Benthic TMDL Development for Black Creek and Hat Creek Watersheds Located in Nelson County, Virginia

Prepared by:

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DEQ VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

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Acronyms

AllForX	All-Forest Load Multiplier
AWC	Available Water Capacity
BMP	Best Management Practice
CADDIS	Causal Analysis Diagnosis Decision Information System
CBP	Chesapeake Bay Program
CGP	Construction General Permit
CREP	Conservation Reserve Enhancement Program
CV	Coefficient of Variation
EQIP	Environmental Quality Incentive Program
ET-CV	Evapotranspiration Coefficient
FG	Future Growth
GIS	Geographic Information System
GWLF	Generalized Watershed Loading Function
HSG	Hydrologic Soil Group
LA	Load Allocation
LTA	Long-Term Average
MDL	Maximum Daily Load
MOS	Margin of Safety
NCDC	National Climate Data Center
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
POC	Pollutant(s) of Concern
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
SCS-CN	Soil Conservation Service Curve Number
SSURGO	Soil Survey Geographic database
STP	Sewage Treatment Plant
SWCB	State Water Control Board
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation
DEQ	Virginia Department of Environmental Quality
VADCR	Virginia Department of Conservation and Recreation

VAHUC6	Virginia Hydrologic Unit Code (Featuring a 6-Digit Basin Scale)
VDH	Virginia Department of Health
VDOT	Virginia Department of Transportation
VGIN	Virginia Geographic Information Network
VLCD	Virginia Land Cover Dataset
VPDES	Virginia Pollutant Discharge Elimination System
VSCI	Virginia Stream Condition Index
VSMP	Virginia Stormwater Management Program
WLA	Wasteload Allocation
WQ	Water Quality
WQS	Water Quality Standard
WQMIRA	Water Quality Monitoring, Information and Restoration Act

1.0 EXECUTIVE SUMMARY

1.1. Background

The Black Creek and Hat Creek watersheds are located in Nelson County, Virginia. Black Creek drains portions of the community of Colleen, and Hat Creek drains portions of the communities of Bryant and Jonesboro. Both Black and Hat Creek are largely rural and forested, and are direct tributaries of the Tye River, which flows southeast to the James River and on to the Chesapeake Bay and the Atlantic Ocean.

> Definition:
>
> Watershed – All of the land area that drains to a particular point or body of water.

Black Creek and Hat Creek are listed as impaired on Virginia's 2022 305(b)/303(d) Integrated Report (DEQ, 2022a) due to their failure to meet the general aquatic life (benthic) standard. The impaired segments addressed in this document are shown in **Table 1-1**. The watersheds of the impaired streams are show in **Figure 1-1**.

Table 1-1. Impaired segments addressed in this TMDL study.

TMDL Watershed	305(b) Segment ID	Cause Group Code 303(d) Impairment ID	Listing Station	Year Initially Listed
Black Creek	VAV-H09R_BKC01A14 (1.96 mi)	H09R-05-BEN	2-BKC001.43/ 2-BKC001.55	2014
Hat Creek	VAV-H09R_HAT01A04 (9.52 mi)	H09R-02-BEN	2-HAT000.14	2012

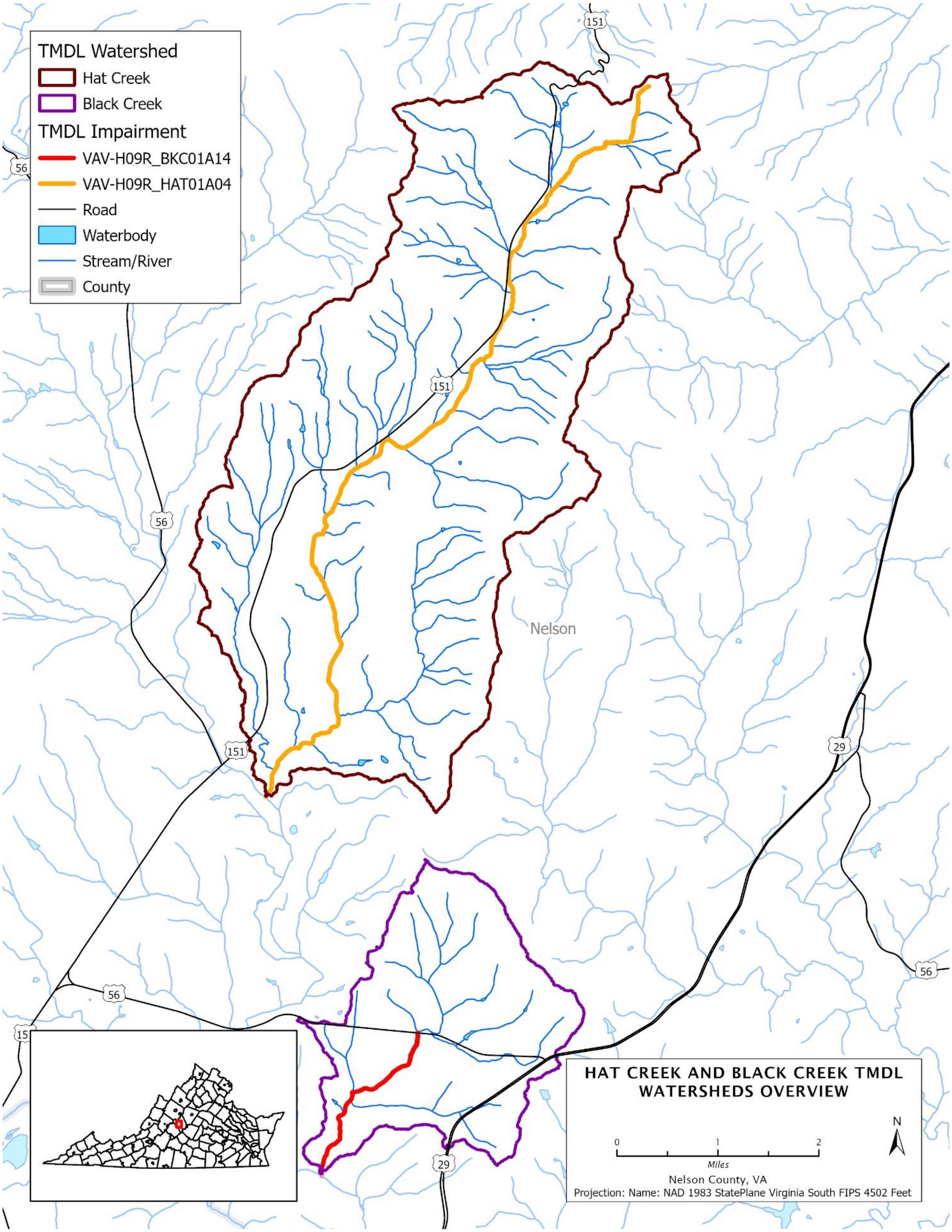


Figure 1-1. Location of the Black Creek and Hat Creek watersheds and impairments.

1.2. The Problem

1.2.1. Impaired Aquatic Life

The Commonwealth of Virginia establishes designated uses for all the waters in the state. Some of these uses include recreation, fishing, wildlife, and aquatic life. Water quality standards have been developed to ensure that some of these uses are met, while others are assessed using narrative criteria. One of those standards is the expectation that every stream will support a healthy and diverse community of bugs and fish (the aquatic life standard). The Virginia Department of Environmental Quality (DEQ) determines whether this standard is met by monitoring the benthic macroinvertebrate community (bugs that live on the bottom of the stream) in our waterways. The health and diversity of these bugs are assessed using the Virginia Stream Condition Index (VSCI). The VSCI is a multimetric index used to derive stream health scores ranging from 0 to 100. Scores below 60 are categorized as impaired. **Figure 1-2** shows the various monitoring stations throughout the watershed, color-coded by the average score at each site. Red and yellow icons indicate that the streams do not support a healthy and diverse community of aquatic life. This shows that the various impaired streams in this study fail the aquatic life standard, and pollutants within the watershed need to be identified and reduced.

A benthic stressor analysis study was conducted in 2022 to determine the cause(s) of benthic impairment in the Black Creek and Hat Creek watersheds (DEQ, 2022b). DEQ employed the Causal Analysis/Diagnosis Decision Information System (CADDIS) to complete this analysis (USEPA, 2018). Available physical, chemical, and biological data collected throughout the watersheds, published water quality standards and threshold values, and available literature from other cases were used to investigate the potential causes of impairment in each stream. Based on the weight of evidence supporting each potential candidate, stressors were then separated into the following categories: non-stressor(s), possible stressor(s), and probable stressor(s).The study found that the most probable cause of the impairments in Hat Creek and Black Creek was excess sediment. Additionally, excess phosphorus was found to be a probable stressor causing the impairment in Black Creek.

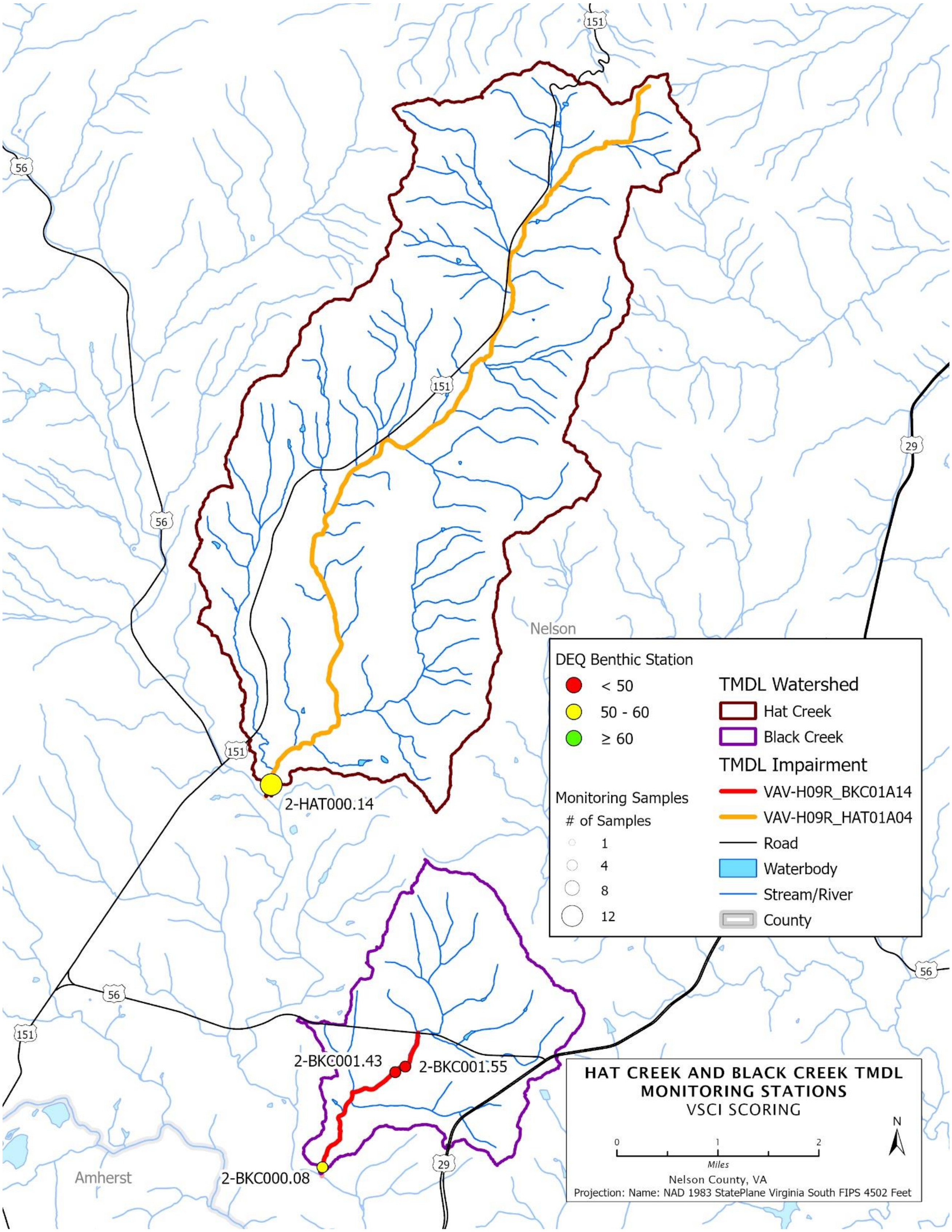


Figure 1-2. Average stream health score summaries in the Black Creek and Hat Creek watersheds.

1.2.2. Too Much Sediment

Excess sediment was identified as the primary stressor in both Black Creek and Hat Creek. When it rains, sediment is washed off the land surface into nearby creeks and rivers. The amount of soil that is washed off depends upon how much it rains and the characteristics of the surrounding watershed. Rain falling on a construction site or highly tilled cropland without a cover crop may carry a large amount of sediment to a stream. Other land types, like forests and well-maintained pasture, contribute much less sediment to waterways during rainfall events. When that soil gets into nearby streams, it falls to the bottom as sediment where it can destroy valuable habitat for aquatic macroinvertebrates that live underneath and between the rocks and gravel of the streambed. Without this valuable habitat, the diversity of aquatic life in a stream may be severely limited.

1.2.3. Too Much Phosphorus

In addition, total phosphorus was identified as a primary stressor in Black Creek. Phosphorus is a nutrient that helps plants grow. It is primarily found in fertilizers and manures. Just as sediment can wash off the land surface into nearby creeks, phosphorus contained in fertilizers or manures that are applied to lawns or farm fields can also wash off. In a stream, phosphorus makes algae grow, and that algae reduces oxygen levels in the water when it dies and decomposes. This limits the diversity of bugs and fish, which need oxygen to survive.

1.3. The Study

To study the problem of excess sediment and phosphorus in the Black Creek watershed and excess sediment in the Hat Creek watershed, a combination of stream monitoring and computer modeling was utilized. Monitoring was used to tell how much sediment and phosphorus is in the streams at any given time and how aquatic life conditions have changed over time. The computer model was used to estimate where the sediment and phosphorus are coming from and to make predictions about how stream conditions would change if those sources were reduced.

> Frequently Asked Question:
>
> *Why use a computer model?*
> Sampling and testing tell you a lot about the present and the past, but nothing about the future. A computer model is a tool that can help you make predictions about the future. This is necessary to figure out how much effort is needed to clean up a stream.

For this purpose, a computer model called the Generalized Watershed Loading Function model (GWLF) was used. This model considers the slope, soils, land cover, erodibility, and runoff to estimate the amount of soil eroded in the watershed and deposited in the stream. The model was calibrated against real-world flow measurements taken from the stream in order to ensure that it is producing accurate results. The calibrated model was then used to estimate the sediment reductions that would be needed to completely restore healthy aquatic life to the impaired streams in the watershed.

> Definition:
>
> TMDL – Total Maximum Daily Load. This is the amount of a pollutant that a stream can receive and still meet water quality standards. The term TMDL is also used more generally to describe the state's formal process for cleaning up polluted streams.

This report summarizes the study and sets goals for a clean-up plan. The study is called a Total Maximum Daily Load (TMDL) study because it determines the maximum amount of a pollutant that can get into a certain stream without harming the stream or the creatures living in it.

1.4. Current Conditions

For this report, the Virginia Geographic Information Network (VGIN) 2016 Virginia Land Cover Dataset (VLCD) was used to represent the current land use with minor modifications (discussed in **Section 3.3**). The land cover distribution for each impaired watershed is shown in **Figure 1-3** and

Figure 1-4. Both Black Creek and Hat Creek watersheds are largely forested (67% and 75% respectively) with most agricultural lands being in pasture or hay.

