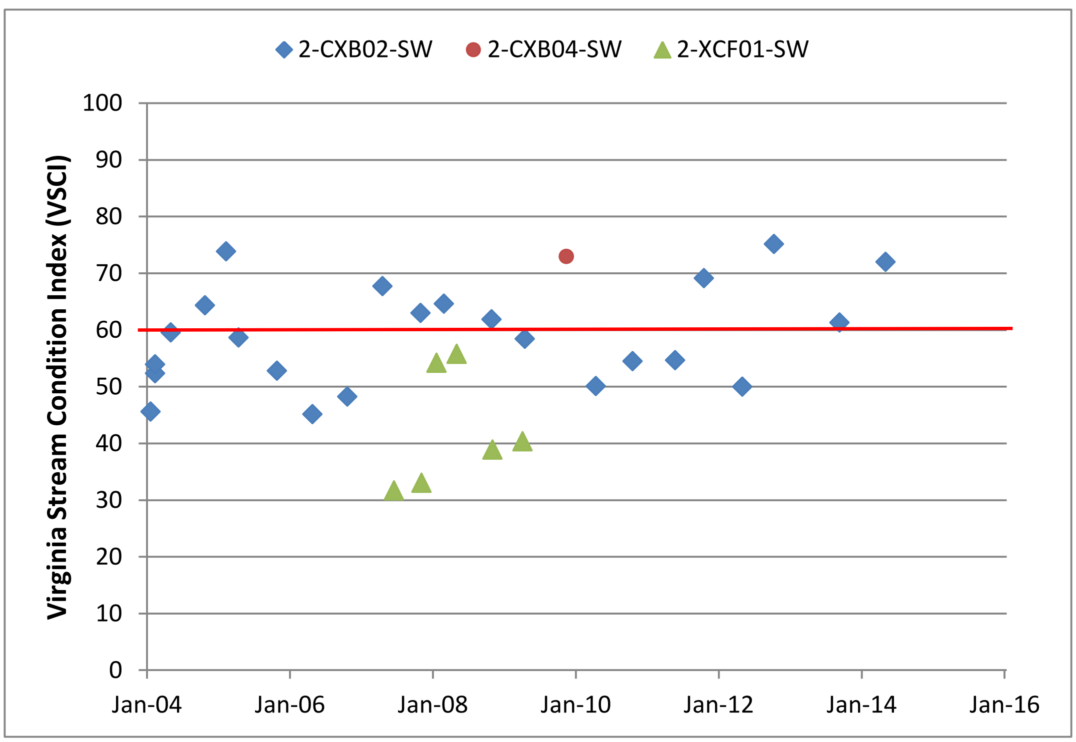

Figure 1-5. Stream Watch VSCI Summary for Cunningham Creek and Unnamed Tributary to the North Fork

Habitat data were also collected by Stream Watch along select reaches of the Middle Fork Cunningham Creek and along the main stem Cunningham Creek using many of the same metrics as DEQ, as shown in Table 1-17. However, the number of recorded metrics varied from date to date, and was always less than the ten metrics used for a Total Habitat score by DEQ. Metric values shown as blank were either missing or not collected and should not be equated with a "0".

The maximum score for each metric is 20. Scores in the range of 1-5 are rated as “poor”, and those in the range of 6-10 as “marginal”. The “riparian vegetative zone” and “sediment deposition” metrics received the most “marginal” or “poor” scores at all sites, with some possible “bank stability” issues in the Middle Fork.

Table 1-17. Stream Watch Habitat Evaluation Summary for Middle Fork and main stem, Cunningham Creek

StreamWatch Site	Middle Fork Cunningham Creek, 2-CNM05-SW					Cunningham Creek, 2-CXB02-SW						
Reach Code	CNM-R05		CNM-R09		CNM-R11	CXB-R04			CXB-R08	CXB-R09		
Sample Date	02/06/05	02/07/06	02/11/09	07/21/14	02/15/11	05/05/04	03/07/05	02/07/06	02/15/08	02/09/09	02/15/11	07/21/14
Bank Stability	6	10	14	7	13	14	17	16	13	13	12	6
Channel Alteration	15	16	19	19	14	12	13	13	13	15	13	14
Embeddedness	7	11	17	13		12	10	11	14	11		
Epifaunal substrate	6	11	8	8		11	9	8	13	11		
Frequency of Riffles	14	12	19	18	18	11	12	17	8	13	17	16
Riparian Vegetative Zone	9	8	7	2	6	13	14	10	8	6	8	2
Sediment Deposition	8	4	4	7	4	7	15	7	5	6	7	10
Vegetative Protection	11	18	14	10		14	15	16	16	17		
Velocity and Depth Regime	18	15				17	16	18				
9-metric Total	**94**	**105**				**111**	**121**	**116**				

[shaded] - Marginal or Poor habitat metric rating.

1.4. Save Our Streams (SOS) Biological Data

Save Our Streams monitoring data were provided by the Valley Regional Office. SOS has been monitoring stream health since 2002 and is recognized by DEQ as a Level II data provider, suitable for supplementary use in assessments. The SOS protocol produces a multi-metric index, with scores less than 8 considered “unacceptable”, and those greater than 8 as “acceptable”, although a grey zone is acknowledged around that threshold. SOS metrics and Multi Metric scores for benthic samples collected along the Middle Fork Cunningham Creek are shown in Table 1-18, with a plot of the Multi Metric scores in Figure 1-6. Those for North Fork Cunningham Creek, an unnamed tributary to the North Fork, and the main stem Cunningham Creek are shown in Table 1-19, with the plot of Multi Metric scores in Figure 1-7.

Table 1-18. SOS Metric and Multi Metric Scores (Middle Fork Cunningham Creek)

DEQ Station ID	2-CNM01-SOS				2-CNM02-SOS					2-CNM05-SOS				
Date	03/21/02	07/11/02	06/04/03	10/16/03	03/20/02	07/11/02	05/06/06	08/05/06	11/15/06	02/06/05	04/17/05	10/31/05	05/04/07	11/02/07
Metric 1	40.6	0	14.0	37.5	20.4	53.0	16.5	61.4	22.1	75.3	80.4	5.4	78.0	0.2
Metric 2	3.0	0	3.6	6.3	0.0	0.3	0.0	20.2	13.0	1.5	0.5	27.4	0.0	4.1
Metric 3	0.0	33.3	0.0	0.0	1.4	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.8
Metric 4	11.4	0	1.6	3.9	11.6	24.4	2.9	7.8	27.9	6.3	1.6	43.5	2.0	30.1
Metric 5	41.6	100	70.5	39.8	62.0	14.9	79.9	6.8	34.0	12.2	8.5	20.6	18.0	62.6
Metric 6	25.7	91.7	8.3	21.1	13.9	12.9	1.4	1.4	27.9	1.1	0.0	2.2	0.0	63.4
Multi Metric Score	**10**	**2**	**5**	**9**	**7**	**11**	**7**	**11**	**8**	**11**	**10**	**9**	**10**	**5**
Ecological Conditions	Ac	Un	Un	Ac	Un	Ac	Un	Ac	Gray Zone	Ac	Ac	Ac	Ac	Un

Metric 1 - Percent Mayflies, Stoneflies, and Most Caddisflies
Metric 2 - Percent Common Netspinners
Metric 3 - Percent Lunged Snails
Metric 4 - Percent Beetles
Metric 5 - Percent Tolerant
Metric 6 - Percent Non-Insect

Un = Unacceptable
Ac = Acceptable

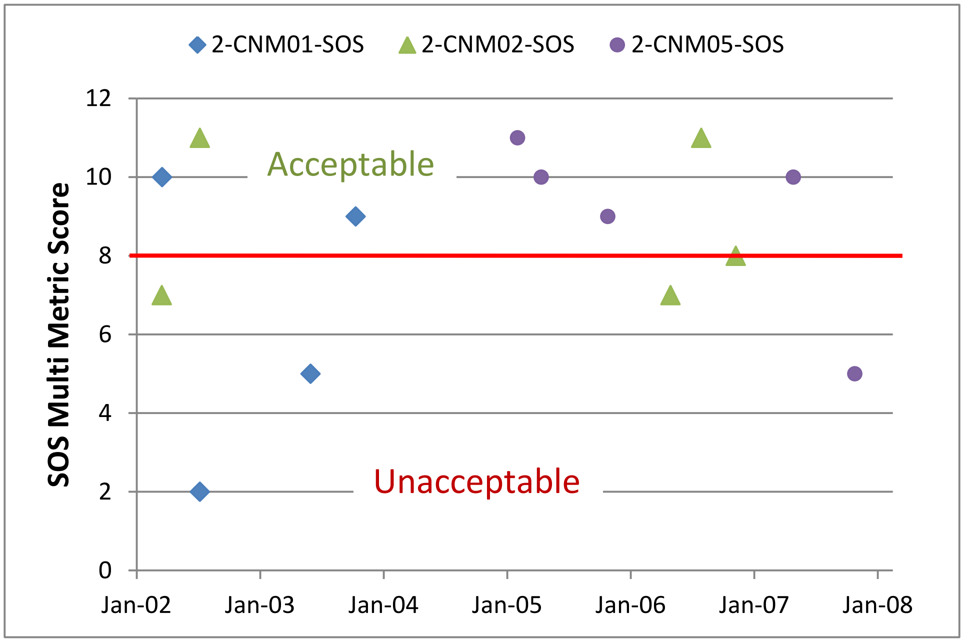

Figure 1-6. SOS Multi Metric Scores for Middle Fork Cunningham Creek

Table 1-19. SOS Metric and Multi Metric Scores (North Fork, Unnamed tributary to NF, and Main Stem, Cunningham Creek)

DEQ Station ID	2-CXB02-SOS		2-CXB13-SOS							2-CFK01-SOS	2-XCF01-SOS
Date	04/22/07	11/03/07	03/20/02	02/12/05	04/17/05	10/29/05	04/30/06	10/14/06	10/25/06	03/21/02	06/20/07
Metric 1	65.7	44.8	16.3	61.0	39.3	18.8	36.4	34.5	15.9	38.6	2.1
Metric 2	0.4	20.7	3.2	10.3	13.1	14.3	0.7	16.4	9.6	2.9	38.6
Metric 3	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.4
Metric 4	4.2	8.6	18.6	4.7	2.2	6.3	3.0	7.3	2.9	0.0	1.3
Metric 5	28.9	10.8	54.8	20.7	41.9	46.4	59.6	27.3	49.5	54.8	47.5
Metric 6	9.2	15.1	17.6	8.0	8.2	49.1	0.7	21.8	19.7	5.9	4.7
Multi Metric Score	**10**	**10**	**9**	**10**	**9**	**6**	**9**	**10**	**6**	**8**	**4**
Ecological Conditions	Ac	Ac	Ac	Ac	Ac	Un	Ac	Ac	Un	Ac	Un

Metric 1 - Percent Mayflies, Stoneflies, and Most Caddisflies
Metric 2 - Percent Common Netspinners
Metric 3 - Percent Lunged Snails
Metric 4 - Percent Beetles
Metric 5 - Percent Tolerant
Metric 6 - Percent Non-Insect

Un = Unacceptable
Ac = Acceptable

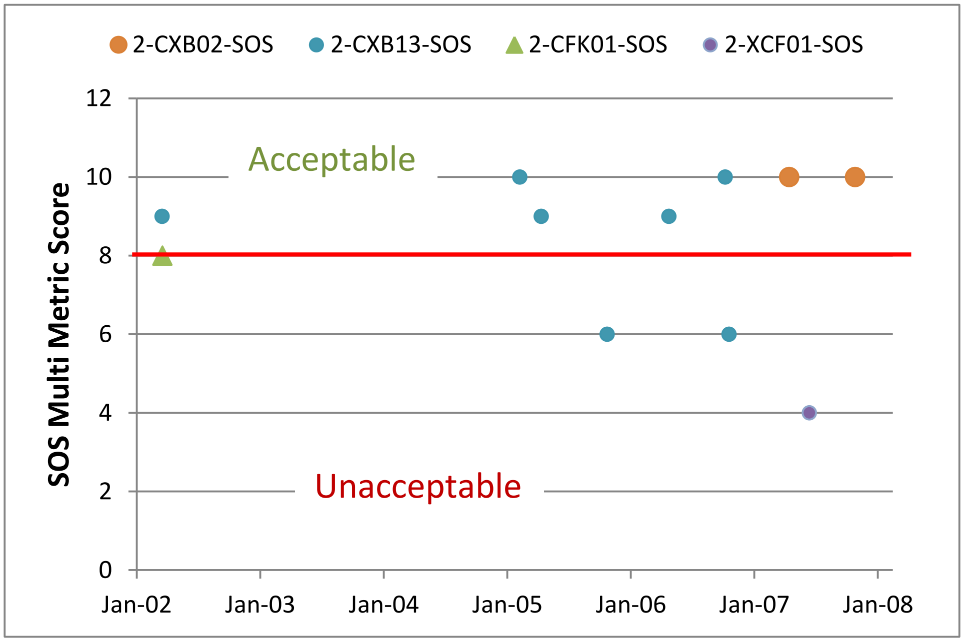

Figure 1-7. SOS Multi Metric Scores for North Fork, and unnamed tributary to North Fork, and main stem Cunningham Creek

1.5. Focus of the Investigation

The Investigation's Purpose

The purpose of the stressor analysis is to look for a stressor or stressors that have most likely caused the listing on the impaired waters list. The stressors may be something that either directly affected the benthic community or indirectly affected its habitat.

1.6. Watershed Characterization

The Cunningham Creek watershed is part of the Middle James River basin (USGS HUC 02080204) and comprises part of state hydrologic unit H32 (National Watershed Boundary Dataset JR20). Cunningham Creek is located primarily in Fluvanna County with a minor portion of the headwaters of the Upper North Fork Cunningham Creek in Albemarle County. The Cunningham Creek watershed is 23,169 acres in size. The Fluvanna Ruritan Lake is located in the watershed in the headwaters of the North Fork Cunningham Creek. Cunningham Creek flows east south-east and discharges into the Rivanna River, which discharges into the James River. The James River flows into the Chesapeake Bay.

The Cunningham Creek watershed is located entirely within the Northern Inner Piedmont (45e) sub-division of the Piedmont (45) ecoregion. Ecoregion 45e is a dissected upland composed of hills, irregular plains, and isolated ridges and mountains. The Northern Inner Piedmont (45e) is characteristically underlain by highly deformed and deeply weathered Cambrian and Proterozoic feldspathic gneiss, schist, and melange. It is intruded by plutons and is veneered by clay-rich weathering products (i.e. saprolite). Ultisols occur widely and have developed from residuum; they are typically clay-rich, acid, and relatively low in base saturation (Omernik and Griffith, 2008).

The dominant soil type in Cunningham Creek watershed is Nason silt loam, comprising 36.7% of the watershed. The next most abundant soil types are Tatum silt loam at 27.2% and Manteo silt loam at 19.6%. Each of these soil types are comprised of rolling and undulant phases (USDA-NRCS, 2013a and 2013b). Soils of the Nason series are classified as fine, mixed, semiactive, thermic Typic Hapludults and are deep and well drained. They occur on uplands and are formed in material weathered from schist and other fine grained metamorphic rocks. Soils of the Tatum series are also classified as fine, mixed, semiactive, thermic Typic Hapludults. Similarly, they are deep and well drained soils. They occur in woodland areas and are formed in material weathered from sericite schist, phyllite, and other fine grained metamorphic rocks. Soils of the Manteo are classified as loamy-skeletal, mixed, semiactive, thermic Lithic Dystrudepts. This series is shallow, somewhat excessively drained, and often found in hardwood woodlands. They formed in material weathered from very strongly acid serecite schist (USDA-NRCS, 2008).

Climate data for the Cunningham Creek watershed were based on meteorological observations made by the Palmyra 3S National Climatic Data Center station (446491) located 2.57 miles south of the watershed outlet. Average annual precipitation at this station is 41.8 inches; while the average annual daily temperature is 54.0°F. The highest average daily temperature of 74.1°F occurs in July while the lowest average daily temperature of 33.9°F occurs in January, as obtained from the NCDC 1981-2010 Climate Normals for this station (NOAA, 2016).

Approximately 736 people live in the Cunningham Creek watershed, as estimated from the US Census Bureau's digital file of Block Groups and 2007-2011 population estimates (ACS, 2012).

Land use categories for the Cunningham Creek watershed were derived from the 2012 National Agricultural Statistics Service cropland data layer (USDA-NASS, 2012) for Virginia. The major land uses in the watershed are forest, which comprises approximately 60.0% of the watershed, followed by 18.2% in pine plantations, 17.3% in pasture and hay, with cropland and residential land uses, each comprising less than 1%. Generalized categories of land use in the watershed are shown in Figure 1-8, with acreages summarized in Table 1-20.

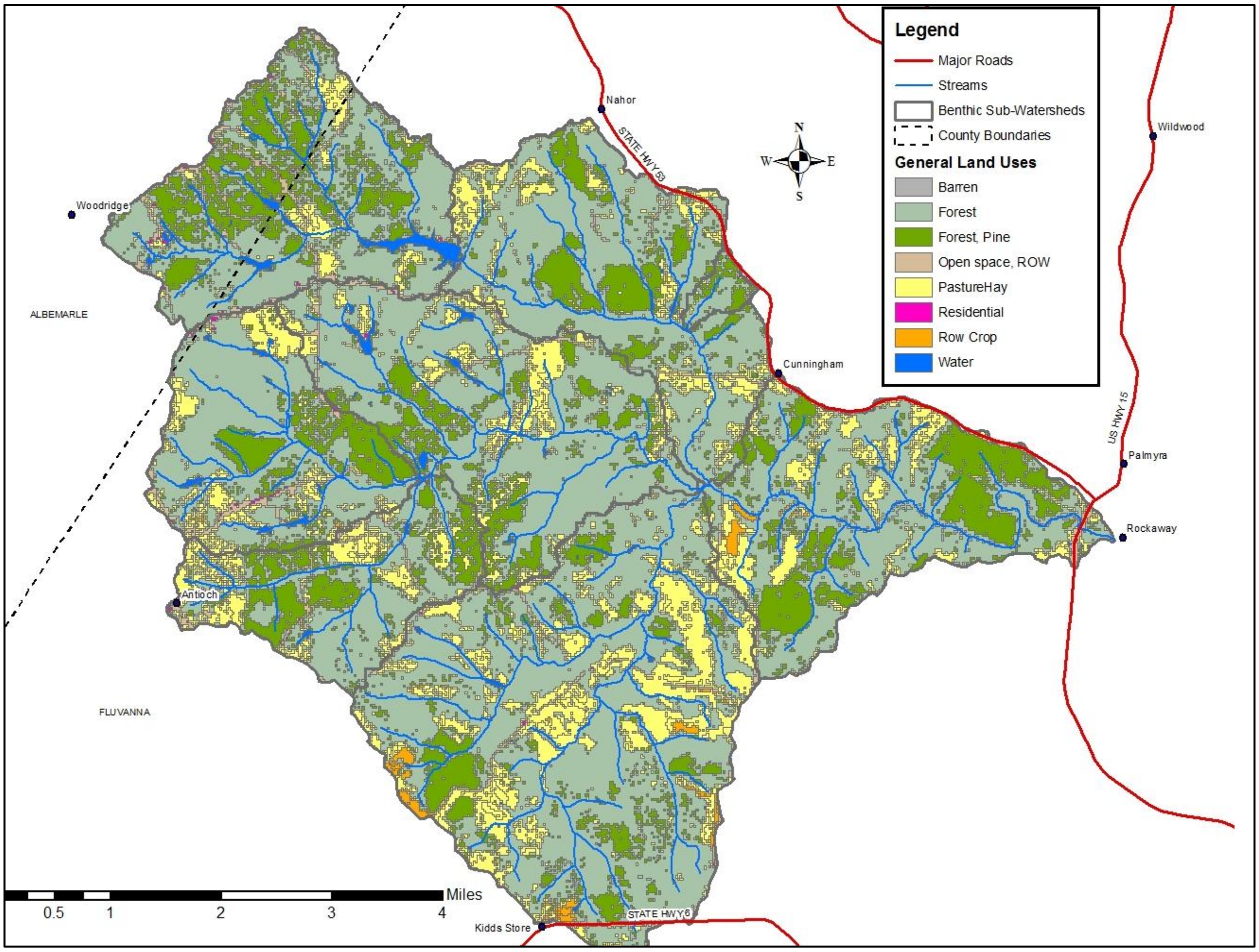

Figure 1-8. Generalized Categories of NASS Land Use

Table 1-20. Cunningham Creek Land Use Distribution by Sub-Watershed

	1	2	3	4	5	6	7	8	
Sub-Watershed	Cunningham Creek	Lower NF Cunningham Creek	X-trib to NF Cunningham Creek	Upper NF Cunningham Creek	South Fork Cunningham Creek	Lower MF Cunningham Creek	X-trib to MF Cunningham Creek	Upper MF Cunningham Creek	Land Use Percentages
Impaired Segment	**CXB01A00**	**CFK01A00**	**XCF01A10**			**CNM01A00**		**CNM02A04**	
	Area in acres								
Barren	0.7	0.9	0.0	0.2	1.1	1.1	0.5	1.3	0.0%
Forest	1827.1	2000.6	82.8	1770.0	3811.0	2251.5	853.2	1307.4	60.0%
Forest, Pine	805.5	503.5	52.9	832.1	657.0	525.2	434.5	413.5	18.2%
Residential	4.1	1.1	0.3	15.3	3.5	2.3	4.2	11.5	0.2%
PastureHay	519.4	490.0	7.4	252.9	1451.1	506.9	403.5	375.1	17.3%
Open Space, ROW*	88.7	81.1	2.6	160.5	115.8	91.3	70.0	91.0	3.0%
Row Crop	33.4	3.4	0.0	2.7	104.8	2.3	6.5	7.0	0.7%
Water	2.6	3.7	0.4	70.6	8.7	25.1	5.3	9.1	0.5%
Grand Total	**3,281.53**	**3,084.24**	**146.38**	**3,104.32**	**6,153.03**	**3,405.80**	**1,777.60**	**2,215.89**	

* ROW = road, pipeline, or transmission right-of-way.

2.0 Candidate Causes of Impairment

A list of candidate stressors was developed for Cunningham Creek and evaluated to determine the pollutant(s) responsible for each of the 5 benthic impairments in the watershed. A potential stressor checklist was used to evaluate known relationships or conditions that may show cause and effect between potential stressors and changes in the benthic community. An outline of available evidence was then summarized as the basis for each potential stressor. Depending on the strength of available evidence, the potential stressors were either “eliminated”, considered as “possible” stressors, or recommended as the “most probable” stressor(s). Candidate stressors included:

- ammonia,
- pH,
- temperature,
- metals,
- toxic organic compounds,
- nutrients (dissolved oxygen),
- organic matter,
- streambed sedimentation,
- ionic strength (sulfates, conductivity, total dissolved solids), and
- flow/hydrologic modification.

The data used in the evaluation are detailed in Section 3.0, and the evaluation of each candidate stressor is discussed in Section 4.0.

3.0 Data Sources Used in Stressor Identification

In order to investigate and verify the stressor(s) causing the benthic impairment, available bioassessment data, water quality data, special study data, permitted point source data, and ancillary data were examined together with field observations. The extent and content of these data sources are summarized in Table 3-1. Evidence relevant to each candidate cause is summarized in Table 3-2.

Table 3-1. Inventory of Monitoring Data Used in the Cunningham Creek Stressor Analyses

Data Type/Location	Stream	Collection Period	No. of Samples	Description
Biological (Benthic) Samples				
2-CNM001.75	Lower MF	04/08 – 10/15	8	DEQ: species counts; Virginia Stream Condition Index (VSCI) scores and ratings; habitat assessment scores.
2-CNM002.25		04/02 – 05/07	5	
2-CNM003.82	Upper MF	04/02, 03/03	2	
2-CFK001.31	Nork Fork	04/10 – 10/15	6	
2-CXB000.86	Cunn. Cr.	04/08 – 10/15	8	
2-CNM05-SW	Lower MF	02/04 – 11/06	9	SW: Species counts; VSCI metric scores; VSCI scores; habitat metrics.
2-CNM07-SW		05/07 – 04/14	15	
2-XNM01-SW	MF X-trib	11/09	1	SW: VSCI scores.
2-CXB02-SW	Cunn. Cr.	01/04 – 05/14	23	
2-CXB04-SW		11/09	1	
2-XCF01-SW	NF X-trib	06/07 – 04/09	6	
2-CNM01-SOS	MF X-trib	03/02 – 10/03	4	SOS: Multi Metric and component metric scores.
2-CNM02-SOS	Lower MF	03/02 – 11/06	5	
2-CNM05-SOS		02/05 – 11/07	5	
2-CFK01-SOS	North Fork	03/02	1	
2-CXB02-SOS	Cunn. Cr.	04/07, 11/07	2	
2-CXB13-SOS		03/02 – 10/06	7	
2-XCF01-SOS	NF X-trib	06/07	1	
Ambient Water Quality Samples				
2-CFK001.31	North Fork	01/15 – 01/16	12	DEQ: ambient physical and chemical water quality data (temp, DO, pH, conductivity, TSS, ammonia-N, nitrite-N, nitrate-N, TKN, TN, TP, *E. coli*, ortho-P, turbidity, chloride, and sulfate.
2-CNM001.75	Lower MF	01/15 – 01/16	11	
2-CNM002.25		07/03 – 05/06	18	
2-CNM004.16	Upper MF	07/04 – 05/06	12	
2-XPA000.57	MF X-trib	07/03 – 05/05	12	
2-CXB000.86	Cunn. Cr.	01/15 – 01/16	12	
2-CXB005.39		08/91 – 09/15	76	
Other Monitoring				
Various		08/15	4	DEQ: Phab measurements, incl. LRBS.
Various		12/09 – 12/10	1	DEQ: PReP Incidents
Various		1999 - 2014		VADCR: BMP Installation Data

Data Type/Location	Stream	Collection Period	No. of Samples	Description
Various	MF and Main Stem	06/07 – 05/10	5	SW: reach geomorphic survey data
Various		1994, 2009	3	INSTAR: habitat metrics and fish counts
Watershed-wide		2010-2015	49	VDOF: timber harvest acreages
Fluvanna Ruritan Lake Dam		2007-2011	6	VDGIF Dam inspection reports
Virginia DEQ Permitted Point Sources				
VPDES permits			1	DEQ: VA0090905 Tenaska
Virginia Household Water Quality Program Household Drinking Water Analyses				
Albemarle Co. + Fluvanna Co.	2009 (Alb: n=142; Flu: n=15)		Summaries of household drinking water quality analyses.	
Fluvanna Co. + Louisa Co.	2010 (n=47)		Summaries of household drinking water quality analyses.	

Table 3-2. Evidence Relevant to each Candidate Cause

Candidate Cause	Relevant Evidence
Ammonia	DEQ ambient data
pH	DEQ ambient data, VAHWQP drinking water analyses
Temperature	DEQ ambient data, habitat metrics
Metals	VAHWQP drinking water analyses
Toxic organic compounds	DEQ permits
Nutrients	DEQ ambient data, DEQ species counts, biological metrics, VAHWQP drinking water analyses, biological taxa
Organic Matter	DEQ VSCI metrics, ambient data, biological taxa
Streambed sedimentation	DEQ habitat metrics and total scores, field observations, and physical habitat measurements, incl. LRBS; SW habitat metrics
Ionic strength	DEQ ambient data
Flow/hydrological modifications	Impoundment locations and history of development; permit data

3.1. DEQ Ambient Data

- The one long-term DEQ ambient monitoring station in the watershed is station 2-CXB005.39, which began in 1991 and ran through 2003, and then again between 2009 and the present. Three other ambient sites in the Middle Fork Cunningham Creek are 2-CNM002.25 which was monitored from 2003 to 2006; 2-CNM004.16, which was monitored from 2004 to 2006; and 2-XPA000.57, which was monitored from 2003 to 2005. Ambient monthly monitoring has been performed at DEQ stations 2-CFK001.31, 2-CNM001.75, and 2-CXB000.86 only since January 2015. There have been no ambient monitoring stations on South Fork Cunningham Creek.