> Definition:
>
> Point Source – pollution that comes out of a pipe (like at a sewage treatment plant).
> Nonpoint Source – pollution that does not come out of a pipe but comes generally from the landscape (usually as runoff).

This land cover dataset combined with an accounting of the permitted discharges represent the major pollutant sources in the watersheds. The GWLF model was used to figure out the relative contribution of sources of sediment in the impaired watersheds. **Figure 1-3** and

Figure 1-4 show the distribution of sediment contributions from various sources in the watersheds. The permitted sources include one Virginia Pollutant Discharge Elimination System (VPDES) individual permit and one domestic sewage general permit, in Black and Hat Creek, respectively. The sediment and phosphorus loads from permitted sources were calculated based on the permit language, reported discharge data, and land cover type and area (detailed in **Section 4.3.2**). In both Black Creek and Hat Creek, hay and pasture cover a greater extent than urban areas, and, as such, the majority of the non point source pollutant loads are derived from hay and pasture lands.

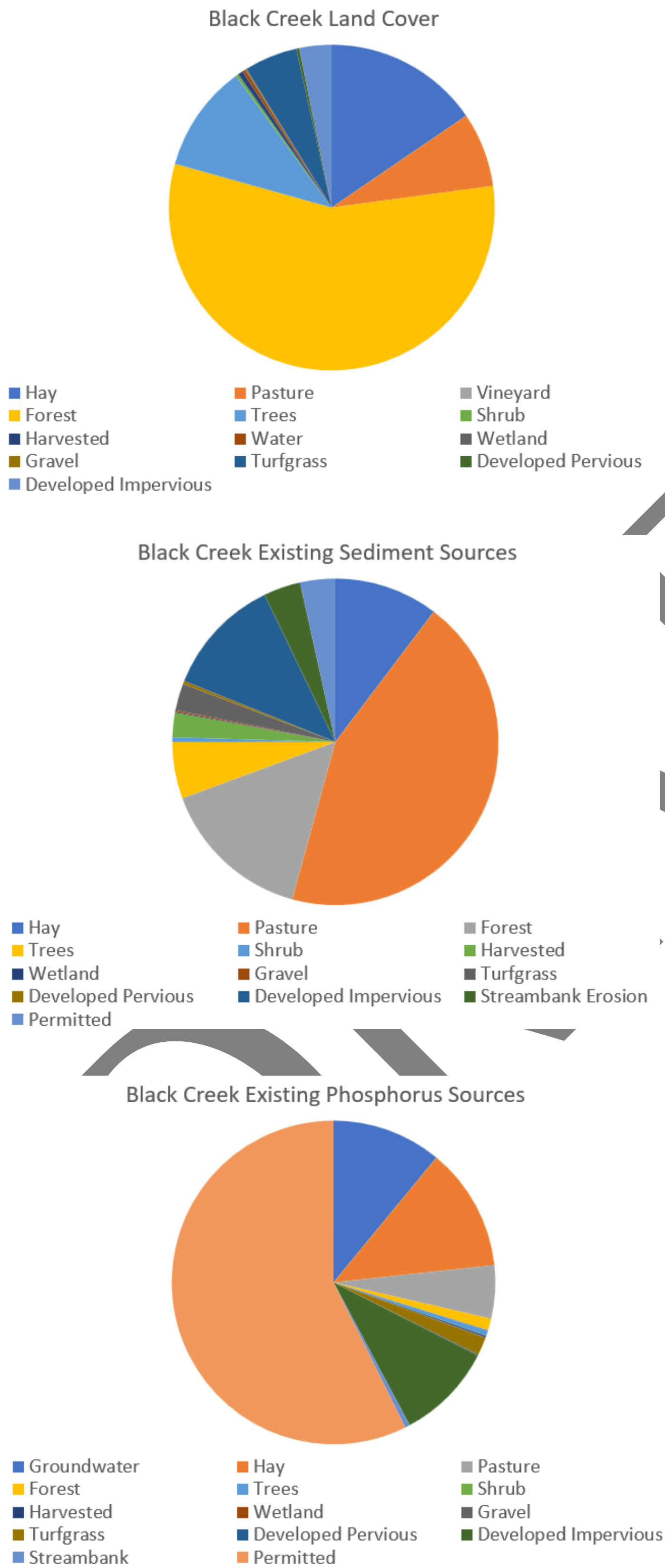
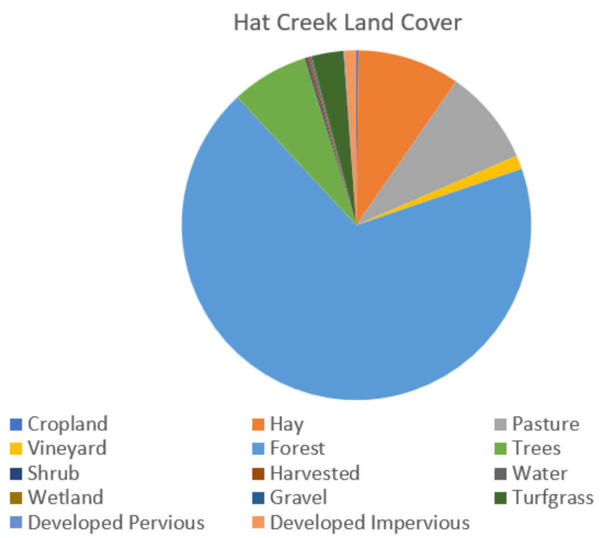


Figure 1-3. Land cover and existing source load distributions in the Black Creek watershed.



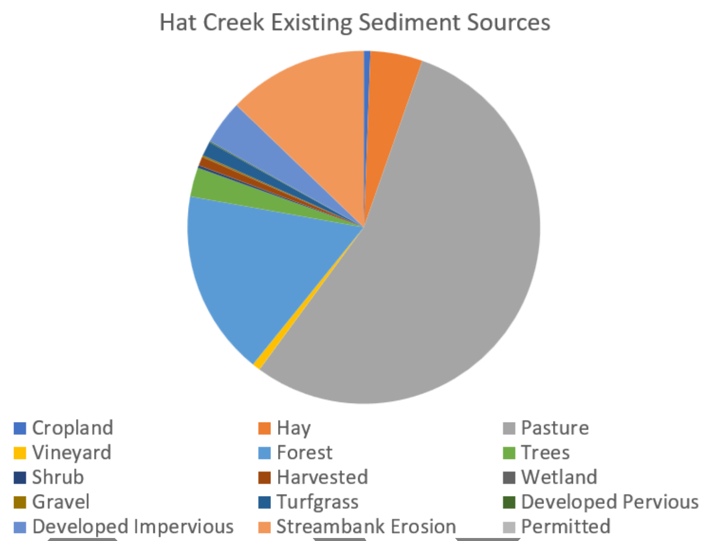


Figure 1-4. Land cover and existing source load distributions in the Hat Creek watershed.

1.5. Future Goals (the TMDL)

After figuring out where the sediment in the impaired streams is currently coming from, a computer model was used to figure out how much sediment and/or phosphorus loads need to be reduced to clean up Hat and Black Creeks. The ultimate goal for these streams is to have sediment and, where applicable, phosphorus levels that allow for diverse and abundant aquatic life. The reductions in sediment and/or phosphorus needed to meet these goals are shown in **Table 1-2** and **Table 1-3**. These scenarios were selected by community engagement participants in an effort to balance reductions across all source sectors while also considering cost effectiveness of associated best management practices and the likelihood of implementation.

Table 1-2. Percent reductions in sediment needed for Hat and Black Creeks.

Source Category	% Reduction	
	Black Creek	Hat Creek
Cropland	-	3.5%
Hay	14%	3.5%
Pasture	30.5%	11%
Vineyard	-	3.5%
Forest, Trees, Shrubs, Harvested, Wetland	0%	0%
Gravel and Turfgrass	10%	1%
Developed Pervious	5%	1%
Developed Impervious	30%	1%
Streambank Erosion	20%	6%
Permitted	0%	0%

Table 1-3. Percent reductions in phosphorus needed for Black Creek.

Source Category	% Reduction
Groundwater	0%
Hay, Pasture	30%
Forest, Trees, Shrubs, Harvested, Wetland	0%
Gravel and Developed Pervious	5%
Turfgrass	25%
Developed Impervious	30%
Septic Systems	0%
Streambank Erosion	25%
Permitted	22%

In order to obtain healthy sediment levels in the impaired streams, significant reductions are needed from several sediment sources. Sediment loads from pasture within the Black Creek watershed need to be reduced by 30.5%, and sediment loads from hayland and streambank erosion would need to be reduced by 15% and 20%, respectively. Loads from developed impervious areas in Black Creek will need to be reduced by 30%, while sediment from gravel roads, turfgrass and developed pervious areas will need to be reduced by 6%. For Hat Creek, a 10.9% reduction in sediment loads from pasture and a 3.5% reduction in sediment loads from cropland, hay and vineyards is needed. Reductions in sediment loads from urban and suburban land covers and streambank erosion need to be reduced by 1% and 6%, respectively. Phosphorus loads from agricultural sources and urban impervious land cover in Black Creek will need to be reduced by 30%. Loads from turfgrass and streambank erosion will need to be reduced by 25%. Permitted phosphorus loads in the watershed will need to be reduced by 25% to meet the TMDL. This reduction was calculated based on the average discharge rate and concentration of the permitted facility. The total maximum daily load, or TMDL, is equal to the annual pollutant load entering these streams after the recommended reductions are made (**Table 1-4** through **Table 1-6**). This load includes permitted sources as well as a future growth allocation to account for potential future permitted sources. These annual loads are converted to daily maximum loads, as described in **Section 6.3**
Table 1-7 through **Table 1-9**). If sediment and phosphorus loads are reduced to these amounts, healthy aquatic life should be restored in Hat and Black Creeks.

Table 1-4. Annual sediment loads that will meet the water quality standard in Black Creek. (For proposed loadings and percent reductions, see Scenario 1 in Table 1-10 or Table 6-9)

Impairment	Allocated Permitted Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Black Creek (VAV-H09R_BKC01A14)	**30,710**	**445,890**	**52,982**	**529,582**
VA0089729	*20,118*			
Future Growth (2% of TMDL)	*10,592*			

Table 1-5. Annual sediment loads that will meet the water quality standard in Hat Creek. (For proposed loadings and percent reductions, see Scenario 1 in Table 1-11 or Table 6-10)

Impairment	Allocated Permitted Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Hat Creek (VAV-H09R_HAT01A04)	**45,461**	**1,996,178**	**226,849**	**2,268,489**
Domestic Sewage General Permits	*91*			
Future Growth (2% of TMDL)	*45,370*			

Table 1-6. Annual phosphorus loads that will meet the water quality standard in Black Creek. (For proposed loadings and percent reductions, see Scenario 1 in Table 1-12 or Table 6-11)

Impairment	Allocated Permitted Point Sources (WLA) (lb/yr TP)	Allocated Nonpoint Sources (LA) (lb/yr TP)	Margin of Safety (MOS) (lb/yr TP)	Total Maximum Daily Load (TMDL) (lb/yr TP)
Black Creek (VAV-H09R_BKC01A14)	**712**	**519**	**137**	**1,368**
VA0089729	*685*			
Future Growth (2% of TMDL)	*27*			

Table 1-7. Maximum daily sediment loads for Black Creek.

Impairment	Allocated Permitted Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Black Creek (VAV-H09R_BKC01A14)	**84**	**2,408**	**277**	**2,769**
VA0089729	*55*			
Future Growth (2% of TMDL)	*29*			

Table 1-8. Maximum daily sediment loads for Hat Creek.

Impairment	Allocated Permitted Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Hat Creek (VAV-H09R_HAT01A04)	**124**	**10,720**	**1,205**	**12,049**
Domestic Sewage General Permits	*0.25*			
Future Growth (2% of TMDL)	*124*			

Table 1-9. Maximum daily phosphorus loads for Black Creek.

Impairment	Allocated Permitted Point Sources (WLA) (lb/day TP)	Allocated Nonpoint Sources (LA) (lb/day TP)	Margin of Safety (MOS) (lb/day TP)	Maximum Daily Load (MDL) (lb/day TP)
Black Creek (VAW-L19R_RAB01A00)	**2**	**3.7**	**0.6**	**6.36**
VA0089729	*1.9*			
Future Growth	*0.1*			

1.5.1. Allocation Scenarios

There are many ways to reduce pollutants to reach TMDL goals. Several versions of these reduction plans, or allocation scenarios, were developed. The first scenario focuses the greatest reductions on the largest non point sources of the pollutant. The second scenario assigns equal reductions to all non point sources. The third scenario focuses all reductions on agricultural sources and the fourth scenario focuses all reductions on urban/residential sources. Only three scenarios were developed for sediment and phosphorus reductions in Black Creek because TMDL endpoints could not be met even if all residential and urban pollutant sources were eliminated. These scenarios were presented to stakeholder meeting members who determined that Scenario 1 was preferred for each watershed (see **Table 1-10** through **Table 1-12**). Meeting participants felt that this scenario was the most likely to be implemented while also balancing reductions between pollutant sources.

Table 1-10. Allocation scenarios for Black Creek sediment loads.

Black Creek Sediment (2-BKC000.08)		**Scenario 1 (preferred)**		**Scenario 2**		**Scenario 3**	
Source	Existing	Red.	Allocation	Red.	Red.	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*%*	*%*	*TSS (lb/yr)*
Hay	59,587	15	50,649	26.6	43,737	33.4	39,685
Pasture	253,951	30.5	176,496	26.6	186,400	33.4	169,132
Forest	87,308	-	87,308	-	87,308	-	87,308
Trees	32,305	-	32,305	-	32,305	-	32,305
Shrub	2,666	-	2,666	-	2,666	-	2,666
Harvested	14,012	-	14,012	-	14,012	-	14,012
Wetland	453	-	453	-	453	-	453
Gravel	908	6	854	26.6	667	-	908
Turfgrass	15,476	6	14,547	26.6	11,359	-	15,476
Developed pervious	1,789	6	1,681	26.6	1,313	-	1,789
Developed impervious	67,858	30	47,501	26.6	49,808	-	67,858
Streambank Erosion	21,197	20	16,957	26.6	15,558	33.4	14,117
VA0089729*	1,613	-	20,118	-	20,118	-	20,118
TOTAL+	**559,123**		**465,547**		**465,704**		**465,827**

** TSS load shown for VA0089729 is based on average discharge rate and TSS concentration data while TMDL scenarios show loads based on permitted design flow and TSS concentration limits.*

+Totals do not include Margin of Safety (52,982) or Future Growth (10,592) allocations

Table 1-11. Allocation scenarios for Hat Creek sediment loads.