- Data have been grouped by stations along the North Fork, Middle Fork, and Cunningham Creek, and various unnamed tributaries to facilitate ease of assessing available data. Since data are only available for a short period of time from one station on the North Fork Cunningham Creek, that data is summarized in tabular form in Table 3-3, rather than in graphical form, as along other streams.

Table 3-3. Monitoring Data for North Fork Cunningham Creek

Parameter	Units	01/29/15	02/10/15	03/30/15	04/27/15	05/06/15	06/15/15	07/28/15	08/24/15	09/23/15	11/19/15	12/21/15	01/20/16	Average
		Sample Collection Date												
Field Temperature	°C	2.41	4.94	10.79	11.22	15.83	21.52	22.59	21.29	16.45	13.41	5.61	0.92	**12.25**
Field pH		7.01	7.82	7.01	6.4	6.85	6.87	7.02	6.69	7.58	6.37		7.86	**7.04**
DO Probe	mg/L	14.41	12.83	11.49	10.97	9.61	7.8	7.55		8.97	10.73	13.32	14.87	**11.14**
00500 Total Solids	mg/L	38	82	37	42	50	48	51	54	65	53	37	58	**51.25**
00530 TSS	mg/L	2	1	4	4	4	3	7	3	1	7	1	2	**3.25**
00600 Total Nitrogen	mg/L	0.38	0.59	0.34	0.42	0.34	0.52	0.83	1.23	1.5	0.5	0.42	0.4	**0.62**
00665 Total Phosphorus	mg/L	0.02	0.02	0.02	0.03	0.03	0.04	0.05	0.07	0.05	0.04	0.02	0.03	**0.04**
82079 Turbidity	NTU	2.54	1.05	4.06	4.46	3.98	2.64	5.4	3.01	3.4	9.57	2.78	3.44	**3.86**

- Plots of monthly water quality monitoring sample data for the ambient monitoring stations along Middle Fork Cunningham Creek and an unnamed tributary are shown in Figure 3-1 through Figure 3-10.
- Where applicable, minimum and/or maximum water quality standards are indicated on the plots.
- Field physical parameters include temperature, pH, and dissolved oxygen (DO). Chemical parameters include total solids (TS), total suspended solids (TSS), ammonia-N, total nitrogen (TN), nitrite + nitrate-N, total phosphorus (TP), *Escherichia coli* (*E. coli*), and turbidity. Ammonia-N was not plotted, as only 2 out of 42 samples taken between 07/03 and 05/06 from stations 2-CNM002.25, 2-CNM004.16, and 2-XPA000.57 were above the minimum detection limit of 0.04 mg/L, and they were just marginally above, at 0.047 and 0.05 mg/L.

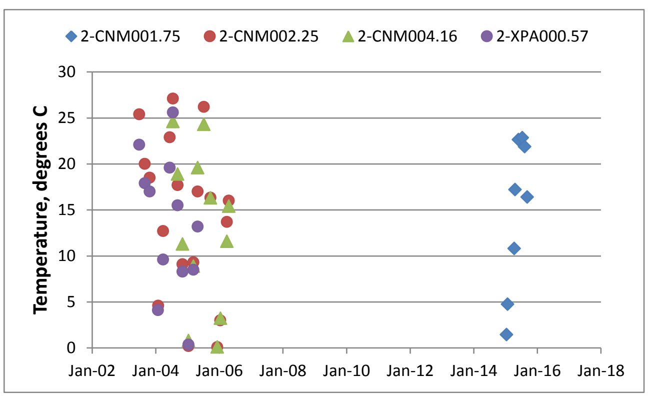

Figure 3-1. Field Temperature – MF and X-Trib

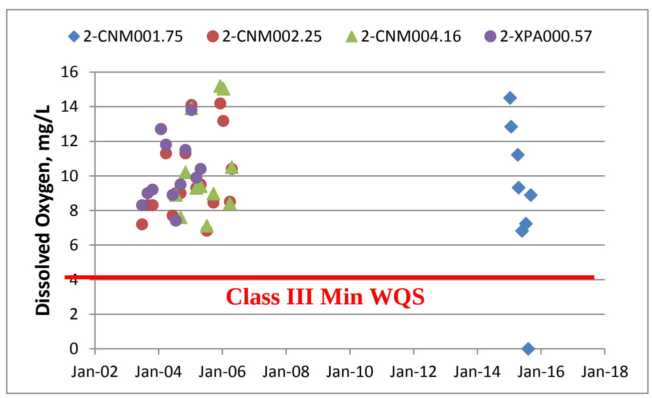

Figure 3-3. Field DO – MF and X-Trib

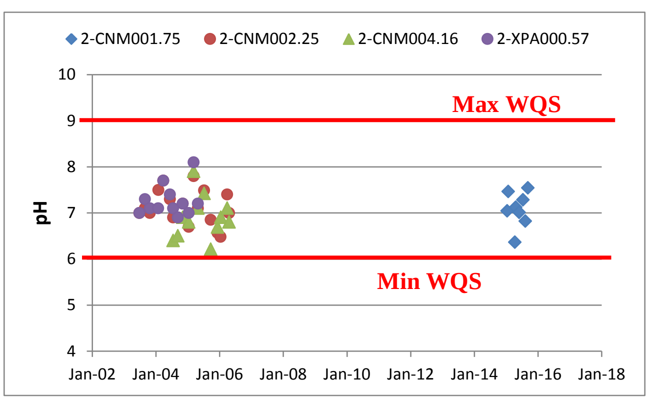

Figure 3-2. Field pH – MF and X-trib

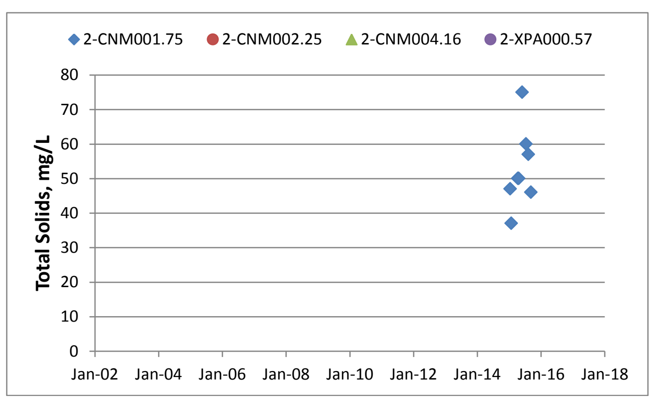

Figure 3-4. Total Solids – MF and X-Trib

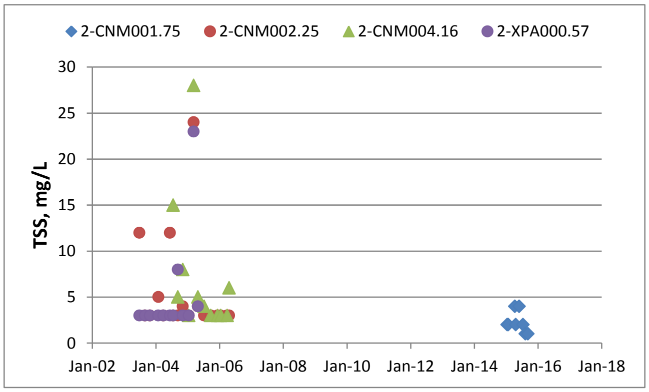

Figure 3-5. Total Suspended Solids – MF and X-Trib

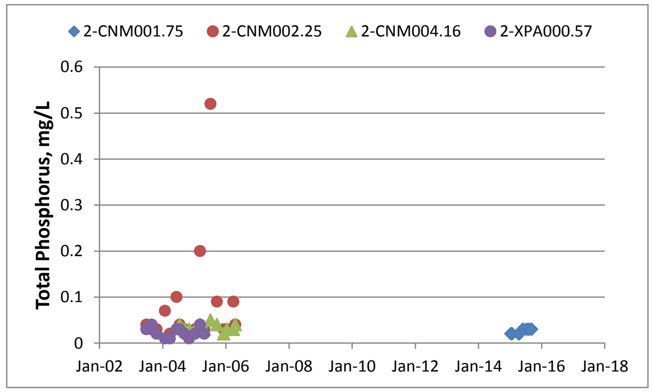

Figure 3-8. Total Phosphorus – MF and X-Trib

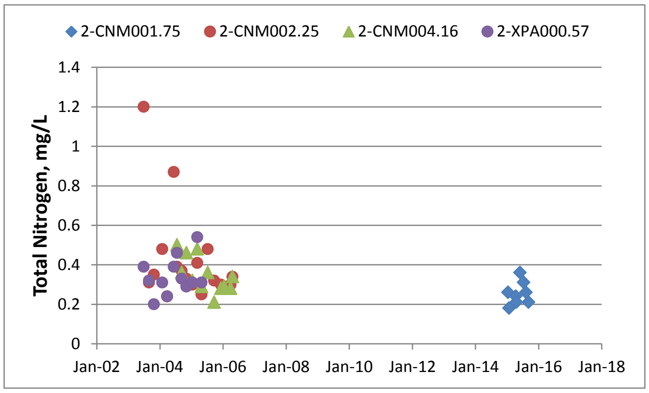

Figure 3-6. Total Nitrogen – MF and X-Trib

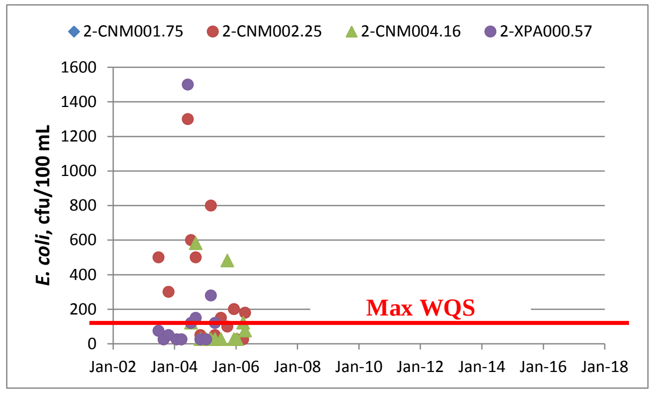

Figure 3-9. Escherichia coli – MF and X-Trib

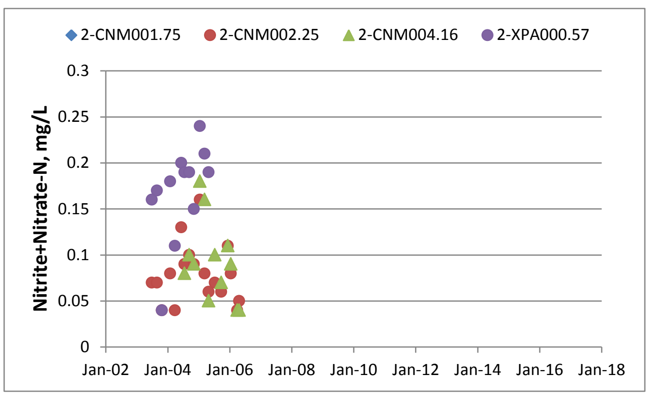

Figure 3-7. Nitrite + Nitrate-N – MF and X-Trib

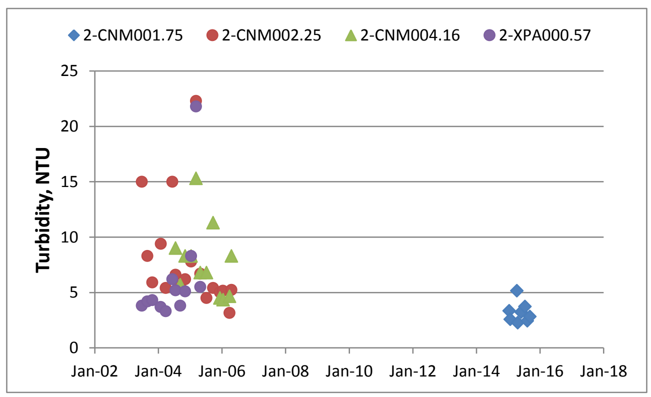

Figure 3-10. Turbidity – MF and X-Trib

- Plots of monthly water quality monitoring sample data for the ambient monitoring stations along Cunningham Creek and an unnamed tributary are shown in Figure 3-11 through Figure 3-27.
- Where applicable, minimum and/or maximum water quality standards (red lines) and minimum detection limits (MDL; green lines) are indicated on the plots. Recorded values for samples of chloride and sulfate taken on 07/30/97 were below the usual MDL and may have resulted from more stringent analysis procedures on that date.
- Field physical parameters include temperature, pH, dissolved oxygen (DO), and specific conductivity. Chemical parameters include total suspended solids (TSS), ammonia-N, nitrite-N, nitrate-N, total Kjeldahl nitrogen (TKN), total nitrogen (TN), total phosphorus (TP), bacteria (fecal coliform and *E. coli*) orthophosphate-P, turbidity, chloride, and sulfate.