Hat Creek Sediment (2-HAT000.14)		**Scenario 1 (Preferred)**		**Scenario 2**		**Scenario 3**		**Scenario 4**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	12,919	3.5	12,467	8.9	11,769	9.5	11,692	-	12,919
Hay	102,647	3.5	99,055	8.9	93,512	9.5	92,896	-	102,647
Pasture	1,173,980	10.9	1,046,016	8.9	1,069,495	9.5	1,062,452	-	1,173,980
Vineyard	15,794	3.5	15,241	8.9	14,389	9.5	14,294	-	15,794
Forest	364,328	-	364,328	-	364,328	-	364,328	-	364,328
Trees	57,301	-	57,301	-	57,301	-	57,301	-	57,301
Shrub	5,220	-	5,220	-	5,220	-	5,220	-	5,220
Harvested	17,614	-	17,614	-	17,614	-	17,614	-	17,614
Wetland	176	-	176	-	176	-	176	-	176
Gravel	3,028	1.0	2,998	8.9	2,759	-	3,028	38	1,878
Turfgrass	28,358	1.0	28,074	8.9	25,834	-	28,358	38	17,582
Developed pervious	2,191	1.0	2,169	8.9	1,996	-	2,191	38	1,358
Developed impervious	87,040	1.0	86,169	8.9	79,293	-	87,040	38	53,965
Streambank Erosion	275,435	6.0	258,909	8.9	250,921	9.5	249,268	38	170,770
Domestic Sewage General Permits	91	-	91	-	91	-	91	-	91
TOTAL+	**2, 146,122**		**1,995,828**		**1,994,698**		**1,995,949**		**1,995,623**

+*Totals do not include Margin of Safety (226,849) and Future Growth (45,370) allocations.*

Table 1-12. Allocation scenarios for Black Creek phosphorus loads.

Black Creek Watershed		Scenario 1 (Preferred)		Scenario 2		Scenario 3	
Source	**Existing TP (lb/yr)**	**Reduction (%)**	**Allocation TP (lb/yr)**	**Reduction (%)**	**Allocation TP (lb/yr)**	**Reduction (%)**	**Allocation TP (lb/yr)**
Groundwater	168.0	-	168.0	-	168.0	-	168.0
Hay	188.6	30.0	132.0	30.0	132.0	50.0	94.3
Pasture	81.4	30.0	57.0	30.0	57.0	50.0	40.7
Forest	17.9	-	17.9	-	17.9	-	17.9
Trees	8.6	-	8.6	-	8.6	-	8.6
Shrub	0.4	-	0.4	-	0.4	-	0.4
Harvested	2.5	-	2.5	-	2.5	-	2.5
Wetland	0.1	-	0.1	-	0.1	-	0.1
Gravel	0.4	5.0	0.4	30.0	0.3	-	0.4
Turfgrass	27.7	25.0	20.8	30.0	19.4	-	27.7
Developed Pervious	1.2	5.0	1.2	30.0	0.8	-	1.2
Developed Impervious	149.3	30.0	104.5	30.0	104.5	-	149.3
Streambank	7.4	25.0	5.6	30.0	5.2	-	7.4
VA0089729*	914	25.1	685.0	25.1	685.0	25.1	685.0
TOTAL[+]	**1,568**		**1,204**		**1,202**		**1,204**

** Existing TP load shown for VA0089729 is based on an average discharge rate 0.12 MGD and an average TP concentration of 2.5 mg/L.*

1.6. Public Participation

Public participation was elicited at every stage of the TMDL study in order to receive input from stakeholders and to apprise the stakeholders of progress made. A series of two public meetings and six community engagement meetings took place during the TMDL development process. Since a TMDL implementation plan was being developed concurrently with the TMDL study, implementation actions were also discussed at several of these meetings. Public meetings and community engagement meetings included representatives from the James River Association, Nelson County Board of Supervisors, Nelson County Service Authority, Thomas Jefferson SWCD, Thomas Jefferson Planning District Commission, Virginia Department of Energy, Virginia Farm Bureau, the Nelson County Times, as well as many residents of the watersheds.

The first public meeting (32 attendees, January 25th, 2023) was held at the Nelson Memorial Library in Lovingston, VA. This meeting introduced attendees to DEQ's water quality planning process, the TMDL purpose and process, reviewed benthic monitoring data collected in the study watersheds, discussed the impairments, reviewed the preliminary results of the stressor analysis, and solicited input on the benthic stressors identified in the benthic stressor analysis study. This meeting was followed by a 30-day public comment period, which closed on February 24, 2023. No comments were received during this time.

The first community engagement meeting (24 attendees, March 1st, 2023) was held at the Nelson Memorial Library in Lovingston, VA to discuss the TMDL process and the benthic stressor analysis. In addition, the group discussed land cover estimates and loading rates assigned to each land cover type. The group also discussed the method used to account for future permitted land disturbance and how the AllForX method will be used to develop target pollutant loads for the watersheds.

The second community engagement meeting (18 attendees, May 17th, 2023) was held at the Nelson Memorial Library. Participants in this meeting discussed the changes in landcover distributions that were made based on the input from the members of the first stakeholder meeting, revisited a previous discussion about establishing a set aside for construction stormwater permits in the watershed, discussed the future growth allocation and margin of safety, reviewed the pollutant sources and BMPs in the impaired watersheds, and gathered input on the preferred sediment allocation scenario.

The third community engagement meeting was held on January 10, 2024, at the Nelson Memorial Library (18 attending). This meeting was focused on developing a phosphorus endpoint for Black Creek. The group discussed TMDL alternatives and agreed to change paths and shift to developing an advance restoration plan to address sediment and phosphorus targets in Hat and Black Creeks.

The fourth community engagement meeting was held on February 27, 2024, at the Nelson Memorial Library (9 attending). Participants prioritized a series of agricultural best management practices for inclusion in the advance restoration plan. Streambank restoration practices were also discussed and agreed on as a high priority for local stakeholders.

The fifth community engagement meeting was held on September 9, 2024, at the Nelson Memorial Library (11 attending). During this meeting, participants discussed the decision to pivot back to developing a traditional TMDL. The group also discussed the new path forward for the project and revisions to existing loads and reduction scenarios for the two watersheds.

The sixth and final community engagement meeting was held on December 3, 2024, at the Nelson Memorial Library (12 attending). During this meeting, the group reviewed implementation scenarios for best management practices in Hat and Black Creek. Participants reviewed cost estimates and assisted with development of a timeline for implementation efforts. Plans for the final public meeting were also discussed.

A final public meeting was held on March 5, 2025, at The Nelson Center in Lovingston to present the draft TMDL document. The public meeting marked the beginning of the official 30-day public comment period and was attended by ## watershed residents and other stakeholders. The public comment period ended on April 4, 2025. A comment response document was compiled (Appendix D) and includes all comments received during this period in addition to responses prepared by DEQ.

1.7. Reasonable Assurance

Public participation in the development of the TMDL and implementation plan, follow-up monitoring, permit compliance, and current implementation progress within the watersheds all combine to provide reasonable assurance that these TMDLs will be implemented, and water quality will be restored in the impaired watersheds.

1.8. What Happens Next

This report sets the clean-up goals for Black Creek and Hat Creek, but the next step is a clean-up plan (or Implementation Plan) that lays out how those goals will be reached. Clean-up plans set intermediate goals and describe actions that should be taken to improve water quality in the impaired streams. Some of the potential actions that could be included in an implementation plan for the Black Creek and Hat Creek watersheds are listed below:

> **Frequently Asked Question:**
>
> ***<u>How will the TMDL be implemented?</u>***
>
> For point sources, TMDL reductions will be implemented through discharge permits. For nonpoint sources, TMDL reductions will be implemented through best management practices (BMPs). Landowners will be asked to voluntarily participate in state and federal programs that help defer the cost of BMP installation.

- Fence out cattle from streams and provide alternative water sources
- Implement conservation tillage practices on cropland
- Conduct stream bank restoration projects in areas where banks are actively eroding
- Leave a 35 – 100 ft band of natural buffer along the stream so that it slows overland flow and filters out sediment from adjacent land (a riparian buffer)
- Encourage timely septic system maintenance and repair.
- Reduce runoff by increasing green spaces and reducing hardened spaces (asphalt or concrete)

These and other actions that could be included in a clean-up plan are identified in the planning process along with associated costs and the extent of each practice needed. The clean-up plan also identifies potential sources of money to help in the clean-up efforts. Most of the money utilized to implement actions in the watersheds to date has been in the form of cost-share programs, which share the cost of improvements with the landowner. Additional funds for urban stormwater practices have been made available through various grant programs, including an annual funding opportunity through the National Fish and Wildlife Foundation's Chesapeake Bay Stewardship Fund program. Please be aware that the state or federal government will not fix the problems with the impaired streams. It is primarily the responsibility of individual landowners and local governments to take the actions necessary to improve these streams. The role of state agencies is to help with developing the plan and find money to support implementation, but actually making the improvements is up to those that live in the watershed. By increasing education and awareness of the problem, and by working together to each do our part, we can make the changes necessary to improve the streams.

DEQ will continue to sample aquatic life in these streams and monitor the progress of clean-up. This sampling will let us know when the clean-up has reached certain milestones listed in the plan. To begin moving towards these clean-up goals, DEQ recommends that concerned citizens come together and begin working with local governments, civic groups, soil and water conservation districts, and local health districts to increase education and awareness of the problem and promote those activities and programs that improve stream health.

2.0 INTRODUCTION

2.1. Watershed Location and Description

The Black Creek watershed is approximately 3,100 acres, and the Hat Creek watershed is approximately 12,400 acres. Both watersheds lie wholly within Nelson County (**Figure 1-1**). The Black Creek watershed includes portions of the unincorporated community of Colleen, while the Hat Creek watershed includes portions of the unincorporated communities of Bryant, Jonesboro, and Roseland. The study watersheds are within VAHU6 watersheds JM23 and JM24. Both Black Creek and Hat Creek are direct tributaries to the Tye River, which flows southeast through Virginia into the James River. The James River flows into the Chesapeake Bay and ultimately discharges into the Atlantic Ocean.

2.2. Designated Uses and Applicable Water Quality Standards

Virginia's Water Quality Standards (9VAC25-260) consist of designated uses established for water bodies in the Commonwealth, and water quality criteria set to protect those uses. Virginia's Water Quality Standards protect the public and environmental health of the Commonwealth and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.).

2.2.1. Designation of Uses (9 VAC 25-260-10)

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

Black Creek and Hat Creek currently do not support the aquatic life designated use based on biological monitoring of the benthic macroinvertebrate community.

2.2.2. General Standard (9VAC 25-260-20)

The following general standard protects the aquatic life use:

> "A. State waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.

> Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled" (SWCB, 2011).

DEQ's biological monitoring program is used to evaluate compliance with the above standard. This program monitors the assemblage of benthic (bottom-dwelling) macro (large enough to see) invertebrates (insects, mollusks, crustaceans, and annelid worms) in streams to determine the biological health of the stream. Benthic macroinvertebrates are sensitive to water quality conditions, important links in aquatic food chains, major contributors to energy and nutrient cycling in aquatic habitats, relatively immobile, and easy to collect. These characteristics make them excellent indicators of aquatic health. Changes in water quality are reflected in changes in the structure and diversity of the benthic macroinvertebrate community. Currently, DEQ assesses the health of the benthic macroinvertebrate community using the Virginia Stream Condition Index (VSCI). This index was first developed by Tetra Tech (2003) and later validated by DEQ (2006). The VSCI is a multimetric index based on 8 biomonitoring metrics. The index provides a score from 0-100, and scores from individual streams are compared to a statistically derived cutoff value based on the scores of regional reference sites.

2.3. 305(b)/303(d) Water Quality Assessment

Under Section 305(b) of the Federal Clean Water Act, states are required to assess the quality of their water bodies in comparison to the applicable water quality standards. States are also required, under Section 303(d) of the Act, to prepare a list of water bodies that do not meet one or more water quality standards. This list is often called the "Impaired Waters List", or the "303(d) List", or the "TMDL List", or even the "Dirty Waters List". The Commonwealth of Virginia accomplishes both of these requirements through the publishing of an Integrated 305(b)/303(d) Water Quality Assessment Report every two years. Each report assesses water quality by evaluating monitoring data from a six-year window. The assessment window for the most recent 2022 305(b)/303(d) Integrated Water Quality Assessment Report was from January 1, 2015 through December 31, 2020. According to DEQ's current Water Quality Assessment Guidance (DEQ, 2019), streams with a calculated VSCI score ≥60 are assessed as "fully supporting" the aquatic life designated use. Streams with VSCI scores <60 are assessed as "impaired" or "not supporting" the aquatic life designated use.

2.3.1. Impairment Listings

According to Virginia's 2022 305(b)/303(d) Integrated Report (DEQ, 2022a), both Black Creek and Hat Creek are listed as impaired (**Table 1-1**, **Figure 1-1**). Data to evaluate streams in the watersheds are collected by DEQ and other government officials.

Both Black Creek and Hat Creek are impaired from their headwaters to their confluence with the Tye River. Both impairments are for failure to support the aquatic life use (i.e., a benthic impairment). Black Creek was initially listed as impaired on Virginia's 2014 303(d) Impaired Waters List due to violations of the general standard for aquatic life based on data collected at DEQ monitoring stations 2-BKC001.43 and 2-BKC001.55. Hat Creek was initially listed as impaired on Virginia's 2012 303(d) Impaired Waters List due to violations of the general standard for aquatic life based on data collected at DEQ monitoring station 2-HAT000.14. Hat Creek was also listed starting in 2004 due to an exceedance of bacteria impairing recreational use. During the 2022 assessment window (January 1, 2015 to December 31, 2020), VSCI scores averaged 63.3 in Black Creek and 62.3 in Hat Creek. Though both TMDL watersheds have average VSCI scores above 60, the streams are still considered impaired because, while some scores fall above 60, DEQ biologists generally recommend two consecutive years of benthic monitoring above the VSCI threshold of 60 before delisting the stream as unimpaired. This recommendation is supported by the fact that the most recent fall and spring scores for both streams within this time frame are not both over 60, and 2021 monitoring indicates that the streams remain impaired.

2.4. TMDL Development

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that fail to meet designated water quality standards and are placed on the state's Impaired Waters List. A TMDL reflects the total pollutant loading that a water body can receive and still meet water quality standards. A TMDL establishes the maximum allowable pollutant loading from both point and nonpoint sources for a water body, allocates the load among the pollutant contributors, and provides a framework for taking actions to restore water quality.

2.4.1. Pollutants of Concern

TMDL target pollutants, or pollutants of concern (POC), are the physical or chemical substances that will be controlled and allocated in the TMDL to result in restored aquatic life (measured by benthic macroinvertebrate health). POCs must be pollutants that are controllable through source reductions, such as sediment, phosphorus, nitrogen, or other substances. Physical factors or environmental conditions, such as flow regimes, hydrologic modifications, or physical structures (like dams) cannot be TMDL POCs, even though these conditions influence ecological communities and may be sources of stress.

In 2022, a stressor identification analysis study was conducted to determine the POC(s) contributing to the benthic impairments in the Black Creek and Hat Creek watersheds (DEQ, 2022b). The stressor analysis study used a formal causal analysis approach developed by USEPA, known as CADDIS (Causal Analysis Diagnosis Decision Information System). The CADDIS approach evaluates 14 lines of evidence that support or refute each candidate stressor as the cause of impairment. In each stream, each candidate stressor was scored from -3 to +3 based on each line of evidence. Total scores across all lines of evidence were then summed to produce a stressor score that reflects the likelihood of that stressor being responsible for the impairment. The study found that sediment (measured as total suspended solids or TSS) was a probable stressor in both Black Creek and Hat Creek watersheds. Total phosphorus (TP) was also identified as an additional probable stressor in Black Creek.

For the impairment on the Black Creek watershed, the stressor identification analysis also identified an existing 6-acre impoundment as a contributing factor. The impoundment is located at the Nelson Couty STP, approximately 130 meters upstream of the DEQ monitoring station 2-BKC001.55. In addition, other contributing factors, such as historic dams and historic sediment loads, may also contributing to the impairment of both streams. These conditions may not be included in the TMDL, but they should still be considered when implementing the TMDL or evaluating its success.

3.0 WATERSHED CHARACTERIZATION

The Black Creek watershed is approximately 3,200 acres, and the Hat Creek watershed is approximately 12,400 acres. Both watersheds lie wholly within Nelson County (**Figure 1-1**). The Black Creek watershed includes portions of the unincorporated community of Colleen, while the Hat Creek watershed includes portions of the unincorporated communities of Bryant, Jonesboro, and Roseland. The study watersheds are within VAHU6 watersheds JM23 and JM24. Both Black Creek and Hat Creek are direct tributaries to the Tye River, which flows southeast through Virginia into the James River. The James River flows into the Chesapeake Bay and ultimately discharges into the Atlantic Ocean.

3.1. Ecoregion

Both Black Creek and Hat Creek are in the Northern Inner Piedmont and Northern Igneous Ridges ecoregions (**Figure 3-1**). A description of each ecoregion is below, adapted from Woods et al., 1999.

> The Northern Inner Piedmont ecoregion is a dissected upland with hills, irregular plains, and some isolated ridges and mountains, and is underlain by deformed and weathered gneiss, schist, and melange, with intrusions of plutons. Originally this ecoregion would have consisted of mixed oak-hickory-pine forests but is now a patchwork of pine dominated forests and agricultural fields.
>
> The Northern Igneous Ridges ecoregion consists of pronounced ridges separated by high gaps and coves. Mountain flanks are steep and well dissected. This ecoregion is naturally dominated by oak forest, but there are localized areas of agricultural production. Soil composition is largely low in fertility, acidic, rocky, and steep.

3.2. Soils

The soil related parameters for the watershed were derived from the Soil Survey Geographic (SSURGO) dataset. The predominant factor analyzed was the hydrologic soil group (HSG). Hydrologic soil groups are an index of the rate at which water infiltrates through the soil with group A having the greatest rate of infiltration and D having the lowest rate of infiltration. When rainfall amounts exceed the capacity of the soil to infiltrate water, the excess water runs off and contributes to erosion. The combined groups such as B/D indicate a naturally slow infiltration rate due to high water table, rather than a lack of infiltration capacity. All study watersheds are predominantly composed of hydrologic soil group B, with Hat Creek having a small but not insignificant component consisting of group C (**Figure 3-2**).

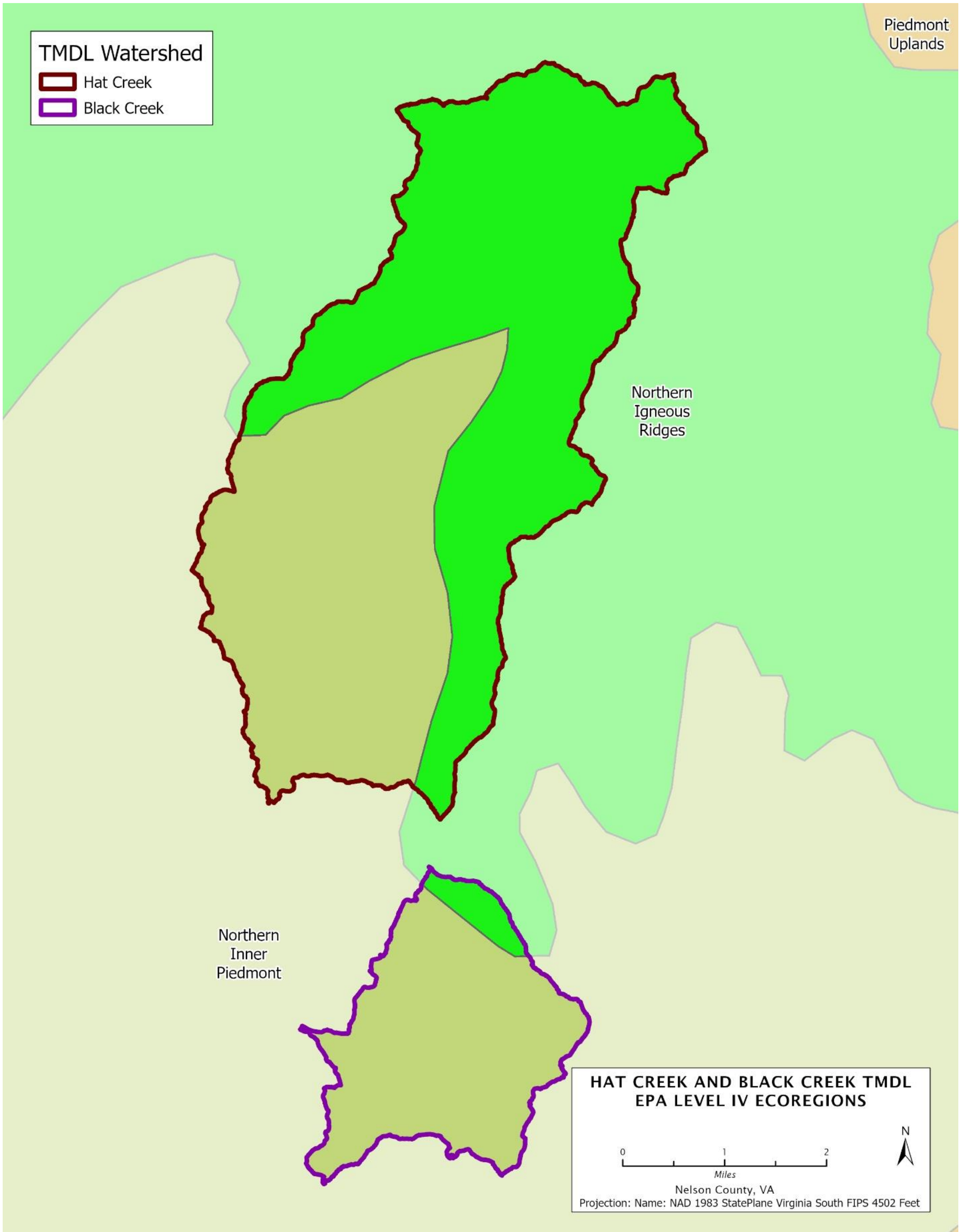


Figure 3-1. USEPA ecoregions included in the Black and Hat Creek TMDL watersheds.

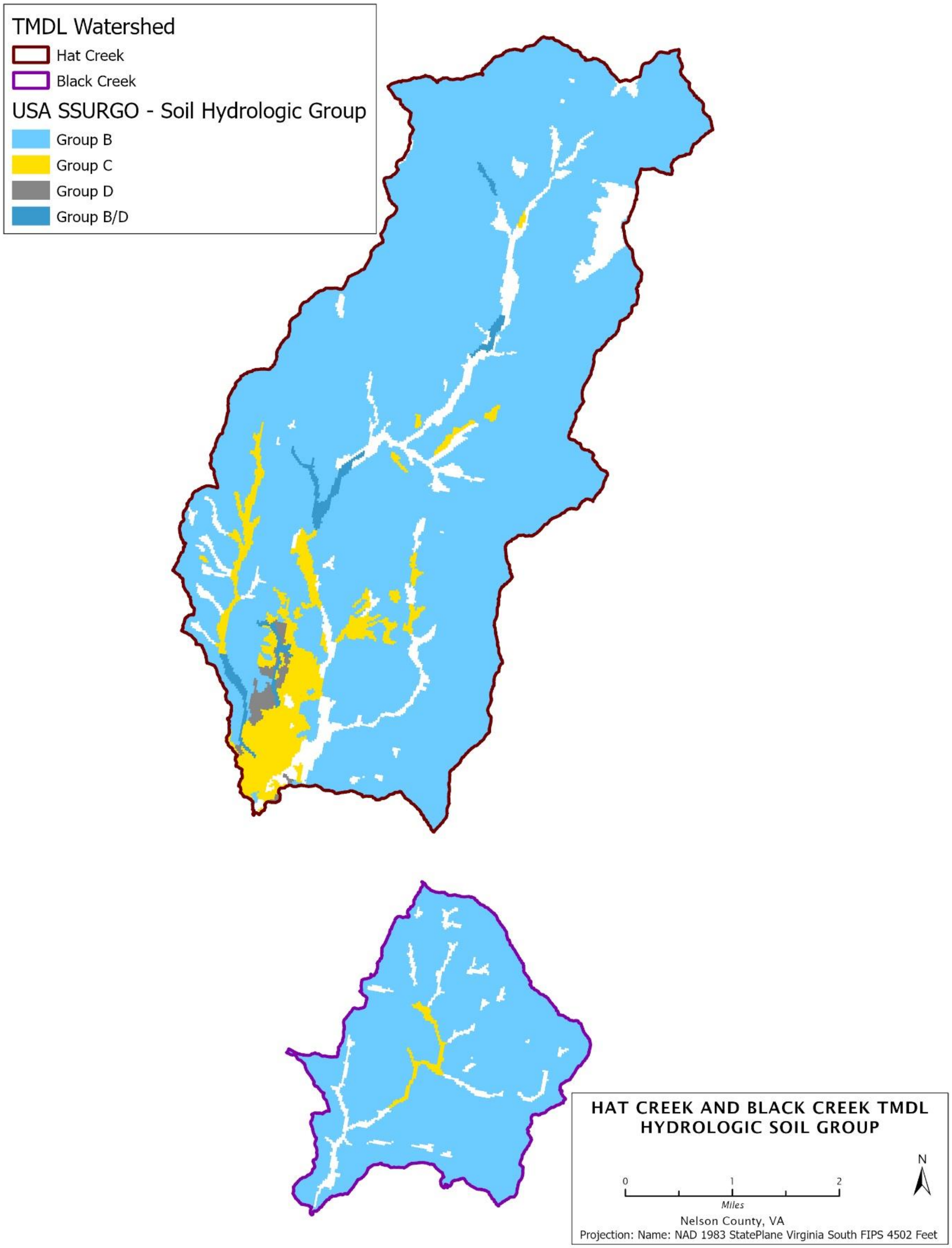


Figure 3-2. SSURGO hydrologic soil groups throughout the Black and Hat Creek TMDL watersheds.

3.3. Climate

Based on climate data from the National Weather Service (weather.gov/wrh/climate), the local annual average precipitation total in the Lynchburg area (closest dataset near the TMDL study area) is 42.76 inches, and the daily average temperature is 56.2° F. The normal summer high temperature is 86.9° F, while the normal winter low temperature is 25.8° F.

Daily rainfall and temperature data for the TMDL calibration was obtained from Oregon State's spatially distributed PRISM model (Parameter-Elevation Regressions on Independent Slopes Model), which interpolates available datasets from a range of monitoring networks and is used as the official spatial climate data sets of the USDA (PRISM, 2022). PRISM was utilized to obtain a more exact estimate of historical weather within the watershed, rather than relying on a nearby gauge outside of the watershed. See Daly et al. 2008 for more information on the PRISM model.

3.4. Land Cover/Land Use

The 2016 VGIN Virginia Land Cover Dataset (VLCD) was used to determine the land cover distribution throughout the watershed (VGIN, 2021). **Table 3-1** and **Table 3-2** summarize the land cover distributions for each of the impaired watersheds.

The VGIN dataset contains two different types of impervious land cover: extracted and local datasets. The local datasets impervious land cover is based on locally-developed datasets covering specifically building footprints, roads, and other known impervious areas. This land cover type is included in the computer model as entirely impervious. VGIN's extracted impervious land cover layer was developed using computer algorithms to extract additional areas that are likely impervious, beyond those areas identified in local datasets. When compared with aerial imagery, the extracted land cover set includes some areas that are not impervious. Based on visual comparisons, the extracted impervious land cover layer from VGIN was treated in the model as 80% developed impervious and 20% developed pervious.

The 'NWI/other' land cover type in the VGIN dataset is based on the combined National Wetlands Inventory and Tidal Marsh Inventory datasets and represents all identified wetland areas in those datasets.

The VGIN dataset contains categories for cropland and pasture, which were subdivided for modeling purposes using the 2020 Nonpoint Source (NPS) Assessment Land Use/Land Cover database maintained by the Virginia Department of Conservation and Recreation (VADCR) (VADCR, 2020). The VADCR NPS land use database includes acreage estimates for acres in conventional and conservation tillage, as well as hay and three quality-based categories of pasture by county and by VAHU6 watersheds. The ratio of conventional to conservation tillage for each modelled subwatershed was used to divide the VGIN cropland acres for that subwatershed into acreages of high till and low till, which were simulated using appropriately different parameters within the model, such as curve number, cover management (C) factor, and practice (P) factor. The VGIN pasture acres for each subwatershed were divided into four categories based on the NPS database: hay, pasture-good, pasture-fair, and pasture-poor. These categories were simulated with appropriately different curve number and C-factor values.

Local stakeholders identified significant portions of the Hat Creek watershed that were identified as cropland in the VGIN VLCD dataset as areas not under row crop production. Upon closer inspection of aerial imagery, the majority of these areas were identified as orchards or vineyards, which the VLCD classification methodology does lump with traditional plowed-field row crops. However, knowing the differences in hydrology and sediment movement in orchards and vineyards compared to traditional row crops, these areas were separated into a new category of ‘vineyard’ with appropriate model parameters adjusted.

The stakeholders also brought up the relative abundance of gravel roads in the watersheds. VDOT maintains a GIS layer of gravel roads, which was used to reclassify those areas into a new land cover type representing loads from gravel roads.

A property on the edge of the Black Creek watershed was removed from the watershed when it was found to drain to a different watershed via a series of stormwater management structures. This flow pattern was verified via conversation with the property owner and a review of the aerial imagery. Finally, an area that was originally deemed to be barren was reclassified as impervious when it was found to be the riprap stabilizing the shores of a stormwater pond.

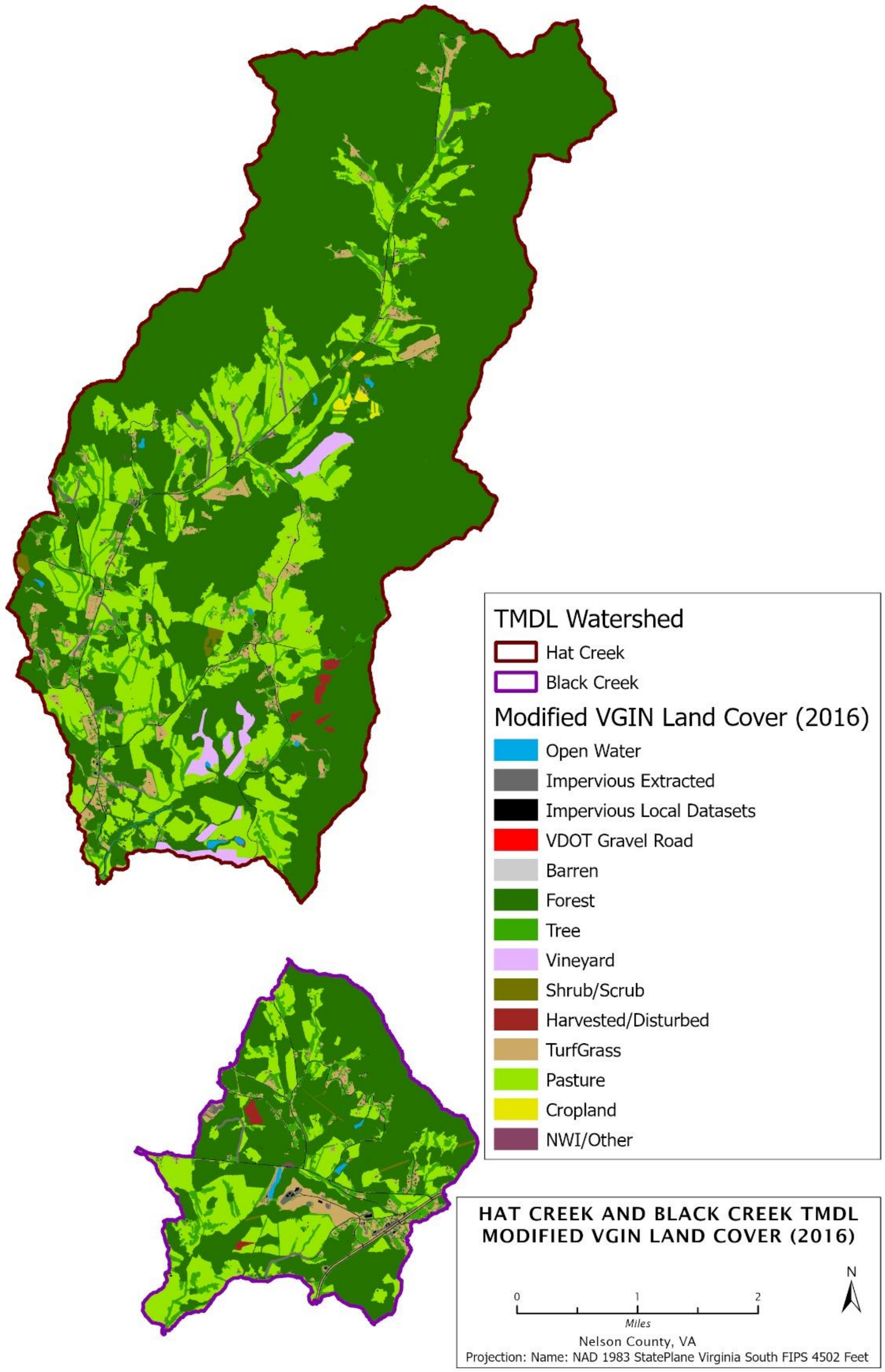


Figure 3-3. Land cover distribution used in the Black and Hat Creek watershed models.