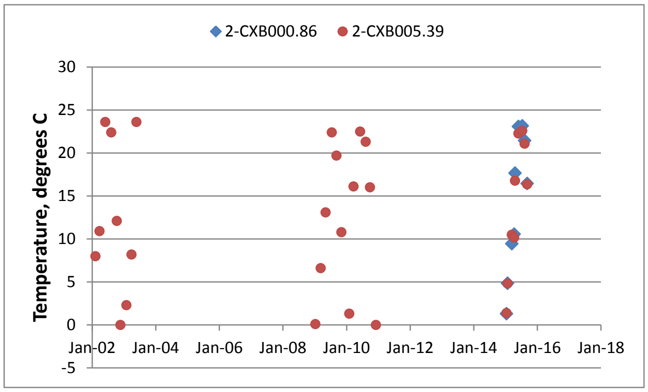

Figure 3-11. Field Temperature – CXB

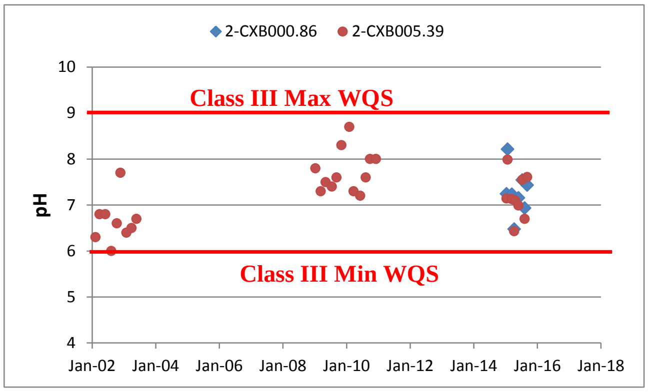

Figure 3-12. Field pH – CXB

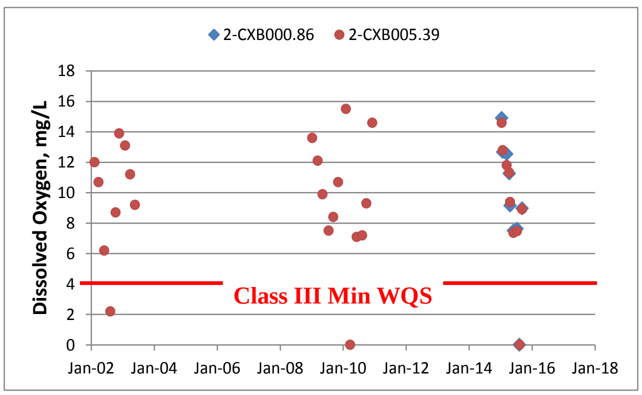

Figure 3-13. Field DO - CXB

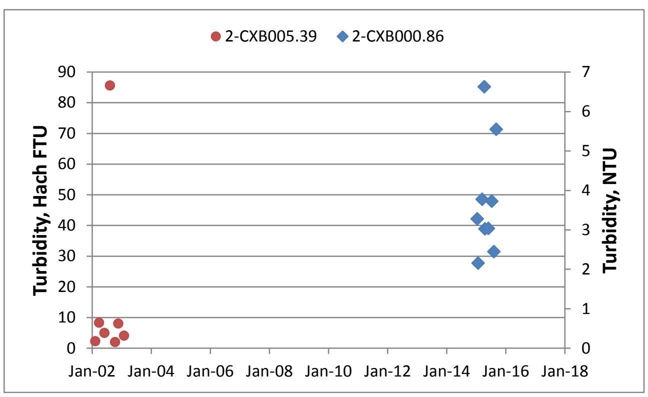

Figure 3-14. Turbidity – CXB

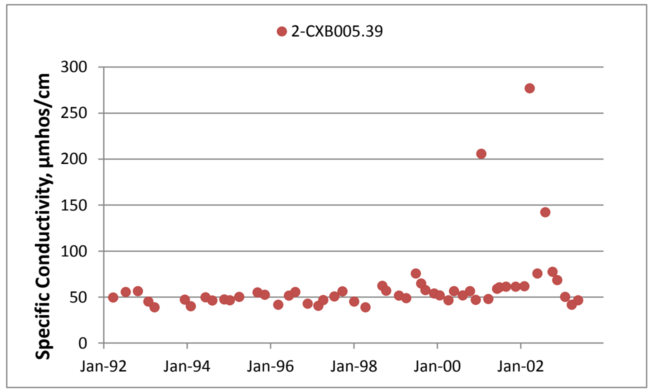

Figure 3-15. Specific Conductivity – CXB

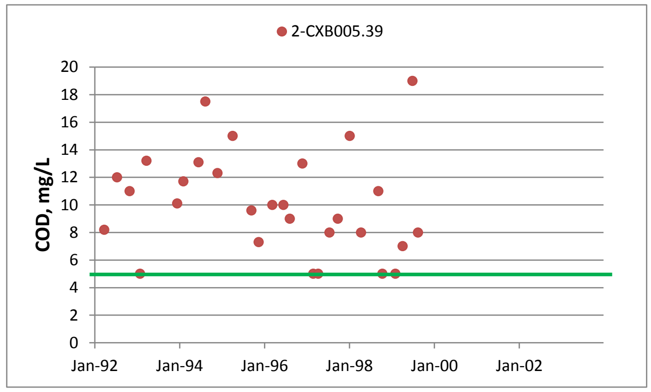

Figure 3-16. COD – CXB

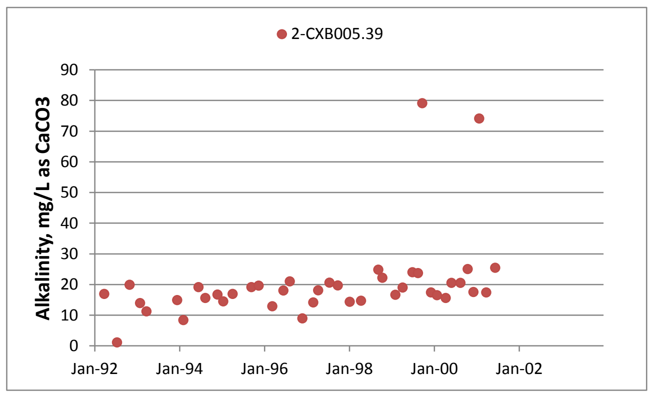

Figure 3-17. Alkalinity - CXB

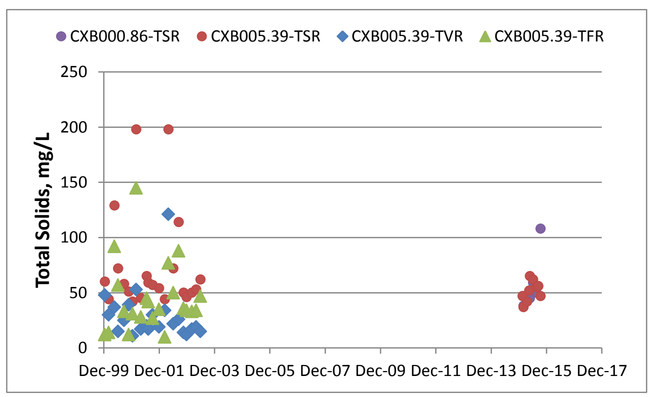

Figure 3-18. Total Solids - CXB

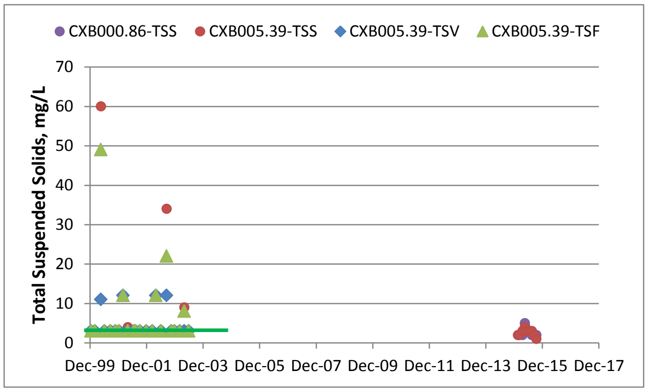

Figure 3-19. Total Suspended Solids - CXB

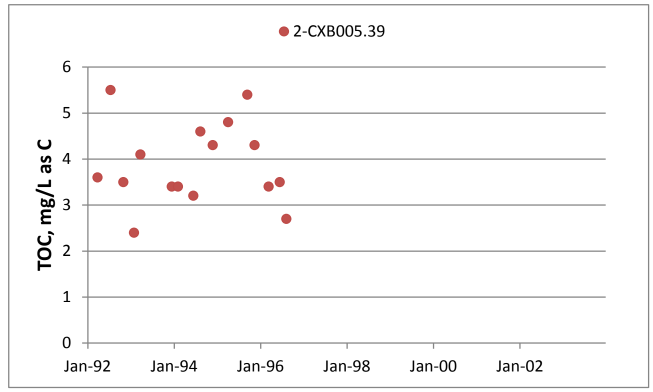

Figure 3-23. Total Organic Carbon – CXB

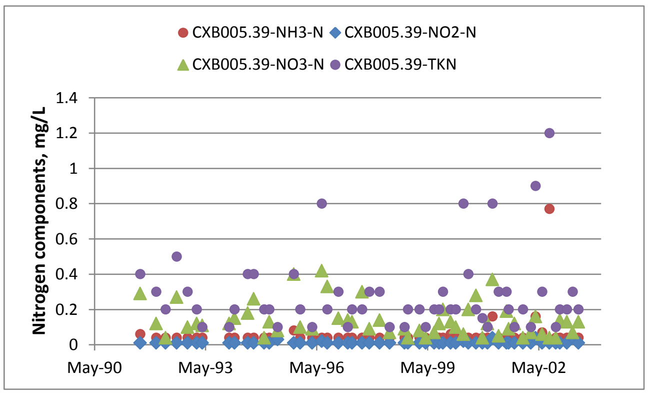

Figure 3-20. Nitrogen Components – CXB

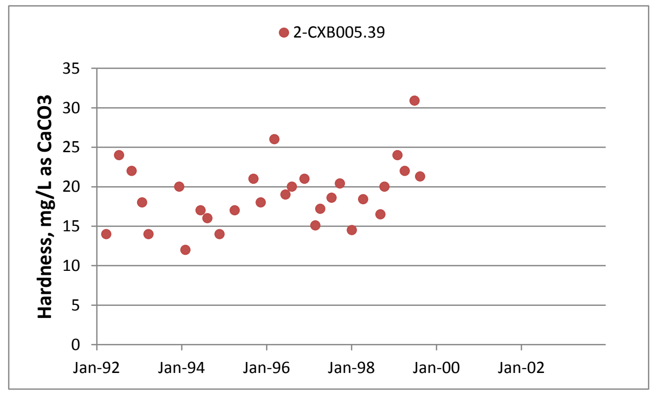

Figure 3-24. Hardness – CXB

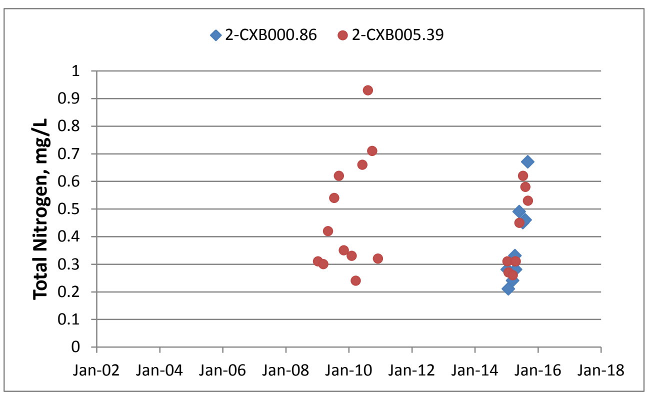

Figure 3-21. Total Nitrogen – CXB

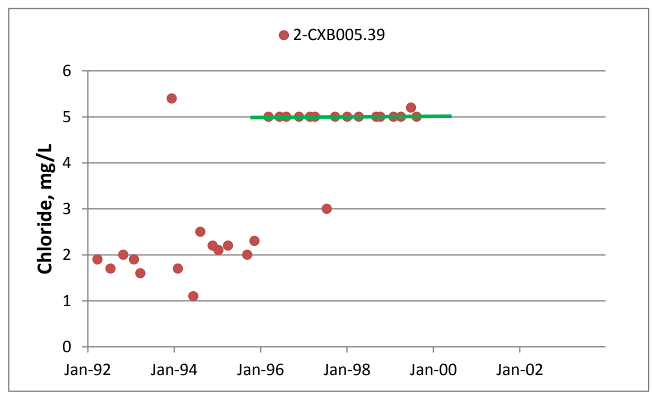

Figure 3-25. Chloride – CXB

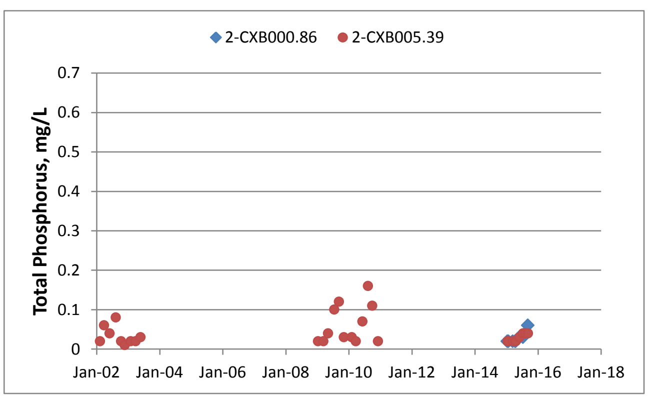

Figure 3-22. Total Phosphorus – CXB

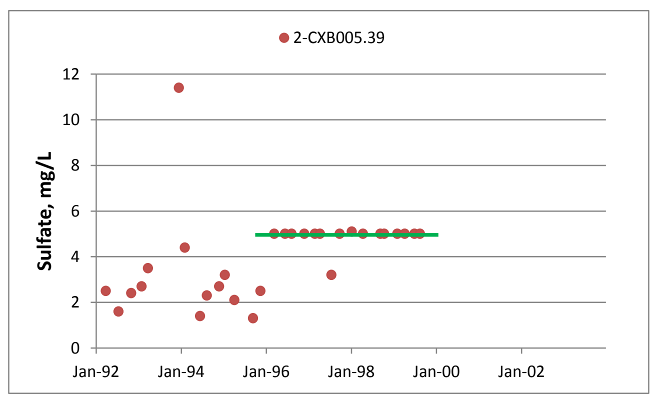

Figure 3-26. Sulfate – CXB

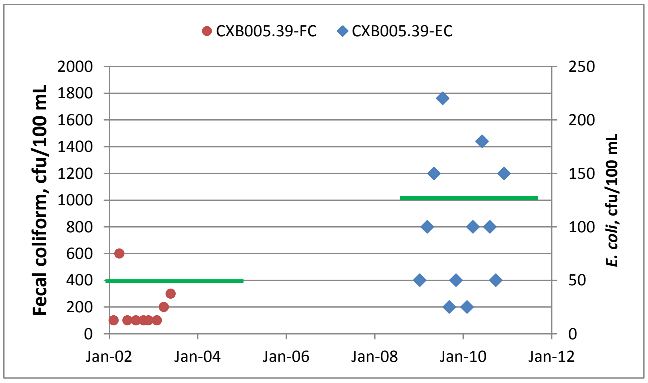

Figure 3-27. Bacteria – CXB

- Nutrient data from various Cunningham Creek stations are summarized in **Error! Reference source not found.** to assist in assessing nutrient influences in these watersheds.

Table 3-4. Nutrient Concentration Averages and Ratios at all Cunningham Creek Monitoring Stations

Station	TN		NO2 + NO3-N		TKN		TP		TN:TP	TKN:TN
	No.	Ave	No.	Ave	No.	Ave	No.	Ave	Ratio	Ratio
2-CFK001.31	12	0.623					12	0.035	17.8	
2-CNM001.75	11	0.275					11	0.026	10.4	
2-CNM002.25	18	0.418	18	0.079			18	0.080	5.2	
2-CNM004.16	12	0.348	12	0.093			12	0.034	10.2	
2-XPA000.57	12	0.341	12	0.169			12	0.023	14.6	
2-CXB000.86	12	0.380					12	0.029	13.0	
2-CXB005.39	55	0.494	110	0.151	55	0.283	55	0.082	6.0	0.573

No. = number of samples; Ave. = average concentration in mg/L.

3.2. DEQ Stream Tests for Metals and Organic Compounds

No samples were analyzed for dissolved metals at any of the DEQ monitoring sites in Cunningham Creek and so, their effect is unknown, but not suspected.

3.3. Virginia DEQ Permits

- There are no domestic septic system discharge permits for single-family homes (SFH) in the watershed.
- There is one industrial VPDES permit in the watershed, as described in Table 3-4.

Table 3-5. VPDES Permits in Cunningham Creek watershed

Permit No	Facility Name	Classification	Start Date	Water Body	Receiving Stream
VA0090905	Tenaska Virginia Generating Station	Active	01-JUL-2012	VAV-H32R	Middle Fork Cunningham Creek

Tenaska is a natural gas powerplant that withdraws water from the Rivanna to use as cooling water. The water is treated, stored in detention ponds and then pumped back to the Rivanna (as of 2011). There are 6 outfalls on the property. Two of these outfalls go to internal detention ponds. There are four external outfalls. Two of these are stormwater only and discharge to the Rivanna. The Industrial Stormwater permit conditions are included in the VPDES permit for this facility (as opposed to other facilities that chose to have two separate permits). The other two discharges are as follows:

- 001 goes to Cunningham Creek. It was used from 2002-2010. Since January of 2011, there is not been discharge from outfall 001.
- 004 discharges to the Rivanna and has been Tenaska's preference due to the lower limits. This has been the primary outfall since the pipeline completion in 2011.

Tenaska is in good standing with their permit and no compliance actions have been enforced. The Tenaska Virginia Generating Station was constructed in 2002-2003 with primary discharge being to the Middle Fork Cunningham Creek. The plant began monthly discharge monitoring in January 2004 and continued through December 2010, when its discharge was diverted to the Rivanna River. During that time, the discharge averaged 0.63 MGD, with a permitted daily average of 1.25 MGD. Prior to 2008, Tenaska's discharge occasionally exceeded its permitted maximum temperature limit (Figure 3-28), although temperature at downstream stations reported no in-stream exceedences. Although neighboring land owners detected the smell of chlorine near the Tenaska discharge, all monthly discharge concentrations (Figure 3-29) were well below the human health criterion of 230 mg/L.

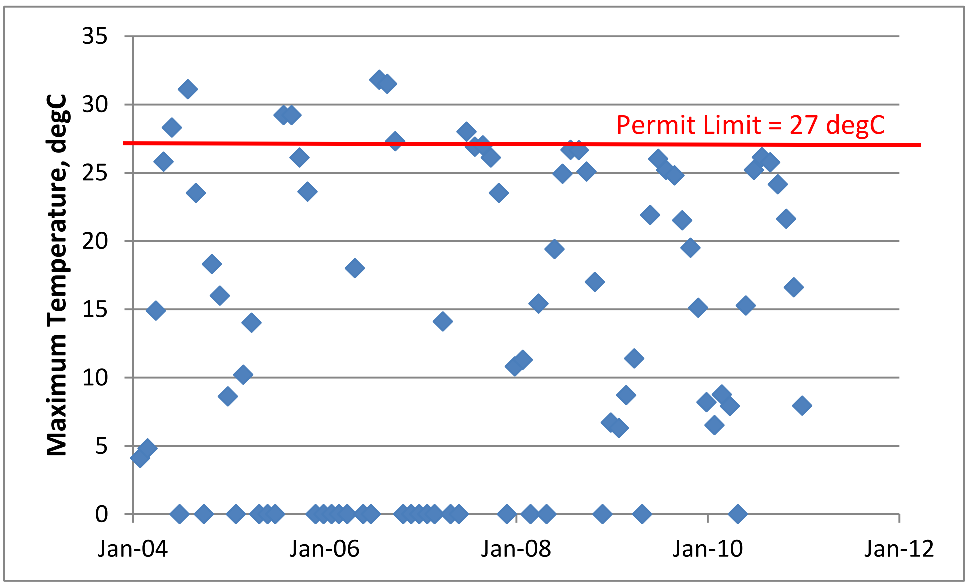

Figure 3-28. Tenaska Discharge Monthly Maximum Temperature

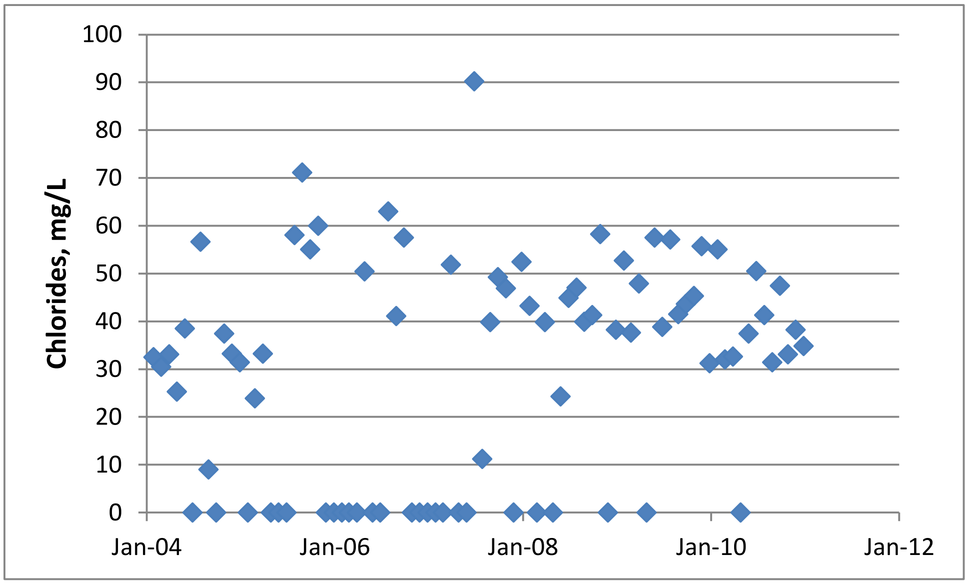

Figure 3-29. Tenaska Discharge Monthly Average Chloride Concentration

- There are no Industrial Stormwater General Permits in the watershed.
- There are no AFO or poultry permits in the watershed.
- There are various parcels of land in the SF and mainstem Cunningham Creek sub-watersheds that are permitted for biosolids application, though there history is unknown. None of the permitted areas are currently receiving applications.

3.4. DEQ Pollution Response Preparedness (PReP) Reports

Since October 1, 2009, only one PReP incident has been reported in the Cunningham Creek watershed, as described in Table 3-6.

Table 3-6. Record of PReP Incidents

Incident Date/Time	Site Name	Site Address	Quantity	Units	Site Summary
20-Dec-10	Tenaska Virginia Generating Station VA0090905	Pipeline leak @ outfall 004	37,000	gallons	Valve failure on pipeline. leak located on Tenaska property and the water flowed to UT that flows to cunningham creek.

3.5. Virginia DEQ – Other Relevant Monitoring or Reports

- Relative Bed Stability (RBS) Analysis: A Log Relative Bank Stability (LRBS) test is a type of siltation index. An LRBS score of negative one (-1) indicates that sediments ten times larger than the median are moving at bankfull flow, with a medium probability of impairment from sediment. LRBS scores < -1 are considered sub-optimal, while scores > -0.5 are considered optimal. RBS scores were analyzed in conjunction with other Physical Habitat (PHAB) measures in Spring 2015 at 4 sites around the watershed (Table 3-7).

Table 3-7. PHAB Analysis Results

StationID	Date	Slope	% Bedrock	% Sand + Fines	Embeddedness (%)	LRBS*
2-CFK001.31	08/13/15	0.31	6.7	32.4	61.1	-0.101
2-CNM001.75	08/13/15	0.39	0.0	39.0	65.3	-0.641
2-CXB000.86	08/11/15	0.28	12.4	25.7	46.2	-0.156
2-CSF000.03	08/12/15	0.37	0.0	38.1	62.0	-0.793

* LRBS > -0.5 indicates a normal sediment load;
LRBS < -1.0 indicates excessive sediment load.

3.6. VAHWQP Household Drinking Water Analyses

- The Virginia Household Water Quality Program (VAHWQP) conducted drinking water clinics in Fluvanna County together with Albemarle County in March-May 2009 (Benham et al., 2009) and again in October 2010 jointly with Louisa County (Benham et al., 2010), where homeowners brought tap water samples collected from homes that use a private water supply system (e.g., well) for water quality testing and analysis (Table 3-8). Although the VAHWQP samples were collected from inside the home where water treatment systems, if present, may have altered the water chemistry, data from the VAHWQP samples do provide some general information about the nature of groundwater in the area.
- This program uses the EPA primary and secondary standards of the Safe Drinking Water Act, which are enforced for public systems and serve as guidelines for private water supplies.

Table 3-8. Virginia Household Water Quality Program, County Drinking Water Clinic Results

2009 Albemarle and Fluvanna Counties VAHWQP Drinking Water Clinic Results N = 157 participants (142 Albemarle and 15 Fluvanna)			
Test	Standard	% Exceeding Std (Alb)	% Exceeding Std (Flu)
Iron (mg/L)	0.3	1.4	6.7
Manganese (mg/L)	0.05	8.5	6.7
Hardness (mg/L)	180	3.5	0
Sulfate (mg/L)	250	0	0
Chloride (mg/L)	250	0.7	0
Fluoride (mg/L)	2.0/4.0	1.4 (2-4)	0
Total Dissolved Solids (mg/L)	500	0.7	0
pH	6.5 to 8.5	27.7 (<6.5)	46.7 (<6.5)
Copper (mg/L)	1.0/1.3	0.7	0
Sodium (mg/L)	20	9.9	0
Nitrate-N (mg/L)	10	0.7	0
Total Coliform Bacteria	ABSENT	22	40
E. coli Bacteria	ABSENT	3.5	13.3

2010 Fluvanna and Louisa Counties VAHWQP Drinking Water Clinic Results N = 47 samples				
Test	Standard	Average	Maximum Value	% Exceeding Standard
Iron (mg/L)	0.3	0.06	0.983	2.1
Manganese (mg/L)	0.05	0.024	0.162	16.7
Hardness (mg/L)	180	76.2	224.9	6.3
Sulfate (mg/L)	250	6.4	76.6	0
Chloride (mg/L)	250	7	50	0
Fluoride (mg/L)	2.0/4.0	0.14	0.46	0
Total Dissolved Solids (mg/L)	500	128	355	0
pH	6.5 to 8.5	6.66	7.82	52.1 (<6.5)
Copper (mg/L)	1.0/1.3	0.047	0.334	0
Sodium (mg/L)	20	11.23	90.9	8.3
Nitrate-N (mg/L)	10	0.916	11.5	2.1
Total Coliform Bacteria	ABSENT	--	--	37.5
E. coli Bacteria	ABSENT	--	--	4.2

3.7. Stream Watch Reach Geomorphic Survey Data

Table 3-9. Summary of Geomorphic Survey Parameter Measurements

	MF Cunningham Creek			Cunningham Creek	
Reach Code	**CNM-R07**	**CNM-R09**	**CNM-R09**	**CXB-R07**	**CXB-R07**
Sample Date	**22-Jun-07**	**26-Jun-09**	**06-May-10**	**09-Oct-07**	**29-Jun-09**
Bankfull Channel Width (feet)	25.4	23.2		48	64.8
Bankfull Mean Depth (feet)	2.7	2.3		6.4	4.4
Width/Depth Ratio	9.41	10.09		7.50	14.73
Bankfull cross-sectional area (square feet)	68.58	53.36		307.2	285.12
Bankfull Maximum Depth (feet)	3.38	3.1		8.5	5.9
Width of flood-prone area	>500	~400		>200	~160
Entrenchment Ratio	>19.69	~17.24		>4.2	~2.47
Field-measured Slope	0.002	0.003		0.003	0.004
Rosgen classification	C4	E4		E4	C4
Visual Rating of Bio-sampling Riffle	1			2	2
d50 particle (mm)	11.3	7.9	7.9	11.3	7.9
d50 particle class	medium gravel	fine gravel	fine gravel	medium gravel	fine gravel
d84 particle (mm)	31.9	22.5	22.5	255.9	255.9
d84 particle class	coarse gravel	coarse gravel	coarse gravel	large cobble	large cobble
Description of Reach Particles	gravel and fine sand	mostly gravel with fine sand		small gravel with riprap riffles	gravel/sand pool
% Fine Sand/Clay	9	10	19	19	21
% Medium to Coarse Sand	7	3	9	6	2
% Gravel	80	87	71	51	51
% Cobble	4	0	1	13	10
% Boulder	0	0	0	9	14
% Bedrock	0	0	0	2	2

GeomorphSurveyComments:
CNM-R07 06/22/07: width-depth ratio is low, but we feel that it should really be moderate, making it a C stream. Confidence in Rosgen key:entrenchment ratio: very confident that stream is slightly entrenched; width/depth ratio: we feel that this is a high ratio for thes types of streams.
CXB-R07 10/09/07: pebble count cross sections were set at equally speaced points- no differentiation between riffle and pool (2 riffles are man made)

3.8. DCR BMP Installation Data for VAHU6 JR20 (1999-2014)

Virginia Agricultural Cost-share data were provided by Virginia DCR for the JR20 6th Order Hydrologic Unit through program year 2014. The extent of installed BMPs are summarized by Cunningham Creek sub-watershed in Table 3-10, with Table 3-11 showing the preponderance of installation taking place since 2010. The number and type of livestock associated with the livestock exclusion practice are given in Table 3-12.