Table 3-1. Land cover distribution in the Black Creek watershed.

Black Creek Watershed		
Land Cover Category	***Acres***	***%***
Cropland	-	-
Hay	483	15.5%
Pasture	232	7.4%
Vineyard	-	-
Forest	1,764	56.5%
Trees	333	10.7%
Shrub	8	0.3%
Harvested	16	0.5%
Water	10	0.3%
Wetland	1	0.0%
Gravel	3	0.1%
Turfgrass	165	5.3%
Developed pervious	9	0.3%
Developed impervious	100	3.2%
Total	*3,124*	*100.0%*

Table 3-2. Land cover distribution in the Hat Creek watershed.

Hat Creek Watershed		
Land Cover Category	***Acres***	***%***
Cropland	23	0.2%
Hay	1,179	9.5%
Pasture	1,101	8.8%
Vineyard	157	1.3%
Forest	8,499	68.3%
Trees	889	7.1%
Shrub	23	0.2%
Harvested	26	0.2%
Water	19	0.2%
Wetland	2	0.0%
Gravel	9	0.1%
Turfgrass	366	2.9%
Developed pervious	10	0.1%
Developed impervious	138	1.1%
Total	*12,441*	*100.0%*

3.5. Water Quality and Biological Monitoring Data

Biological, physical, and chemical data from four monitoring stations within the TMDL watersheds were used in developing the stressor analysis study. This includes four benthic and two water quality monitoring stations (two sites are co-located benthic and water quality monitoring stations). The data from these monitoring stations are explored in the benthic stressor analysis report (DEQ, 2022b) and summarized in **Table 3-3**. The various benthic monitoring stations are shown in **Figure 3-4**.

Table 3-3. Summary of monitoring data collected in the study watersheds.

Benthic Station ID	Location	Monitoring Program Type	Years Sampled
2-BKC000.08	Old Stage Rd Culvert on Piney River Farm	Benthic, Water Quality	Benthic: 2020-2021 WQ: 2020-2021
2-BKC001.43	Down Stream of STP Discharge	Benthic	2011-2013
2-BKC001.55	Upstream of STP Discharge	Benthic	2011-2013
2-HAT000.14	100 yards upstream of Route.655 Bridge	Benthic, Water Quality	Benthic: 2008-2021 WQ: 2007-2021

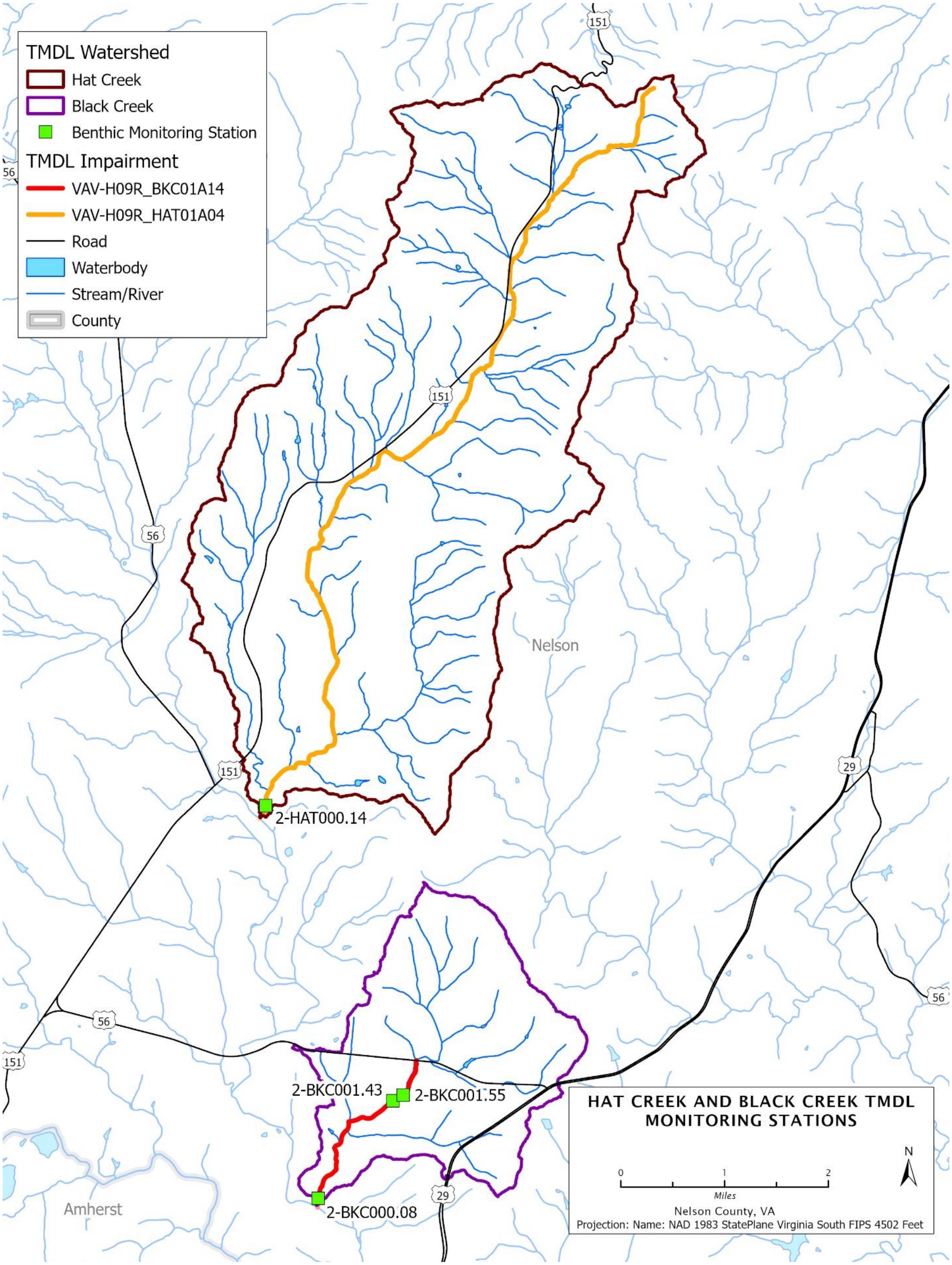


Figure 3-4. Locations of DEQ monitoring stations in the Black and Hat Creek watersheds.

4.0 MODELING PROCESS

A computer model was used in this study to simulate the relationship between pollutant loadings and in-stream water quality conditions.

4.1. Model Selection and Description

The model selected for development of the sediment and phosphorus TMDLs in the Black and Hat Creek watersheds was the Generalized Watershed Loading Functions (GWLF) model, developed by Haith et al. (1992), with modifications by Evans et al. (2001), Yagow et al. (2002), and Yagow and Hession (2007). GWLF is based on loading functions, which are a compromise between the empiricism of export coefficients and the complexity and data-intensive nature of process-based simulations (Haith et al., 1992). GWLF operates in metric units, but outputs were converted to English units for this report.

GWLF is a continuous simulation model that operates on a daily timestep for water balance calculations and outputs monthly runoff, sediment, and nutrient yields for the watershed. The model allows for multiple different land cover categories to be incorporated, but spatially it is lumped, in the fact that it does not account for the spatial distribution of sources and has no method of spatially routing sources within the watershed.

Observed daily precipitation and temperature data are input, along with land cover distribution and a range of land cover parameters, which the model uses to estimate runoff and sediment loads in addition to dissolved and attached nitrogen and phosphorus loads. Surface runoff is calculated using the Soil Conservation Service Curve Number (SCS-CN) approach. Curve numbers are a function of soils and land use type. Erosion is calculated in GWLF based on the Universal Soil Loss Equation (USLE). USLE incorporates the erosivity of rainfall in the watershed area, inherent erodibility of the soils, length and steepness of slopes, as well as factors for cover and conservation practices that affect the impact of rainfall and runoff on the landscape. Impervious or urban sediment inputs are calculated in GWLF with exponential accumulation and washoff functions. GWLF incorporates a delivery ratio into the overall sediment supply to estimate sediment deposition before runoff carries it to a stream segment. GWLF's sediment transport algorithm takes into consideration the transport capacity of the runoff based on calculated runoff volume.

Stream bank and channel erosion is calculated using an algorithm by Evans et al. (2003) as incorporated in the AVGWLF (GWLF with an ArcView interface) version (Evans et al., 2001) of the GWLF model and corrected for a flow accumulation coding error (DEQ, 2005). This algorithm incorporates the stream flow, fraction of developed land (i.e. impervious cover) in the watershed, and livestock density in the watershed with the area-weighted curve number and soil erodibility factors and the mean slope of the watershed.

Groundwater discharge to the stream is calculated using a lumped parameter for unsaturated and shallow saturated water zones throughout the watershed. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation from the unsaturated zone to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone contributes groundwater discharge to the stream based on a recession coefficient, and groundwater loss to a deep saturated zone can be modeled using a seepage coefficient.

Surface nutrient losses are determined by applying dissolved nitrogen and phosphorus coefficients to surface runoff and a nutrient content coefficient to the sediment yield for pervious source areas. Impervious or urban nutrient inputs are calculated with exponential accumulation and washoff functions. GWLF also includes functionality for manure applications and septic systems.

4.2. Model Setup

Watershed data needed to run GWLF were generated using spatial data, water quality monitoring data, streamflow data, local weather data, literature values, stakeholder input, and best professional judgement. In general, the GWLF manual (Haith et al., 1992) served as the primary source of guidance in developing input parameters where newer published methods were not available. Values for the various GWLF input parameters for each model are detailed in **Appendix A**. A sensitivity analysis of the model to select parameters is presented in **Appendix B**.

Local weather data, including daily rainfall totals and average daily temperature, was obtained from the National Weather Service and Oregon State's spatially distributed PRISM model (PRISM, 2022). This data was used for calibrating and developing the watershed loads for the Black and Hat Creek models. See **Section 3.3** for more information.

The model allows for multiple land cover categories to be incorporated, but spatially it is lumped, meaning that it does not account for the spatial distribution of sources and has no method of spatially routing sources within the watershed. The standard practice is to then sub-divide larger watersheds into smaller subwatersheds that can be simulated individually to get a more granular assessment of the pollutant loads. The TMDL study area was divided into four subwatersheds to obtain a more granular assessment of the pollutant loads throughout the watershed. The Black Creek study area was divided into subwatersheds one through three, while the Hat Creek study area was not divided into separate subwatersheds and was fully represented by subshed four (**Figure 4-1**). Locations of monitoring stations were used to guide subwatershed development to take advantage of available data.

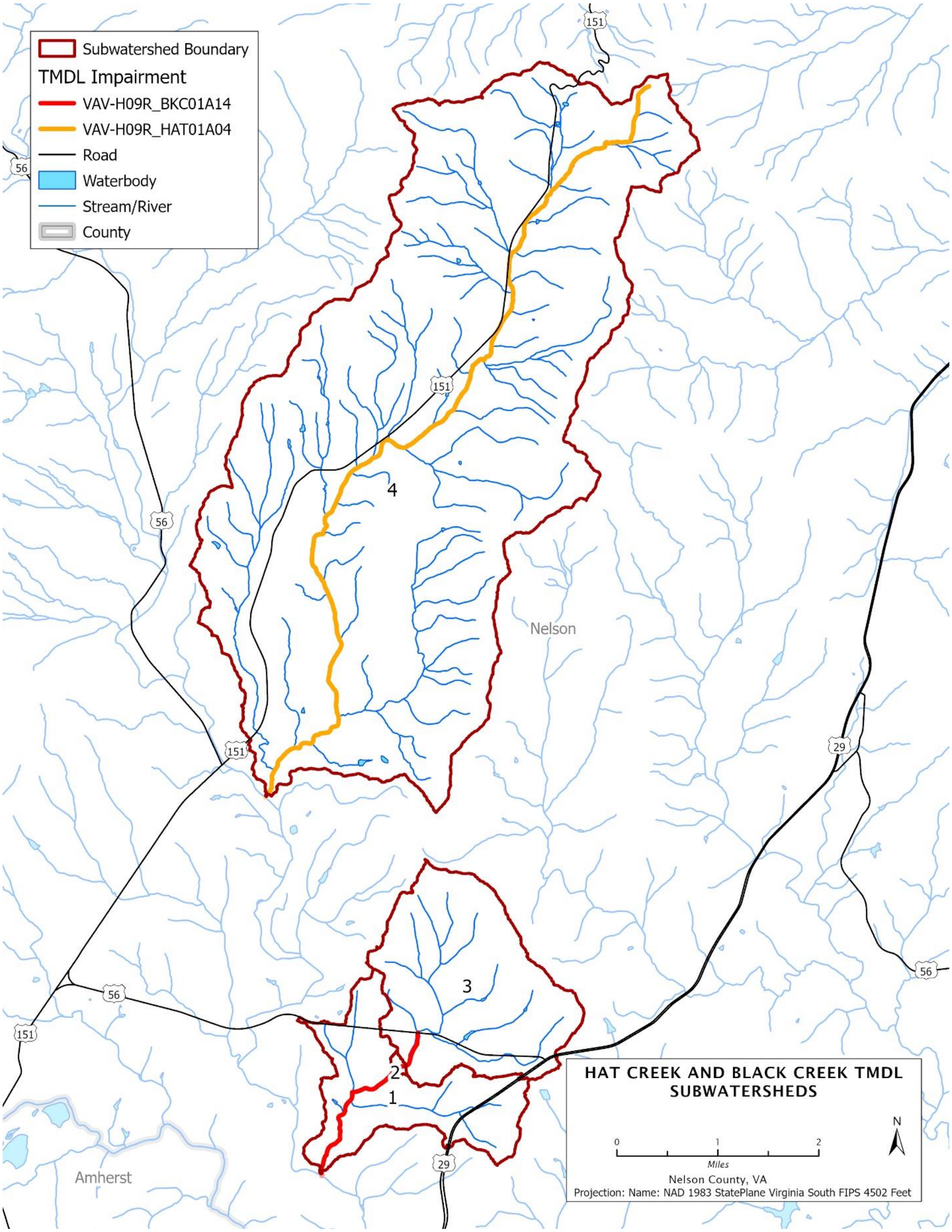


Figure 4-1. Black and Hat Creek TMDL model subwatersheds.