Table 3-10. Summary of Installed BMPs 1999-2014 by Sub-watershed

SubWs_ID	Subwatershed Name	CCI-CNT	FR-1	SL-6	SL-6B	SL-8B
		Long Term Continuous No-Till Planting System	Aforestation of erodible crop and pastureland	Stream Exclusion With Grazing Land Management*	Alternative Water System	Small Grain and Mixed Cover Crop for Nutrient Management and Residue Management
		Acres	Acres	Lin. Feet	Acres	Acres
1	Cunningham Creek	0	10	1,400	0	0
2	Lower NF Cunningham Creek	0	45	0	18	0
4	Upper NF Cunningham Creek	0	0	2,762	0	0
5	South Fork Cunningham Creek	21.2	0	14,707	0	40.7
6	Lower MF Cunningham Creek	0	0	3,400	0	0
7	X-trib to MF Cunningham Creek	0	0	2,698	0	0
	Grand Total	**21.2**	**55**	**24,967**	**18**	**40.7**

* Includes 265.2 acres of Grazing Land Management.

Table 3-11. Extent BMPs Installed over Two Time Periods

Practice Code	Practice Name	Extent Units	Extent Installed		
			1999-2005	2010-2014	Total
CCI-CNT	Long Term Continuous No-Till Planting System	Acres	0	21.2	21.2
FR-1	Aforestation of erodible crop and pastureland	Acres	55	0	55
SL-6	Stream Exclusion With Grazing Land Management	Lin. Feet	1,608	23,359	24,967
SL-6B	Alternative Water System	Acres	18	0	18
SL-8B	Small Grain and Mixed Cover Crop for Nutrient Management and Residue Management	Acres	0	40.7	40.7

Table 3-12. Summary of Animals Excluded from Streams due to BMPs

SubWs_ID	Subwatershed Name	Animal Type and Number		
		Beef	Horse	Goat
4	Upper NF Cunningham Creek	20	0	0
5	South Fork Cunningham Creek	52	0	0
6	Lower MF Cunningham Creek	0	5	35
7	X-trib to MF Cunningham Creek	8	20	0
	Grand Total	**80**	**25**	**35**

3.9. INteractive STream Assessment Resource (INSTAR) Database

INSTAR consists of a comprehensive (and growing) database representing over 2,000 aquatic (stream and river) collections statewide. Data represent fish and macroinvertebrate assemblages, instream habitat, and stream health assessment, based on integrative, multimetric indices at the watershed scale and a stream reach scale. The INSTAR program began in 2003 as a collaboration between the Center for Environmental Studies at VCU and several agencies, including the Virginia Healthy Waters Program at the Virginia Department of Conservation and Recreation and the Virginia Coastal Zone Management Program. Three monitoring sites were identified within the Cunningham Creek watershed. One site (H32500) on the Upper Middle

Fork Cunningham Creek is an older data point from EPA's old Environmental Monitoring and Assessment Program (EMAP), dating back to 1994. The other two sites have been monitored more recently in 2009 by VCU. Habitat metrics are shown in Table 3-13 and corresponding fish inventories in Table 3-14.

Table 3-13. INSTAR Habitat Metrics

Location	**H32001**	**H32010**	**H32500**
Sub-watershed Name	**MF Cunn. Cr. X-trib**	**Cunn. Cr.**	**Upper Middle Fork Cunn. Cr.**
Sample Date	**10/29/09**	**10/29/09**	**05/05/94**
Bank Stability_Left	5	7	4
Bank Stability_Right	5	7	4
Bank Vegetation_Left	10	10	9
Bank Vegetation_Right	10	10	9
Channel alteration	16	17	20
Channel flow status	11	15	14
Embeddedness	11	13	9
Epifaunal substrate	12	14	9
Frequency of riffles	11	13	14
Riparian Zone Width_Left	10	10	10
Riparian Zone Width_Right	10	10	10
Sediment deposition	12	14	8
Velocity	14	13	18
Total Score	**137**	**153**	**138**
Comments			High Gradient-Correct Total

Table 3-14.INSTAR Fish Inventory Data

	InSTAR Location Code:	H32001	H32010	H32500	Grand Total
	Sub-watershed Name:	MF Cunn. Cr. X-trib	Cunn. Cr.	Upper Middle Fork Cunn. Cr.	
	Sample Date:	10/29/09	10/29/09	05/05/94	
FISH_CODE	**COMMON_NAME**	**Fish Count**			
SAT	creek chub	1	0	1	2
ARO	American eel	1	1	0	2
ASY	pirate perch	1	1	1	3
CAN	central stoneroller	0	1	0	1
CCO	white sucker	0	0	1	1
CFU	rosyside dace	1	0	1	2
CYA	satinfin shiner	0	1	0	1
EFL	fantail darter	1	1	1	3
ENG	johnny darter	1	1	0	2
ENI	chain pickerel	0	0	1	1
EOB	creek chubsucker	0	0	1	1
EOL	tessellated darter	0	0	1	1
LAR	rosefin shiner	0	1	1	2
LAU	redbreast sunfish	0	1	1	2
LCO	common shiner	1	1	1	3
LCY	green sunfish	0	1	0	1
LGI	pumpkinseed	1	0	1	2
LMA	bluegill	1	1	1	3
MCE	black jumprock	0	1	0	1
MDO	smallmouth bass	0	1	0	1
MSA	largemouth bass	1	1	0	2
NIN	margined madtom	1	1	1	3
NLE	bluehead chub	1	1	1	3
NPR	swallowtail shiner	0	1	0	1
NRA	bull chub	0	1	0	1
NTE	telescope shiner	0	1	0	1
PMA	sea lamprey	0	1	0	1
PNO	stripeback darter	0	0	1	1
POR	Mountain redbelly dac	1	0	0	1
PRO	Roanoke darter	0	1	1	2
RAT	eastern blacknose dac	1	0	1	2
SCO	fallfish	0	1	1	2
TRH	torrent sucker	1	0	1	2
Grand Total		**15**	**22**	**20**	**57**

3.10.Timber Harvesting History in Cunningham Creek Sub-watersheds

The following summary of timber acres harvested in the watershed was derived from information provided by the Virginia Division of Forestry, Central Region, in Charlottesville.

Table 3-15. Area of Timber Harvested by Year and Sub-watershed (VDOF)

SubWs_ID	Sub-Watershed Name	2010	2011	2012	2013	2014	2015	Grand Total
		Area Harvested, acres						
1	Cunningham Creek	0	0	4	0	208	50	262
2	Lower NF Cunningham Creek	43	93	93	117	30	0	376
3	X-trib to NF Cunningham Creek	0	0	5	0	0	0	5
4	Upper NF Cunningham Creek	75	0	0	220	170	267	732
5	South Fork Cunningham Creek	190	324	51	0	137	68	770
6	Lower MF Cunningham Creek	30	60	0	60	0	0	150
7	X-trib to MF Cunningham Creek	0	0	478	55	44	0	577
8	Upper MF Cunningham Creek	0	30	0	0	0	135	165
	Grand Total	**338**	**507**	**631**	**452**	**589**	**520**	**3,037**

4.0 DEQ's Freshwater Probabilistic Monitoring – Stressor Condition Classes

DEQ assesses biological condition using benthic aquatic organisms as indicators of stream health. Impairments to the biological communities may be caused by stressors like streambed sedimentation, habitat disturbance, and nutrients, which are not subject to water quality criteria. To assist in interpreting some of these related water quality parameters, screening values (non-regulatory thresholds) are often used. DEQ has derived screening values from its Probabilistic Monitoring (ProbMon) database which are listed in the Draft 2014 305(b)/303(d) Integrated Report and shown in Table 4-1. The two threshold categories shown in the table have an intermediate classification of "fair" (VDEQ, 2014), and are used to help put values from this analysis in perspective.

Table 4-1. DEQ ProbMon Screening Value Categories for Parameters without Water Quality Criteria

DEQ Stressor Parameters	Alternate Name	Units	Suboptimal	Optimal	Reference
Total Nitrogen	Total Nitrogen	mg/L	>2	<1	VDEQ, 2006a
Total Phosphorus	Total Phosphorus	mg/L	>0.05	<0.02	VDEQ, 2006a
Habitat Degradation	Total Habitat Score	unitless	<120	>150	USEPA, 1999
Streambank Sedimentation	LRBS siltation Index	unitless	<-1.0	>-0.5	Kaufmann, 1999
Ionic strength	TDS	mg/L	>350	<100	VDEQ, 2006b
Metals Water Column	Metals Cumulative Criterion Unit (CCU)	unitless	>2	<1	Clements, 2000

Available data from monitoring stations within the Middle Fork Cunningham Creek sub-watersheds were compared with these various screening values in Table 4-2. Available data from monitoring stations within the North Fork, South Fork, and main stem Cunningham Creek are compared in Table 4-3. Average values were calculated for the 6 potential stressor parameters based on the available data at each monitoring. Since there was a natural break noted in the available data between 2006 and 2009, the data were summarized and a Condition Class assigned to the "1991-2006" and "2009-2015" data separately. The number of samples of each parameter at each site is also provided in the tables, as are summary statistics at the bottom of each table that show the number of parameters in each rating category for each station. Although the data are limited, it is instructive to summarize the data, where available, by their condition classes.

In Table 4-2 for the Middle Fork Cunningham Creek, TN received an "Optimal" condition class rating at 3 stations in the earlier period and at a 4th station in the most recent period. TP, on the other hand, received only "Fair" or "Sub-optimal" ratings at the four sites. Two "Sub-optimal" ratings were received at station 2-CNM002.25 – one for TN and the other for Total Habitat.

In Table 4-3 regarding the North Fork and main stem Cunningham Creek, TN received an "Optimal" condition class rating at all 3 stations in the most recent period. TP, on the other hand, uniformly received a "Fair" rating in the most recent period. The one station and parameter for which data were available to look at change over time was at station 2-CXB005.39 for TP, which received a "Sub-optimal" rating in the earlier period, but has improved to a "Poor" rating in the most recent period. Total Habitat ratings at the two stations with data both rated only as "Fair", while the same stations rated "Optimal" for the LRBS siltation index. The one measurement on the South Fork Cunningham Creek was a "Fair" rating for the siltation index.

Note that there were different amounts of data from different periods available at each site, so the summary statistics at the bottom of each table are not directly comparable with other sites. Also, because of the use of two time periods, the total number of metrics in the Summary Statistics portion may be greater than the 6 parameters in this set.

Table 4-2. ProbMon Stressor Ratings at DEQ Stations on the Middle Fork Cunningham Creek

Parameter	Units		2-CNM001.75		Condition Class	2-CNM002.25		Condition Class	2-CNM004.16		Condition Class	2-XPA000.57		Condition Class
		Period	average	no. of samples	Average	average	no. of samples	Average	average	no. of samples	Average	average	no. of samples	Average
Total dissolved solids (TDS)	mg/L				**			**			**			**
Total nitrogen	mg/L	1991 - 2006			**	0.42	18	Optimal	0.35	12	Optimal	0.34	12	Optimal
		2009 - 2015	0.25	9	Optimal			**			**			**
Total phosphorus	mg/L	1991 - 2006			**	0.080	18	Suboptimal	0.034	12	Fair	0.023	12	Fair
		2009 - 2015	0.023	9	Fair			**			**			**
Dissolved metals Cumulative Criterion Unit (CCU)	unitless				**			**			**			**
Total Habitat	unitless	2009 - 2015	129.1	7	Fair	114.8	5	Suboptimal			**			**
Relative Bed Stability (LRBS)	unitless	2009 - 2015	-0.641	1	Fair						**			**
Summary Statistics														
Suboptimal					0			2			0			0
Fair					3			0			1			1
Optimal					1			1			1			1
Total No. of Metrics					4			3			2			2

Table 4-3. ProbMon Stressor Ratings at DEQ Stations on the North Fork, South Fork and Main Stem of Cunningham Creek

Parameter	Units		2-CSF000.03		Condition Class	2-CFK001.31		Condition Class	2-CXB000.86		Condition Class	2-CXB005.39		Condition Class
		Period	average	no. of samples	Average	average	no. of samples	Average	average	no. of samples	Average	average	no. of samples	Average
Total dissolved solids (TDS)	mg/L				**			**			**			**
Total nitrogen	mg/L	1991 - 2006			**			**			**			**
		2009 - 2015			**	0.68	9	Optimal	0.32	11	Optimal	0.45	21	Optimal
Total phosphorus	mg/L	1991 - 2006			**			**			**	0.072	63	Suboptimal
		2009 - 2015			**	0.037	9	Fair	0.025	11	Fair	0.047	21	Fair
Dissolved metals Cumulative Criterion Unit (CCU)	unitless				**			**			**			**
Total Habitat	unitless	2009 - 2015			**	130.2	5	Fair	135.0	7	Fair			**
Relative Bed Stability (LRBS)	unitless	2009 - 2015	-0.793	1	Fair	-0.101	1	Optimal	-0.156	1	Optimal			**
Summary Statistics														
Suboptimal					0			0			0			1
Fair					1			2			2			1
Optimal					0			2			2			1
Total No. of Metrics					1			4			4			3

5.0 Stressor Analysis Overview

A list of candidate stressors was developed and evaluated for the each impaired segment along Cunningham Creek and its tributaries in order to determine the most probable pollutant(s) responsible for the benthic impairments. A potential stressor checklist was used to evaluate known relationships or conditions that may show associations between potential stressors and changes in the benthic community. Depending on the strength of available evidence, the potential stressors were "eliminated", considered as "possible" stressors, or recommended as the "most probable" stressor. Candidate stressors included ammonia, ionic strength, pH, hydrologic modifications / flow, metals, pH, temperature, toxic organic compounds, nutrients, organic matter, and sediment.

5.1. Eliminated Stressors

Some stressors with little to no available data, but no suspected sources, are first discussed for all impaired segments. Where data were available, most were below the minimum analytical detection limit (MDL) or were below applicable water quality standard (WQS) concentration criteria, as shown in Table 5-1. Following the discussion of the eliminated stressors, an evaluation of the more probable stressors is included for each impaired segment.