4.3. Source Assessment

Sediment and phosphorus can be delivered to streams by either point or nonpoint sources. Point sources include permitted sources such as water treatment facilities. Nonpoint sources encompass all of the other sources in the watersheds. Nonpoint sources of sediment and phosphorus are primarily from surface runoff and erosion happening within and on the banks of streams. Phosphorus can be bound to and transported with eroded sediment or dissolved in water directly.

4.3.1. Nonpoint Sources

4.3.1.1. Surface Runoff

Sediment and attached phosphorus can be transported from both pervious and impervious surfaces during runoff events. Between rainfall events, sediment accumulates on impervious surfaces and can then be washed off these surfaces during runoff events. On pervious surfaces, soil particles are detached by rainfall impact and shear stress from overland flow and then transported with the runoff water to nearby streams. Various factors including rainfall intensity, storm duration, surface cover, topography, tillage practices, soil erosivity, soil permeability, and other factors all impact these processes. Surface applications of manure and other fertilizers are also subject to being suspended and transported in runoff. In addition to phosphorus attached to mobilized particles, phosphorus can also be dissolved in water. Surface runoff can ‘pick up’ soluble phosphorus and then contribute directly to dissolved phosphorus in streams.

VGIN 2016 land cover data was used to determine the distribution of different land cover types in the watersheds (with the modifications noted in **Section 3.4**). Values for various parameters affecting sediment and phosphorus loads were gleaned from literature guidance (CBP, 1998; Haith et al., 1992; Hession et al., 1997, CTBMPEP, 2016, SSDCEP, 2015). Slopes and overland flow lengths were generated based on elevation data from USGS 3D Elevation Program Digital Elevation Model (USGS 3DEP DEM) (USGS, 2022). Soil parameters were derived from the Soil Survey Geographic (SSURGO) dataset (USDA NRCS, 2022).

4.3.1.2. Streambank Erosion

Sediment transport in streams is a natural process. However, changes to the landscape can alter this process, in turn changing the balance of sediment mobilization and deposition within the stream system. Phosphorus binds tightly to sediment and is transported in the stream along with the associated sediment.

Increases in impervious areas can increase the amount and rate of flow in streams following rainfall events, which provides more erosive power to the streams and increases the channel erosion potential. This is often the cause of the entrenchment, or downcutting, of urban streams – disconnecting higher flow events from the surrounding floodplain. The higher flows are then increasingly confined to the channel, thus mobilizing more sediment, both as total suspended solids (TSS) in the water column and bedload (the movement of larger particles along the bottom of the channel). Erosion of entrenched streams continues as steep banks are more susceptible to erosion and eventually mass wasting as chunks of undercut banks are dislodged into the stream. Sediment deposition between storm events and the highly mobile bed material during erosive storm flows negatively impact aquatic life.

Additionally, impacts to riparian (streambank) vegetation from livestock access and other management practices weaken the stability of the streambanks themselves as root system matrices break down. Weakened streambanks are more easily eroded by storm flows and can lead to excessive channel migration and eventual channel over-widening. Increasing channel width decreases stream depth which can lead to increased sediment deposition and increased water temperatures, which both negatively impact aquatic life.

Stream bank and channel erosion is calculated in GWLF using an algorithm by Evans et al. (2003) as incorporated in the AVGWLF version (Evans et al., 2001) of the GWLF model and corrected for a flow accumulation coding error (DEQ, 2005). This algorithm estimates average annual streambank erosion as a function of cumulative stream flow, fraction of developed land (i.e. impervious cover) in the watershed, livestock density in the watershed, area-weighted curve number and soil erodibility factors, and the mean slope of the watershed. A calculated lateral erosion rate is then applied to an average bank height estimated from NRCS Regional Hydraulic Curves (USGS, 2009) and perennial stream length as estimated from the USGS NHD at 1:24,000 scale.

4.3.1.3. Groundwater

Shallow surface groundwater interacts with phosphorus that is dissolved in percolating runoff and attached to the soil. The higher the concentration of soil-bound phosphorus and dissolved phosphorus in runoff, the higher the levels of phosphorus in shallow groundwater. Groundwater can contribute directly to streamflow through upwelling, taking its dissolved phosphorus with it and adding to the overall total phosphorus (TP) load in streams.

4.3.1.4. Residential Septic Systems

Residential septic systems are designed so that their drainfields dissipate the effluent over an area to be adsorbed to soil particles and used by plant roots and microorganisms. When systems are failing, they can discharge nutrient-rich waste to the surface where it is easily transported to surface waters during runoff events, or directly to surface waters if they are located nearby.

The number and distribution of dwellings with septic systems throughout the watersheds was determined using a dataset provided by Virginia Department of Health (VDH) dated March 2021

(**Table 4-1**). However, depending on the location, this dataset may only cover septic system installations that happened after the year 2000. Stakeholder input helped determine 80 and 90 as a best estimate of the number of functional septic systems to incorporate in the model for the Black Creek and Hat Creek watersheds, respectively. Residences with failing (ponded) septic systems were estimated based on a failure rate of 3.3%, derived from the assumption that each septic system fails, on average, once during an expected lifetime of 30 years. Without reliable estimates or stakeholder input to stating otherwise, it was assumed that there were no straight pipes in the study area. Census data (US Census Bureau, 2018) for the localities was used as the reference for number of persons per household, which was applied to the number of residences on septic systems to obtain a population distribution to be input to GWLF.

Table 4-1. Estimated numbers of residences with septic systems.

Watershed	Functioning Septic Systems	Ponded Septic Systems
Black Creek	80	3
Hat Creek	90	3
Total	*170*	*6*

4.3.2. Point Sources

Point sources of sediment and phosphorus within the Black Creek and Hat Creek watersheds were identified. These point sources are permitted under the Virginia Pollutant Discharge Elimination System (VPDES) program and include the following categories of permits: individual permits and domestic sewage general permits. The approaches for determining loads from each of these permits are described below. Permits included in the study were limited to those active as of May 2022.

4.3.2.1. VPDES Individual Permit

There is one VPDES individual permit within the study area, associated with a wastewater treatment facility discharging to Black Creek. The typical (existing) TSS load was calculated based on the average discharge rate and average TSS concentration, and was used to model existing conditions in the watershed (**Table 4-2** and **Table 4-3**).

Table 4-2. Sediment loads associated with VPDES individual permit.

Permit No	Facility Name	Watershed	Average Flow (MGD)	Design Flow (MGD)	Average Conc. (mg/L TSS)	Permitted Conc. (mg/L TSS)	Typical (Existing) Load (lb/yr TSS)	Permitted Load (lb/yr TSS)
VA0089729	Nelson County Regional STP	Black Creek	0.12	0.22	4.41	30	1,613	20,118

This permit does not include a concentration limit for phosphorus; however, it is a significant source of phosphorus that must be accounted for in the Black Creek watershed. The typical (existing) phosphorus load was calculated based on the average flow and average phosphorus concentration and was used to model existing conditions in the watershed. The permitted load shown in **Table 4-3** is based on the permitted design flow for the facility and the Chesapeake Bay TMDL benchmark target of 2.5 mg/L TP for minor dischargers (< 1 MGD) like the Nelson County Regional STP.

Table 4-3. Total phosphorus (TP) loads associated with VPDES individual permit.

Permit No	Facility Name	Watershed	Design Flow (MGD)	Average Flow (MGD)	Average TP concentration (mg/L)	Typical (Existing) TP Load (lbs/yr)	Permitted Load (lb/yr)
VA0089729	Nelson County Regional STP	Black Creek	0.22	0.12	2.5	914	1,676

4.3.2.2. Domestic Sewage General Permit

There is one domestic sewage general permit in the study area (**Table 4-4**). The domestic sewage general permit specifies a maximum flow rate of 1000 gallons per day at a sediment concentration of 30 mg/L. These permit limits were used to calculate a wasteload allocation of 91.44 lb/yr TSS for the domestic sewage permits in the TMDL. Domestic permits are also a source of phosphorus; however, phosphorus was not identified as a probable stressor in Hat Creek where this permit is located.

Table 4-4. Domestic sewage general permit in the study area.

Permit Number	Watershed	Permitted Load (lb/yr TSS)
VAG408483	Hat Creek	91.44

4.3.2.3. Construction Stormwater General Permit

There are currently no active Virginia Stormwater Management Program (VSMP) Construction General Permits (CGPs) within the study area, nor is there any record of a CGP within the study area in the past 10 years. These permits are a potential source of sediment and phosphorus and are often assigned wasteload allocations in the TMDL based on the typical annually disturbed area associated with VSMP CGPs in the watershed. Following discussions with community engagement meeting participants, it was decided that future construction and associated loads can be accounted for using the future growth set aside of 2% of the TMDL.

4.4. Best Management Practices

Several property owners have installed best management practices (BMPs) within the watersheds. Many BMPs have associated removal efficacies defined in the literature, which can be applied to the raw pollutant accumulation loads for the land areas draining to the BMP. Other BMPs can be simulated as a change in land cover over the treated acreage, such as planting a riparian buffer and turning previous pasture land into forested areas. The BMPs installed in the watersheds are detailed in **Table 4-5** and **Table 4-6**, along with their various removal efficacies. The Chesapeake Bay Phase 5.3 Community Model Documentation Section 6 (USEPA, 2010) was used to guide the TSS and TP removal estimates. Other BMPs exist within the watersheds, but these are either maintenance practices or contribute only bacteria reductions without an associated sediment reduction.

Table 4-5. BMPs installed in the Black Creek watershed.

BMP Code	BMP Type	# Projects	Extent Installed	TSS Efficacy Method (fraction removal, other)	TP Efficacy Method (fraction removal, other)	TSS Removal (lb/year)	TP Removal (lb/year)
RB-1	Septic Tank Pumpout	1	-	-	Load removal	-	1.80
RB-3	Conventional Onsite Sewage System Repair	2	-	-	Load removal	-	3.59
RB-4	Conventional Onsite Sewage System Installation/ Replacement	1	-	-	Load removal	-	1.80
RB-4P	Conventional Onsite Sewage System Installation/ Replacement with Pump	2	-	-	Load removal	-	3.59
LE-IT-W	Livestock Exclusion with Riparian Buffers for TMDL Imp.	1	4.82 ac	0.56, Land cover change	0.42, Land cover change	20,520	4.67
SL-6	Stream Exclusion With Grazing Land Management	1	13.61 ln ft	0.56, Land cover change, 0.30	0.42, Land cover change, 0.24*	119,300	26.05

* 0.42 TSS filter reduction, 0.24 TSS Grazing Management. Also, though the watershed draining to this BMP can be larger, no more than two times the area of the buffer itself may benefit from the filter reduction.

Table 4-6. BMPs installed in the Hat Creek watershed.

BMP Code	BMP Type	# Projects	Extent Installed	TSS Efficacy Method (fraction removal, other)	TSS Removal (lb/year)
LE-1T-N	Livestock Exclusion with Reduced Setback for TMDL Imp.	1	2.11 ac	0.56, Land Cover Change	8,959
SL-6	Stream Exclusion with Grazing Land Management	2	19.52 ln ft	0.56, Land cover change, 0.30*	99,960

* 0.56 TSS filter reduction, 0.30 TSS Grazing Management. Also, though the watershed draining to this BMP can be larger, no more than two times the area of the buffer itself may benefit from the filter reduction.

4.5. Flow Calibration

GWLF was originally developed as a planning tool for estimating nutrient and sediment loadings in ungauged watersheds and was designed to be implemented without calibration. When appropriate data is available for comparison, though, calibration can improve the accuracy of GWLF. Hydrologic calibration was performed as a preliminary modeling step to ensure that hydrology was being simulated as accurately as possible.

Historic daily flow data was available from USGS flow gauge #02024915 – Pedlar River near Buena Vista beginning in 2002. This gauge is co-located with DEQ monitoring station 2-POL020.03 near the confluence of Pedlar River with Brown Mountain Creek, and was selected for inclusion in the development of the AllForX regression (**Section 5.0**). Above this point, the Pedlar River watershed is about 17,000 acres, a reasonable size compared to the TMDL watersheds. It is larger than the Hat Creek watershed (12,000 acres), and it is about 5.5 times as large as the Black Creek watershed (3,000 acres). The size difference between the Pedlar River watershed and the Black Creek watershed was considered acceptable in the absence of a smaller watershed with the appropriate amount of USGS flow data in the general geographical area. The Pedlar River watershed has similar land cover distributions to both TMDL watersheds and is geographically close to the watersheds. These factors indicate that it is likely to have a similar hydrologic response to both of the TMDL watersheds. Hydrologic calibration was completed for the Pedlar River watershed, and calibrated parameters were applied to the other modeled watersheds. Daily rainfall and temperature data for the watershed was obtained from Oregon State's spatially distributed PRISM model (PRISM, 2022). Leaving a 'warm-up' period for the model (year 2003), the years from 2013 to 2020 were used as the calibration period, and years 2004 to 2012 were used as a validation dataset. These ranges are sufficiently long that a range of both dry and wet years are encompassed in each to better assess the model's performance.

Calibration efforts focused on adjusting watershed scale parameters, such as the recession coefficient and seepage coefficient, that cannot be calculated or estimated reliably from available guidance. The typical target ranges for GWLF calibration efforts are to achieve ±5% of the observed total flow and ±20% compared to seasonal flow distribution. While calibration efforts make a best effort at meeting the target for all criteria, this is not always possible as no model is a perfect simulation of the reality it is approximating. The final GWLF calibration results are shown in **Figure 4-2** and **Figure 4-3** and summarized in **Table 4-7**. The results of the calibration were also assessed for overall correlation by calculating an R^2 value for the datasets. Generally, for GWLF, an R^2 value greater than 0.7 indicates a strong positive correlation between simulated and observed data. Following calibration, the model output was run compared to the observed 2004-2012 discharge as a validation of the model calibration. The final GWLF validation results are summarized in **Table 4-7** and shown in **Figure 4-4** and **Figure 4-5**.

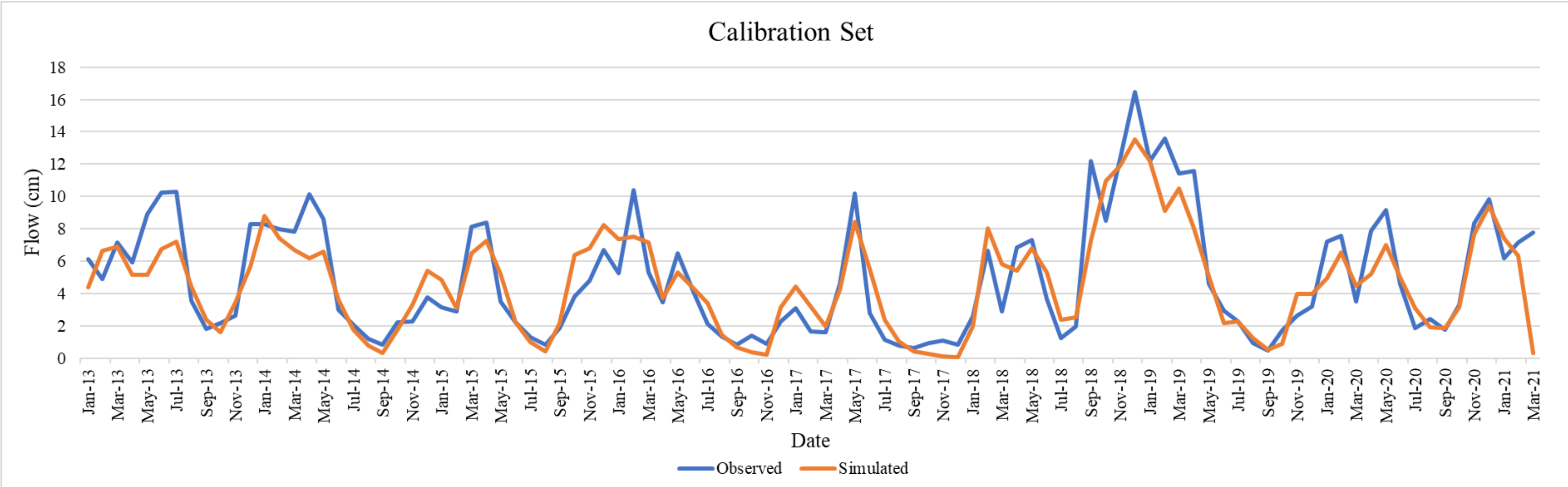


Figure 4-2. Calibration data set of simulated stream flow compared to observed flow (USGS# 02024915).

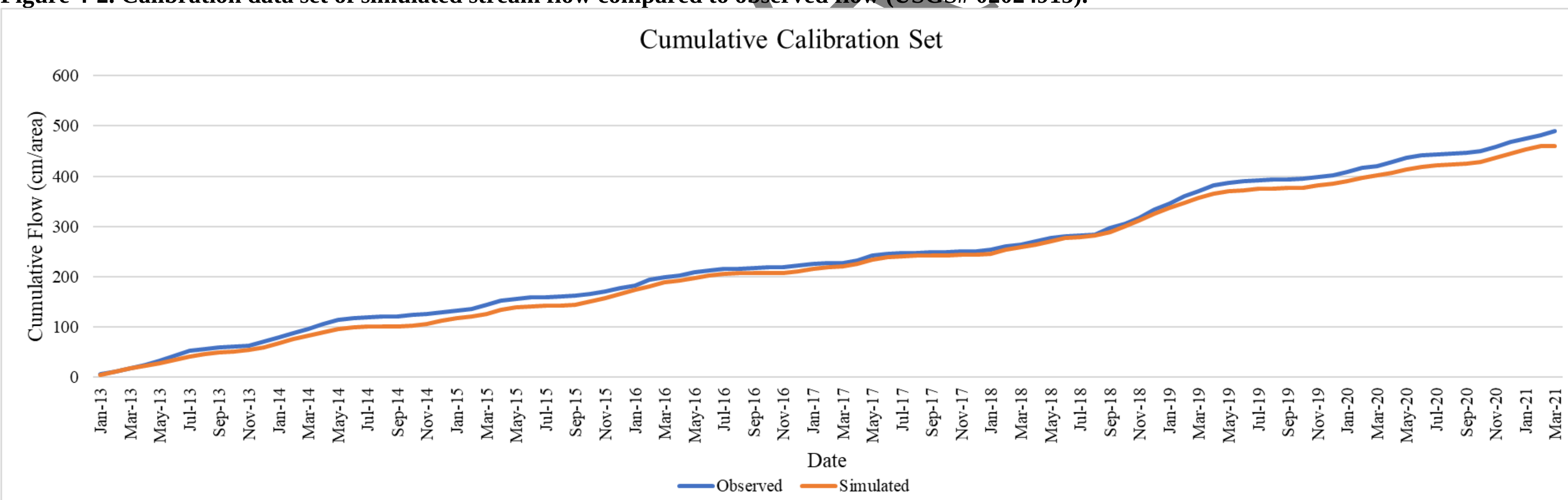


Figure 4-3. Calibration data set simulated cumulative flow from model compared to observed (USGS#02024915).

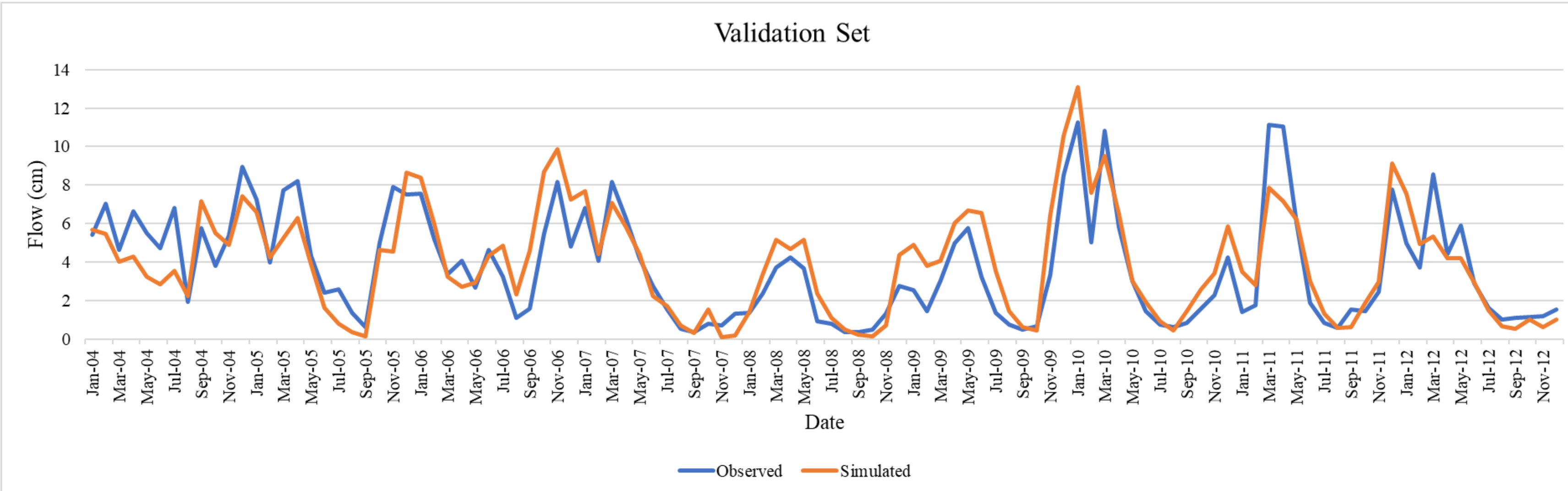


Figure 4-4. Validation data set of simulated stream flow compared to observed flow (USGS#02024915).

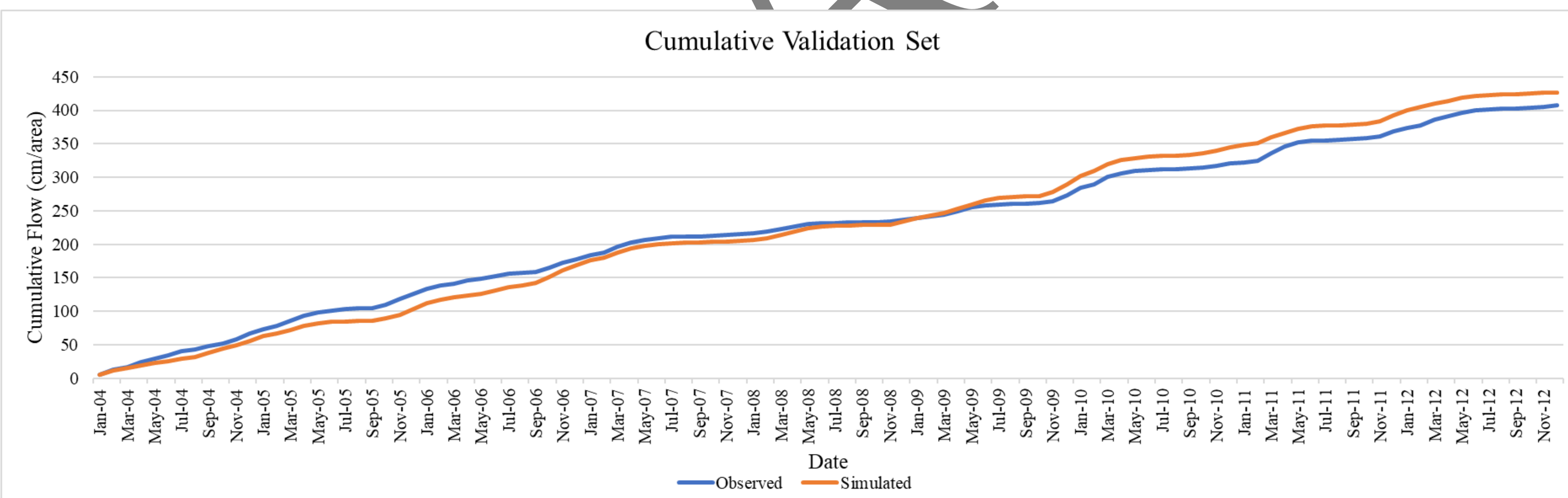


Figure 4-5. Validation data set simulated cumulative flow from model compared to observed (USGS#02024915).

Table 4-7. Results of hydrology calibration of GWLF model compared to observed data.

Criteria	Calibration Range Percent Difference (%)	Validation Range Percent Difference (%)
Total Cumulative Discharge	-4.98	4.88
Spring Discharge	-14.20	-5.21
Summer Discharge	-5.10	9.19
Fall Discharge	1.77	13.72
Winter Discharge	-0.66	6.01
R^2	0.81	0.74

4.6. Consideration of Critical Conditions and Seasonal Variations

To quantify existing conditions and develop reduction allocations, the GWLF model simulated a 16-year period (2004 through 2020) with an additional buffer period of nine months at the beginning of the run serving as a 'warm-up' period for the model to equilibrate and minimize the impact of uncertain initial conditions. Using this extended modeling period allows the results to account for both annual and seasonal variations in hydrology and sediment and phosphorus loads.

The modeled time period encompasses a range of weather conditions for the area, including 'dry', 'normal', and 'wet' years, which allows the model to represent critical conditions during both low and high flows. Critical conditions during low flows are generally associated with point source loads, while critical conditions during high flows are generally associated with nonpoint source loads.

GWLF considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data inputs and water balance equation calculations. GWLF also incorporates parameters that vary by month, including evapotranspiration cover coefficients and average hours per day of daylight. Additionally, the values for the rainfall erosivity coefficient are dependent on whether or not a given month is tagged as part of the growing season. The model is also capable of incorporating data for the land-application of manure in up to two user-set application periods.

4.7. Existing Conditions

Existing sediment and phosphorus loads from the impaired watersheds were simulated in GWLF as described above. **Table 4-8** and **Table 4-9** summarize the resulting loads. While the model is run using weather data from a several year period to capture the range of seasonal and annual variation, the land cover and pollutant sources within the model do not vary over time as the model runs. Instead, the land cover and pollutant sources simulate snapshots in time representing available data and active permits. In this model, the land cover is from 2016 with edits noted in

Section 3.4, and the permits and BMPs included are reflective of conditions in May 2022. These dates reflect the collected water quality monitoring data used to determine the necessity of developing this TMDL and to gauge the existing conditions in the model results. The monitoring window for data analyzed for this study ran through December 2021.

Any apparent differences in calculated values are due to rounding. Model results were rounded to 4 significant figures.

Table 4-8. Existing sediment and phosphorus loads in the Black Creek watershed, accounting for known BMPs (not including MOS or FG detailed in Section Error! Reference source not found.**).**

Black Creek				
Land Cover Category	***TSS (lb/yr)***	***Percent***	***TP (lb/yr)***	***Percent***
Cropland	-	0.0%	-	0.0%
Hay	59,586	10.7%	188.6	12.0%
Pasture	253,951	45.4%	81.4	5.2%
Vineyard	-	0%	-	0.0%
Forest	87,308	15.6%	17.9	1.1%
Trees	32,305	5.8%	8.6	0.6%
Shrub	2,666	0.5%	0.4	<0.1%
Harvested	14,012	2.5%	2.5	0.2%
Wetland	453	0.1%	0.1	<0.1%
Gravel	908	0.2%	0.4	<0.1%
Turfgrass	15,476	2.8%	27.7	1.8%
Developed pervious	1,789	0.3%	1.2	0.1%
Developed impervious	67,858	12.1%	149.3	9.5%
Groundwater	-	0.0%	168.0	10.7%
Septic	-	0.0%	-	-
Streambank	21,197	3.8%	7.4	0.5%
Permitted*	1,613	0.3%	914	58.3%
Total	*559,124*	*100%*	*1,568*	*100%*

**Existing permitted loads for Individual VPDES Permit VA0089729 were calculated using reported Discharge Monitoring Report (DMR) data. This included an average discharge rate of 0.12 MGD, an average TSS concentration of 4.41 mg/L, and an average TP concentration of 2.5 mg/L.*

Table 4-9. Existing sediment loads in the Hat Creek watershed, accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Hat Creek		
Land Cover Category	***TSS (lb/yr)***	***Percent***
Cropland	12,919	0.6%
Hay	102,648	4.8%
Pasture	1,173,980	54.7%
Vineyard	15,794	0.7%
Forest	364,329	17.0%
Trees	57,301	2.7%
Shrub	5,220	0.2%
Harvested	17,614	0.8%
Wetland	176	<0.1%
Gravel	3,028	0.1%
Turfgrass	28,358	1.3%
Developed pervious	2,191	0.1%
Developed impervious	87,040	4.1%
Streambank	275,435	12.8%
Permitted	91	<0.1%
Total	*2,146,121*	*100%*

5.0 SETTING TARGET SEDIMENT AND PHOSPHORUS LOADS

TMDL development requires an endpoint, or water quality goal, to target for the impaired watershed(s). Many pollutants have numeric water quality criteria set in regulatory documentation, and it is assumed that compliance with these numeric criteria will lead the waterbody to achieve support of all designated uses. However, sediment and phosphorus do not have a numeric criteria established, as the acceptable levels of pollutant are expected to vary from stream to stream based on a range of contributing factors. Therefore, an alternative method must be used to determine the water quality target for sediment and phosphorus TMDLs.

The method used to set sediment TMDL endpoint loads for the Black and Hat Creek watersheds is called the "all-forest load multiplier" (AllForX) approach, which has been used in developing many sediment TMDLs in Virginia since 2014. AllForX is the ratio of the simulated pollutant load under existing conditions to the pollutant load from an all-forest simulated condition for the same watershed. In other words, AllForX is an indication of how much higher current sediment loads are above an undeveloped condition. These ratios were calculated for the watersheds of monitoring stations within the impaired watersheds as well as other nearby watersheds of similar size and within the same ecoregions as or adjacent ecoregions to the TMDL watersheds (**Appendix C**). AllForX ratios were calculated for a total of 13 watersheds.

The regression developed for total suspended solids (TSS) in Black Creek were created using the average Virginia Stream Condition Index (VSCI) scores calculated at each corresponding monitoring station (**Figure 5-1**). Based on this regression, an average VSCI score of 60 corresponded to a target TSS AllForX ratio of 3.0. This means that Black Creek is expected to achieve consistently healthy benthic conditions if sediment loads are less than 3.0 times the all-forested simulated load. This target ratio was used to determine the target load for the Black Creek sediment TMDL (**Table 5-1**).