Table 5-1. Available Data on Eliminated Stressors

Potential Stressor	Units	Sub-Watershed					
		Upper MF	Lower MF	NF X-trib	Lower NF	CXB 5.39	CXB 0.86
Ammonia	No. > MDL	1/12	1/25	ND	ND	4/63**	ND
Ionic Strength (TDS/ Conductivity/ Sulfates)		ND	ND	ND	ND	*	ND
Metals		ND	ND	ND	ND	ND	ND
pH	No. exceeding WQS	ND	0/25	ND	0/9 (2015)	0/63	0/9 (2015)
Temperature	No. exceeding WQS	0/12	0/25*	ND	0/9 (2015)	0/63	0/9 (2015)
Toxics	No. > MDL	ND	ND*	ND	ND	3/43 (pre-2000)	ND

MDL = minimum analytical detection limit
WQS = water quality standard
ND = no data
* Discussed further under related impaired segment
** One sample taken on 08/22/02 was 0.77 mg/L

5.1.1. Ammonia

High values of ammonia are toxic to many fish species and may affect the benthic community as well. There were no point sources of ammonia, no reported fish kills that might point to ammonia as a possible stressor, and where it was monitored, there were no water quality standard (WQS) exceedences. Therefore ammonia was eliminated from further consideration as a stressor.

5.1.2. Ionic Strength

Total dissolved solids (TDS) are the inorganic salts, organic matter and other dissolved materials in water. Elevated levels of TDS cause osmotic stress and alter the osmo-regulatory functions of organisms (McCulloch et al., 1993). There were three specific conductivity measurements at station 2-CXB005.39 taken during 2001-2002 that exceeded the range of 40-80 µmhos/cm, typically seen at this station. Although there is no specific conductivity water quality criterion, these values are relatively low in comparison to screening values used to identify reference watersheds during development of the VSCI (< 500 µmhos/cm; Tetra Tech, 2003). Therefore, ionic strength, as measured by TDS, conductivity, and sulfates, was eliminated as a possible stressor.

5.1.3. Metals

Increased metals concentrations lead to low diversity and low total abundance of benthic organisms, with specific reduced abundance of metal-sensitive mayflies and increased abundance of metal-tolerant chironomids (Clements, 1994). Although elevated levels of manganese and iron are quite common in household drinking water throughout the watershed, they are regarded as a taste and odor nuisance problem, but not one that would affect benthic macroinvertebrate organisms. Therefore, metals were eliminated from further consideration as a possible stressor.

5.1.4. pH

Benthic macroinvertebrates require a pH range of 6.0 to 9.0 to live and grow. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater, mining discharge and urban runoff can potentially alter in-stream levels of pH. Since 2002, all pH samples reported by DEQ at various sites around the Cunningham Creek watershed fall with the acceptable range. Therefore, pH was eliminated from further consideration as a stressor.

5.1.5. Temperature

Elevated temperature can stress benthic organisms and provide sub-optimal conditions for their survival. All five impaired segments along Cunningham Creek and its tributaries are classified as Piedmont Zones Class III Non-Tidal Waters with a maximum temperature standard of 32°C. No exceedances of the temperature standard were recorded at any of the DEQ ambient monitoring stations. Although there is evidence that vegetation within the riparian corridor is sparse in some spots, which could lead to increased temperatures, and elevated temperatures were reported in Tenaska discharge prior to 2010, however, the in-stream temperature data does not reflect any adverse impact. Therefore, temperature was eliminated as a stressor.

5.1.6. Toxic Organic Compounds

Toxic substances by definition are not well tolerated by living organisms. The presence of toxics as a stressor in a watershed may be supported by very low numbers of any type of organisms, low organism diversity, exceedances of freshwater aquatic life criteria or consensus-based Probable Effect Concentrations (PEC) for metals or inorganic compounds, by low percentages of the shredder population, reports of fish kills, or by the presence of suspected sources. There were no reported fish kills in the watershed. Therefore, because no direct evidence of toxicity could be found (such as absence or very low numbers of organisms), toxic organic compounds have been eliminated as a possible stressor.

6.0 Analysis of Candidate Stressors for Upper Middle Fork (MF) Cunningham Creek

The suspected source of the benthic impairments in the Upper MF Cunningham Creek was listed as “natural sources” in the 2014 impaired waters fact sheets, but was described in 2002 DEQ biologist’s field notes as being due to drought. The original listing was in 2004. The only DEQ monitoring station for biological monitoring in the impaired segment is 2-CNM003.82. A subsequent sample taken in 2003 was healthy, but no other samples have been taken at this site as road access is no longer available. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. The purpose of the stressor analysis is to look for a stressor(s) that affected the abundance, diversity, and pollution-sensitivity of the benthic macroinvertebrates along the Upper MF Cunningham Creek which may have led to the initial listing in 2004.

6.1. Possible Stressors

6.1.1. Hydrologic Modifications/Variability

Hydrologic modifications can cause shifts in the availability of water, sediment, food supply, habitat, and pollutants from one part of the watershed to another, thereby causing changes in the types of biological communities that can be supported by the changed environment. No flow monitoring gages were in the watershed.

Evidence for hydrologic variability being a most probable stressor in 2004 comes from both anecdotal information and from the record of annual rainfall in the area. On 04/29/02, DEQ monitors noted “drought conditions” at station 2-CNM003.82, which corresponded with a poor VSCI score for the one sample included in the 2004 assessment. Hydrologic variability is due to natural and human-induced changes in weather patterns that might affect survival and available habitat for benthic organisms. The annual CFSR rainfall totals generated for Cunningham Creek, as shown in Figure 6-1, support the monitor’s analysis of drought conditions during the period previous to the sample (2000-2002), as well as possibly in 2007-2008. Average annual precipitation at the Palmyra 3S National Climatic Data Center station (446491) located 2.57 miles south of the watershed outlet is 41.8 inches, according to the NCDC 1981-2010 Climate Normals for this station (NOAA, 2016). However, the last 6 years show rainfall totals more in a normal range for this site.

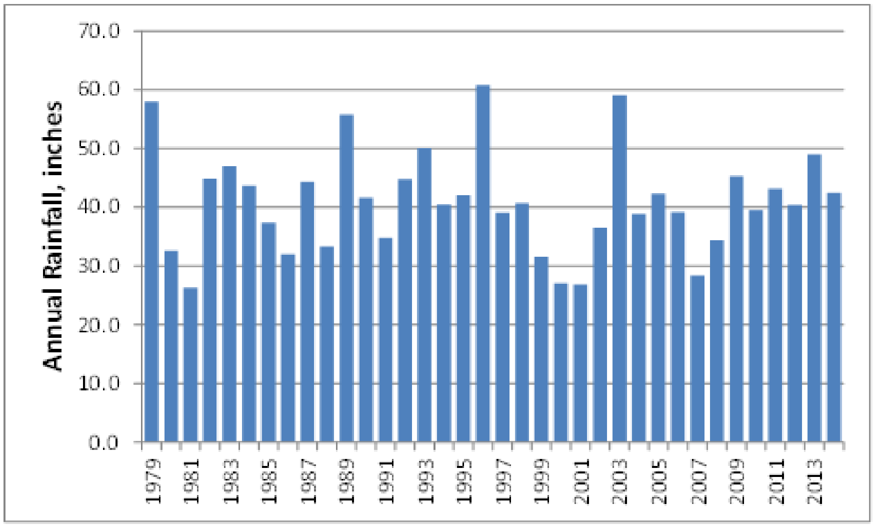

Figure 6-1. Annual Rainfall Totals, Cunningham Creek (CFSR, 2016)

Therefore, hydrologic modifications and climate variability appear to be one of the stressors that led to the poor 2002 benthic sample in this sub-watershed.

6.1.2. Nutrients

Excessive nutrient inputs can lead to increasing algal growth, eutrophication, and low dissolved oxygen (DO) concentrations that may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration. Sources of nitrogen include groundwater, residential wastewater and runoff, atmospheric deposition, and runoff associated with agricultural operations. Although there have been no biosolids applications or TP threshold exceedances in the Upper MF sub-watershed, the 2002 sample had a dominance of chironomids which may be indicative of elevated nutrients; algae has been visible in several ponds; at station 2-CNM004.16, 7 out of 12 samples had TN concentrations > 0.30 mg/L, but still rated as “optimal” by DEQ’s ProbMon Condition Classes, while TP averaged 0.034 mg/L, and was rated as “fair.” Therefore, nutrients were also determined to be a possible stressor to the biological community in 2004.

6.1.3. Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter include household wastewater discharges, spills, malfunctioning septic systems, livestock manures, and runoff from impervious areas.

The 2002 sample had a high percentage of filterer-collector organisms, which could be indicative of elevated organic matter. Also, during the 07/04-05/06 period, ambient monitoring at 2-CNM004.16 had 2 out of 12 samples exceeding the *E. coli* bacteria standard. Unfortunately, no BOD, COD, or DO samples were available to assess additional impacts from nutrients, although both the 2002 and 2003 samples had low MFBI metric values, which are not indicative of organic matter as a stressor. Although all the evidence is not supportive, the persistent visible algae on the ponds show the system is enriched and organic matter may have contributed to the stress in the 2002 sample. Since the 2003 sample was healthy even though algae persists even in current imagery, organic matter is listed only as a possible stressor.

6.2. Most Probable Stressor

6.2.1. Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forestry and agricultural runoffs, livestock access to streams, construction sites, and in-stream disturbances.

None of the samples had elevated TSS or turbidity concentrations, not unsurprisingly, as they are primarily ambient baseflow samples, and 20 species of fish were identified in a 1994 EMAP survey (VCU, 2015). However, the 2002 sample had a low percentage of haptobenthos organisms which might be indicative of habitat loss due to sediment, and on a March 2016 tour of the watershed, some bank stability issues were noted, along with considerable sediment deposition at 2-CNM004.16, although the flow was clear. Therefore, currently, sediment appears to be the most probable cause of stress, with possible contributions from nutrients.

7.0 Analysis of Candidate Stressors for Lower Middle Fork (MF) Cunningham Creek

The suspected source of the benthic impairments in the Lower MF Cunningham Creek was listed as “non-point sources” in the 2014 impaired waters fact sheets, with an original listing in 2010. Monitoring stations for biological monitoring in the impaired segment include DEQ stations 2-CNM001.75 and 2-CNM002.25, as well as StreamWatch stations 2-CNM05-SW and 2-CNM07-SW. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. The purpose of the stressor analysis is to look for a stressor(s) that affected the abundance, diversity, and pollution-sensitivity of the benthic macroinvertebrates and which may have led to the initial listing in 2010, as well as looking at current probable stressors.

7.1. Possible Stressors

7.1.1. Nutrients

Excessive nutrient inputs can lead to increasing algal growth, eutrophication, and low dissolved oxygen (DO) concentrations that may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration. Sources of nitrogen include groundwater, residential wastewater, atmospheric deposition, and agricultural activities. A dominance of chironomids, hydropsychids, and simuliids, which may be indicative of elevated nutrients were reported in 5 out of 7 samples prior to the 2010 assessment, and in 8 out of 10 samples since then. At station 2-CNM002.25 between 2003-2006, average TN = 0.418 mg/L, and average TP = 0.080 mg/L, with 2 exceedences of the TP screening threshold of 0.20 mg/L, along with 7 out of 53 samples that exceeded the fecal coliform bacteria WQS of 400 cfu/100 mL. Downstream, at station 2-CNM001.75 in 2015, TN averaged 0.275 mg/L and TP = 0.026 mg/L. Livestock with stream access were also in the watershed just above station 2-CNM002.25 prior to the 2010 assessment, which have since been replaced with a vineyard and a small horse and goat operation, all of which were fenced in the last couple of years. There have been no biosolids applications in the Lower MF sub-watershed.

Therefore, nutrients were determined to be a possible stressor to the biological community in the 2010 assessment, but have since been addressed by a land use change and implementation of livestock exclusion fencing.

7.1.2. Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter include household wastewater discharges, spills, malfunctioning septic systems, livestock, and runoff from impervious areas.

Monitoring at 4 stations has reported 6 out of 7 samples prior to 2008 and 7 out of 16 samples since with a high percentage of filterer-collector organisms, which may be indicative of organic contributions. Additionally, 5 out of 20 samples (4 stations) had elevated MFBI values (also indicative of organic-loving organisms) prior to 2008 but 0 out of 6 samples since then. The upstream station prior to 2008 also had 4 out of 7 samples with tubificid and asellid organisms (indicative of sewage or possible rotting carcases), but with no detections of these organisms in the last 16 samples combined.

Also, pre-2008, 9 out of 18 samples were reported with E. coli WQS exceedences, whereas neither of 2 samples taken in 2015 exceeded the WQS. There have been no exceedences of the minimum DO WQS either pre-2008 or since. Although organic matter appeared to contribute to the stress in the 2010 assessment, the effect of the organic contributions has diminished over time, and therefore organic matter is listed only as a possible stressor.

7.2. Most Probable Stressor

7.2.1. Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, runoff from forest harvesting and agricultural sites, livestock access to streams, construction sites, and in-stream disturbances.

The primary evidence for sediment as a stressor comes from the habitat metrics and field observations. A lack of riparian vegetation and sediment deposition were noted repeatedly at all 4 stations, with some bank stability issues noted at the upstream site (2-CNM002.25). In addition, embeddedness and lack of epifaunal substrate were most notable at the downstream DEQ site (2-CNM001.75); the LRBS (though only moderately indicative of enhanced sediment movement) was higher at 2-CNM001.75 than at the other 3 sites monitored around the larger Cunningham Creek watershed.

The most probable stressors in 2010 included sediment, nutrients, and possibly decomposing organic matter from pasture runoff and livestock access near 2-CNM002.25 prior to 2008. There may also have been some effects of construction and discharges from Tenaska prior to 2010.

Since then, however, a major offending livestock pasture area has been turned into a vineyard, with all remaining livestock fenced out, and the Tenaska discharge has been diverted to the Rivanna River. Also, since 2010, 150 acres of timber have been harvested in the sub-watershed, although stream buffers appear to have been kept in place. The most probable stressor currently is sediment due to lack of riparian vegetation.

8.0 Analysis of Candidate Stressors for an Unnamed Tributary (X-Trib) to North Fork (NF) Cunningham Creek

The suspected sources of the benthic impairment in the NF Cunningham Creek X-trib was listed as "municipal (urbanized high density area)" and non-point source in the 2014 impaired waters fact sheet. The listing station for this impaired segment was the StreamWatch station 2-XCF01-SW. The stressor(s) may be something that either directly affected the benthic community or indirectly affected its habitat. The purpose of the stressor analysis is to look for a stressor(s) that may be affecting the abundance, diversity, and pollution-sensitivity of the benthic macroinvertebrates along the NF X-trib which may have led to the initial listing in 2010, based on an assessment of monitoring data between January 1, 2003 and December 31, 2008. Beginning in September 2003, this sub-watershed was primarily forested.

8.1. Possible Stressors

8.1.1. Nutrients

Excessive nutrient inputs can lead to increasing algal growth, eutrophication, and low dissolved oxygen (DO) concentrations that may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration. Sources of nitrogen in this watershed include groundwater, residential lawn fertilization, atmospheric deposition, and unknown feedlot activities.

Monitoring data showed that 2 out of 2 pre-2008 samples had a dominance of chironomids which may be indicative of elevated nutrients; and 3 out of 5 samples lacked diversity with their dominant 2 organisms comprising more than 70% of all organisms. New home construction fertilization occurred beginning in 2005 with massive clearing along the northwest boundary of the sub-watershed, where at least 29 new houses and a few others just outside the sub-watershed boundary were built along Taylor Ridge Way and Chapel Court. Fertilizer from new lawn establishment may also be a contributor. Therefore, nutrients were determined to be a possible stressor to the biological community in 2010.

8.1.2. Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter include household wastewater discharges, spills, malfunctioning septic systems, livestock, and runoff from impervious areas.

Although no specific sources have been identified in this sub-watershed, 2 out of 2 benthic samples had a high percentage of filterer-collector organisms and a low fraction of scraper organisms, both of which could be indicative of organic contributions. Since no BOD, COD, or DO samples were available to assess additional impacts from organic matter, organic matter is listed only as a possible stressor.

8.2. Most Probable Stressor

8.2.1. Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forestry and agricultural runoffs, livestock access to streams, construction sites, and in-stream disturbances.

Both pre-2008 samples had low percentages of haptobenthos organisms which might be indicative of habitat loss due to sediment. On a March tour of the watershed, a continued lack of adequate vegetation on developments close to the sub-watershed were observed, as well as a recent denuding of the road outslope vegetation just upstream from the monitoring site. Sediment depositional areas below the road confirmed the excessive movement of sediment in this sub-watershed. The most probable stressor in 2010 was sediment from new home construction, while the most probable stressor today is sediment from expanded new construction and poor vegetation establishment near the outlet. Other potential sources of stress include residential lawn fertilization and runoff from unknown livestock activity in an unbuffered feedlot off Taylor Ridge Way.

9.0 Analysis of Candidate Stressors for Lower North Fork (NF) Cunningham Creek

The suspected source of the benthic impairments in the Lower NF Cunningham Creek was listed as “non-point sources” in the 2014 impaired waters fact sheet. The only DEQ monitoring station for biological monitoring in the impaired segment is 2-CFK001.31. The 2012 listing was based on one poor benthic sample in 2010. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. The purpose of the stressor analysis is to look for a stressor(s) that may be affecting the abundance, diversity, and pollution-sensitivity of the benthic macroinvertebrates along the Lower NF Cunningham Creek which may have led to the initial listing in 2012, based on an assessment of monitoring data between January 1, 2005 and December 31, 2010.

9.1. Possible Stressors

9.1.1. Nutrients

Excessive nutrient inputs can lead to increasing algal growth, eutrophication, and low dissolved oxygen (DO) concentrations that may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration. Sources of nitrogen include groundwater, residential wastewater, atmospheric deposition, and agricultural activities.

The 2010 sample had a dominance of chironomids and simuliidae organisms, which may be indicative of elevated nutrients; in 2015, TN has averaged 0.623 mg/L, rated as “optimal” by DEQ’s ProbMon Condition Classes, while TP averages 0.035 mg/L, rated as “fair”. There have been no biosolids applications or TP threshold exceedances in the Upper NF sub-watershed. There has been considerable new home construction, in addition to older homes on the boundary of the sub-watershed which may have some septic system maintenance issues, and fertilization of residential lawns, in general, may be contributors. Therefore, nutrients were determined to be a possible stressor to the biological community.

9.1.2. Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter include household wastewater discharges, spills, malfunctioning septic systems, livestock, and runoff from impervious areas.

The 2010 sample had a dominance of chironomids and simuliidae organisms, a high number of filterer-collector organisms and a low fraction of scrapers, which could also be indicative of organic contributions. Since then, in the most recent 6 samples, no dominance was observed and the number of filterer-collectors has been reduced. However, 2 of those samples still showed a low fraction of scrapers and 2 samples included tubificid and asellid organisms, generally associated with raw sewage. No exceedences of the minimum DO WQS have been monitored in 2015. Although no

BOD or COD samples were available to assess additional impacts from organic matter, all of the available evidence is not supportive, so organic matter is only listed as a possible stressor.

9.2. Most Probable Stressor

9.2.1. Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forestry and agricultural runoffs, livestock access to streams, construction sites, and in-stream disturbances.

Between 2007 and 2011, DGIF dam inspectors noted a severely eroded gully in the Fluvanna Ruritan Lake outlet channel, whose sediment contribution may incrementally be moving downstream. Minor occurrences of low percentages of haptobenthos and embeddedness were reported. On a March 2016 tour of the watershed, some bank stability issues were noted, along with turbid water and sediment deposition at 2-CFK001.31, which was consistent with 3 out of 4 samples since 2011 rated with poor habitat scores for the sediment deposition metric. Although the 2015 measurement of the siltation index (LRBS) indicated normal bottom sediment characteristics, the most probable stressor is sediment arising from episodic upstream gully erosion near the lake outlet, residential development, and possibly minor contributions from timber harvesting.

10.0 Analysis of Candidate Stressors for Cunningham Creek

The suspected source of the benthic impairments in Cunningham Creek was listed as "non-point sources" in the 2014 impaired waters fact sheet. DEQ monitoring station 2-CXB000.86 and StreamWatch station 2-CXB02-SW were stations reporting violations of the General Standard for this stream segment. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. The purpose of the stressor analysis is to look for a stressor(s) that may be affecting the abundance, diversity, and pollution-sensitivity of the benthic macroinvertebrates along Cunningham Creek which may have led to the initial listing in 2012, which included an assessment of monitoring data between January 1, 2005 and December 31, 2010.

10.1. Possible Stressors

10.1.1. Nutrients

Excessive nutrient inputs can lead to increasing algal growth, eutrophication, and low dissolved oxygen (DO) concentrations that may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration. Sources of nitrogen include groundwater, residential wastewater, atmospheric deposition, and agricultural activities.

A combination of chironomids, hydropsychids, and simuliids were dominant in 5 out of 8 samples pre-2010 and in 8 out of 10 samples since, which may be indicative of elevated nutrients. TN concentrations ranged from an average of 0.494 mg/L at station 2-CXB005.39 pre-2010, to 0.444 mg/L since then, to 0.38 mg/L at the downstream station, 2-CXB000.86. Similarly, TP concentrations ranged from an average of 0.082 mg/L at station 2-CXB005.39 pre-2010, to 0.045 mg/L since then, to 0.029 mg/L at the downstream station, 2-CXB000.86. Some older residential homes may contribute TN from septic system failures, and fertilization of residential lawns, in general, may also contribute nutrients. Several fields were permitted for biosolids application, but actual dates and rates of application are unknown. Additionally, there is livestock activity in and above the watershed. Therefore, nutrients were determined to be a possible stressor to the biological community prior to 2010, but since then, TN and TP concentrations have been reduced by 23% and 65%, respectively, and show less evidence of being a stressor.

10.1.2. Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter include household wastewater discharges, spills, malfunctioning septic systems, livestock, and runoff from impervious areas.

In pre-2000, samples at station 2-CXB005.39, 13 out of 31 samples had COD values > 10 mg/L, and pre-2010, 5 out of 18 samples at both DEQ stations had elevated MFBI values indicative of organic-loving organisms, although none of the 4 samples taken since then have shown elevated MFBI values. In 2002, the sole exceedance of the minimum DO WQS was noted at the upstream station, 2-CXB005.39. During the pre-2010 period and in the period since then, about half of the samples showed a dominance of hydropsychids and simuliids, a low fraction of scrapers, and a high percentage of filterer-collectors, all of which could be indicative of organic contributions. Therefore, similar to nutrients, organic matter indicators have shown some decline since the listing period, so that organic matter is considered only to be a possible stressor.

10.2.Most Probable Stressor

10.2.1. Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forestry and agricultural runoffs, livestock access to streams, construction sites, and in-stream disturbances.

During both the pre-2010 period and since then, an abundant number of haptobenthos organisms have been counted which require a non-embedded substrate for habitat. Despite that and an LRBS siltation index in the normal range, about half of the samples have received poor riparian vegetation and sediment deposition habitat scores with all of the 5 samples since the 2012 assessment receiving poor scores for sediment deposition and 3 of the 5 noting poor scores for bank stability. Additionally, 258 acres of timber harvesting occurred in the watershed in 2014-15, although stream buffers appear to be intact which would minimize off-site sediment movement.

The most probable stressors in 2012 were TP and sediment from upstream watersheds as shown by elevated concentrations at station 2-CXB005.39 relative to station 2-CXB000.86, near the outlet. Minor impacts may have been related to isolated elevated ammonia (1) and specific conductivity (3) measurements collected in 2001 and 2002. The source of the ammonia and specific conductivity are unknown, and these data pre-date construction of the upstream Tenaska plant.

The most probable stressor currently is sediment. Although no dominant sources are evident from imagery, some sediment loading may occur from pasture runoff, periodic timber harvesting, and in-stream sediment transport, as evidenced by cloudy stream conditions at 2-CXB005.39 and sediment deposits on the banks and in-stream at 2-CXB000.86. Many, if not all, livestock have been excluded from streams in this sub-watershed between 2009 and 2015 reducing all of the possible stressors.

11.0 Summary

For the Upper MF Cunningham Creek impaired segment (VAV-H32R_CNM02A04) listed originally in 2004, the extended drought of 2000-2002 in the area appears most responsible for the poor 2002 benthic sample, since recent annual rainfall appears normal and the last (2003) benthic sample had a VSCI score in the healthy range. No samples have been taken at the site since 2003, as road access is no longer available. Additional monitoring is needed to further evaluate the current condition of this site. If any lingering impairment should be detected, **sediment** deposition arising from minor upland land disturbance, stream bank instability, and persistent nutrient enrichment would appear to be the most probable causes.

For the Lower MF Cunningham Creek impaired segment (VAV-H32R_CNM01A00) listed originally in 2010, the most probable stressors in 2010 included sediment, nutrients, and possibly decomposing organic matter from pasture runoff and livestock access near 2-CNM002.25 prior to 2008. There may also have been some effects of construction and discharges from Tenaska prior to 2010. Since then, however, the major offending livestock pasture area has been turned into a vineyard, with all remaining livestock fenced out, and the Tenaska discharge has been diverted to the Rivanna River. Also, since 2010, 150 acres of timber have been harvested in the sub-watershed, although stream buffers are intact and should minimize the movement of sediment to the stream from these areas. The most probable stressor currently is **sediment** due to lack of riparian vegetation.

For the X-Trib (unnamed tributary) to the North Fork Cunningham Creek impaired segment (VAV-H32R_XCF01A10) listed originally in 2010, the most probable stressor in 2010 was sediment from major new home construction, while the most probable stressor today is **sediment** from isolated expanded construction with poor vegetation establishment near the outlet. Other potential sources of stress include residential lawn fertilization and runoff from an unknown livestock activity in an unbuffered feedlot off Taylor Ridge Way. Sediment depositional areas below the Taylor Ridge Way confirm the excessive movement of sediment in this sub-watershed.

For the Lower North Fork Cunningham Creek impaired segment (VAV-H32R_CFK01A00) listed originally in 2012, the major sediment influence appears to be one or more episodic gully erosion incidents in the outlet channel below the Fluvanna Ruritan Dam, where between 2007 and 2011, DGIF dam inspectors repeatedly noted severely eroded gully, whose sediment load may incrementally be moving downstream. Although the 2015 measurement of the siltation index (LRBS) indicated normal bottom sediment characteristics, the most probable current stressor appears to be **sediment** arising from upstream gully erosion, considerable residential development, and possibly minor contributions from timber harvesting.

For the Cunningham Creek mainstem impaired segment (VAV-H32R_CXB01A00) listed originally in 2012, the most probable stressors in 2012 were TP and sediment from upstream watersheds as shown by elevated concentrations at station 2-CXB005.39 relative to station 2-CXB000.86, near the outlet. The most probable stressor currently is most likely **sediment**. Although no dominant sources are evident from imagery, sediment is most directly indicated by habitat metrics and direct observation of sediment deposits on the banks and in-stream at 2-CXB000.86. Many, if not all, livestock have been excluded from streams in this sub-watershed between 2009 and 2015 reducing the impact of all of the possible stressors.

Although sediment is considered to be the most probable cause of stress in all of the impaired segments, a pro-active approach to implementation is recommended, as the probable sources in most sub-watersheds appear to be fairly minor. The Technical Advisory Committee is encouraged to take the following actions without waiting for the results of the TMDL study.

- Upper MF: conduct biological assessments; check for septic system failures
- Lower MF: check for isolated bank stability issues; establish riparian vegetation
- Lower NF: eliminate dam outlet erosion
- X-trib to NF: stabilize areas near outlet; add a buffer to unknown livestock activity

Since the Cunningham Creek impairments are minor and the causes of excess sediment are fairly apparent, it is recommended that narrative TMDLs be developed to address the aquatic life use impairment on each of these five impaired segments. Narrative TMDLs and targeted implementation would be the most expeditious route to reducing the excess sediment loads in these sub-watersheds and to restoring healthy conditions to the benthic communities along these stream segments.

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