The VSCI scores in Hat Creek fluctuate both above and below 60, with an average value of 58.7. As such, this stream is impaired, but it is close to a VCSI score consistently above 60. DEQ generally prefers two consecutive years of benthic monitoring above the VSCI threshold of 60 before classifying the stream as unimpaired and delisting the stream. Based on a 6-yr assessment window and typical DEQ monitoring every 2 years, no more than a third (33%) of benthic scores could be below the threshold of 60 and meet the qualifications for delisting. As such, the regression for TSS in Hat Creek was created using the 33rd percentile VSCI scores, rather than the average VSCI scores. This approach accounts for natural variability in VSCI scores over time and considers the methodology for assessing and delisting Virginia streams.

Figure 5-2 shows the regression developed for TSS in Hat Creek. Based on the regression, a 33rd percentile VSCI score of 60 corresponds to a target TSS AllForX ratio of 2.8. This means that Hat Creek is expected to achieve consistently healthy benthic conditions if sediment loads are less than

2.8 times the all-forested simulated load. The TSS AllForX target of 2.8 was then used to determine the allowable sediment load in Hat Creek (**Table 5-1**).

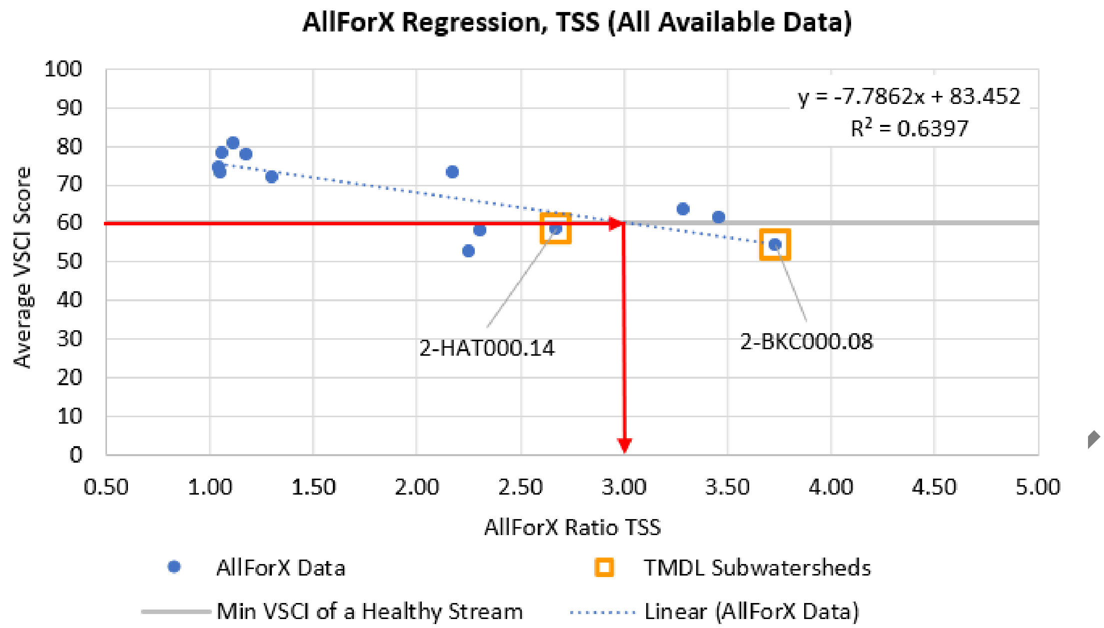


Figure 5-1. Regression between the average VSCI scores and all-forest multiplier for sediment, resulting in a TSS AllForX target ratio of 3.0 in the Black Creek TMDL

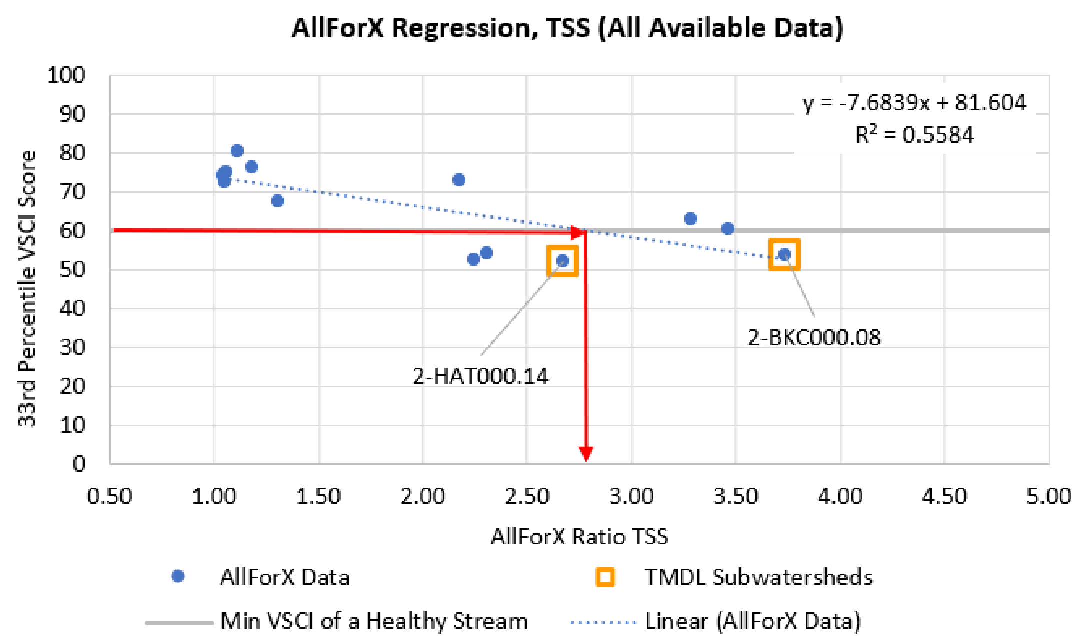


Figure 5-2. Regression between 33rd percentile VCSI scores and all-forest multiplier for sediment, resulting in a TSS AllForX target ratio of 2.8 in the Hat Creek TMDL

Table 5-1. Target sediment loading rates for the Black and Hat Creek watersheds

Impaired Stream	TSS All-Forested (lb/yr)	All-Forested Regression Multiplier	TSS Target (lb/yr)
Black Creek	176,157	3.0	529,582
Hat Creek	806,839	2.8	2,268,489

AllForX was considered for establishment of a phosphorus endpoint in Black Creek; however, given the proportion of the total phosphorus load in the watershed originating from the Nelson County STP (57.3%), this approach did not appear suitable for the watershed. Alternatively, a concentration-based approach was used to establish the phosphorus endpoint in Black Creek. This approach was used in the Little Otter River Benthic TMDL in 2014, where a TP endpoint was set to an average annual in-stream concentration of 0.070 mg/L based on the 90th percentile concentration at a reference station on the Big Otter River (DEQ, 2014b). Hat Creek was identified as a suitable reference for Black Creek. While the stream had a borderline benthic impairment, phosphorus concentrations in the creek are not the cause of the benthic impairment. The TP endpoint for Black Creek was set to an average annual in-stream concentration of 0.092 mg/L (**Table 5-2**). The existing phosphorus load was calculated using the average discharge rate and total phosphorus concentration from the Nelson County Regional STP. The target total phosphorus load shown in the table below includes existing sources of phosphorus in addition to a future growth allocation and a margin of safety.

Table 5-2. Target phosphorus concentration and load for the Black watershed

	Existing Condition		TMDL Target	
Impaired stream	**Mean In-Stream TP Concentration (mg/L)**	**Total Phosphorus Load (lb/yr)**	**Mean In-Stream TP Concentration (mg/L)**	**Total Phosphorus Load (lb/yr)**
Black Creek	0.16	1,568	0.092	1,368

6.0 TMDL ALLOCATIONS

Total maximum daily loads are determined as the maximum allowable load of a pollutant among the various sources. Part of developing a TMDL is allocating this load among the various sources of the pollutant of concern (POC). Each TMDL is comprised of three components, as summed up in this equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

where ΣWLA is the sum of the wasteload allocations (permitted sources),
ΣLA is the sum of the load allocations (nonpoint sources), and
MOS is a margin of safety.

The wasteload allocation (WLA) is calculated as the sum of all the permitted sources of the POC within the watershed as if they were discharging at their permitted allowable rate. A description of the permitted sources and their permitted loads are included in **Section 4.3.2**. A set-aside for future growth is also included in the WLA to account for potential future permitted activity in the watershed. The margin of safety (MOS) is determined based on the characteristics of the watershed and the model used to develop the TMDL loads (see **Section 6.1**). The overall load allocation (LA) is then calculated by subtracting the total WLA and MOS from the TMDL. Various allocation scenarios are typically developed to show different breakdowns of how this LA can be divided among the various nonpoint sources of the POC (**Section 6.4**).

For model runs to develop the annual existing loads and target loads using the AllForX methodology, a 16-year period was simulated (2004 through 2020) with an additional buffer period of nine months at the beginning of the run to serve as a 'warm-up' period for the model to equilibrate and minimize the impact of uncertain initial conditions. Using this extended modeling period allows the results to account for both annual and seasonal variations in hydrology and sediment/phosphorus loading.

6.1. Margin of Safety

To account for uncertainties inherent in model outputs, a margin of safety (MOS) is incorporated into the TMDL development process. The MOS can be implicit, explicit, or a combination of the two. An implicit MOS involves incorporating conservative assumptions into the modeling process in an effort to ensure that the final TMDL is protective of water quality in light of the unavoidable uncertainty in the modeling process. A MOS can also be incorporated explicitly into the TMDL development by setting aside a portion of the TMDL.

This TMDL includes both implicit and explicit MOSs. An example of implicit MOS assumptions incorporated into this TMDL are the inclusion of permitted loads at their maximum permitted rates, even when data shows that they are consistently discharging well below that threshold. Another implicit MOS incorporated is the exclusion of BMPs with lifespans ending prior to the snapshot date of current permits and BMPs, even though some BMPs outside of their noted lifespan may still be providing benefit to the watershed. An explicit MOS of 10% is also included in the sediment and phosphorus TMDLs. This is a typical value used in TMDLs throughout the state to account for unavoidable uncertainties in the modeling process.

6.2. Future Growth

An allocation of 2% of the total load is specifically set aside for future growth within this TMDL. This leaves flexibility in the plan for future permitted loads to be added within the watersheds, as the development of a TMDL looks at a snapshot in time of a dynamic system within the watershed and is not meant to prevent future economic growth. Participants in community engagement meetings noted that the area is poorly suited for large scale development due to the topography. However, in the absence of a discrete allocation for VA Stormwater Construction Permits in the Hat or Black Creek TMDLs, a 2% future growth allocation ensures that the TMDLs do not eliminate opportunities for development within the project area.

6.3. TMDL Calculations

Sediment was determined in the stressor analysis (as a primary cause of the benthic impairments in both Black and Hat Creek watersheds. Phosphorus was also determined to be a primary cause of the impairment in Black Creek. TMDLs were developed for sediment in both Black Creek and Hat Creek, and an additional TMDL for phosphorus was developed for Black Creek. The final sediment and phosphorus average annual loads allocated in the TMDL are presented in **Table 6-1** through **Table 6-3**. GWLF output data, being in monthly increments, is most logically presented as annual aggregates.

Table 6-1. Annual average sediment TMDL components for Black Creek. (For proposed loadings and percent reductions, see Scenario 1 in Table 1-10 or Table 6-9)

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Black Creek (VAV-H09R_BKC01A14)	**30,710**	**445,890**	**52,982**	**529,582**
VA0089729	*20,118*			
Future Growth (2% of TMDL)	*10,592*			

Table 6-2. Annual average sediment TMDL components for Hat Creek. (For proposed loadings and percent reductions, see Scenario 1 in Table 1-11 or Table 6-10)

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Hat Creek (VAV-H09R_HAT01A04)	**45,461**	**1,996,178**	**226,849**	**2,268,489**
Domestic Sewage General Permits	*91*			
Future Growth (2% of TMDL)	*45,370*			

Table 6-3. Annual average phosphorus TMDL components for Black Creek. (For proposed loadings and percent reductions, see Scenario 1 in Table 1-12 or Table 6-11)

Impairment	Allocated Point Sources (WLA) (lb/yr TP)	Allocated Nonpoint Sources (LA) (lb/yr TP)	Margin of Safety (MOS) (lb/yr TP)	Total Maximum Daily Load (TMDL) (lb/yr TP)
Black Creek (VAV-H09R_BKC01A14)	**712**	**519**	**137**	**1,368**
VA0089729	685			
Future Growth (2% of TMDL)	*27*			

In 1991, the USEPA released a support document that included guidance for developing maximum daily loads (MDLs) for TMDLs (USEPA, 1991). A methodology detailed therein was used to determine the MDLs for the watersheds. The long-term average (LTA) daily loads, derived by dividing the average annual loads in **Table 6-1** through **Table 6-3** by 365.24, are converted to MDLs using the following equation:

$$MDL = LTA * \exp\left(Z_p\sigma_y - 0.5\sigma_y^2\right)$$

where Z_p = pth percentage point of the normal standard deviation, and
σ_y = sqrt(ln(CV^2+1)), with CV = coefficient of variation of the data.

The variable Z_p was set to 1.645 for this TMDL development, representing the 95th percentile. The CV values and final calculated multipliers to convert LTA to MDL values are summarized in **Table 6-4** and **Table 6-5**.

Table 6-4. "LTA to MDL multiplier" components for TSS TMDLs.

Watershed	CV of Average Annual Loads	"LTA to MDL Multiplier"
Black Creek	0.48	1.91
Hat Creek	0.50	1.94

Table 6-5. “LTA to MDL multiplier” components for TP TMDLs.

Watershed	CV of Average Annual Loads	“LTA to MDL Multiplier”
Black Creek	0.41	1.76

The daily WLA was estimated as the annual WLA divided by 365.24. The daily MOS was estimated as 10% of the MDL. Finally, the daily LA was estimated as the MDL minus the daily MOS minus the daily WLA. These results are shown in **Table 6-6** through **Table 6-8**.

Table 6-6. Maximum ‘daily’ sediment loads and components for Black Creek.

Impairment	Allocated Permitted Point Sources (WLA) (lb/day)	Allocated Nonpoint Sources (LA) (lb/day)	Margin of Safety (MOS) (lb/day)	Maximum Daily Load (MDL) (lb/day)
Black Creek (VAV-H09R_BKC01A14)	**84**	**2,408**	**277**	**2,769**
VA0089729	*55*			
Future Growth (2% of TMDL)	*29*			

Table 6-7. Maximum ‘daily’ sediment loads and components for Hat Creek

Impairment	Allocated Permitted Point Sources (WLA) (lb/day)	Allocated Nonpoint Sources (LA) (lb/day)	Margin of Safety (MOS) (lb/day)	Maximum Daily Load (MDL) (lb/day)
Hat Creek (VAV-H09R_HAT01A04)	**124**	**10,720**	**1,205**	**12,049**
Domestic Sewage General Permits	*0.25*			
Future Growth (2% of TMDL)	*124*			

Table 6-8. Maximum ‘daily’ phosphorus loads and components for Black Creek.

Impairment	Allocated Permitted Point Sources (WLA) (lb/day)	Allocated Nonpoint Sources (LA) (lb/day)	Margin of Safety (MOS) (lb/day)	Maximum Daily Load (MDL) (lb/day)
Black Creek (VAW-L19R_RAB01A00)	**2**	**3.7**	**0.6**	**6.36**
VA0089729	*1.9*			
Future Growth	*0.1*			

6.4. Allocation Scenarios

Multiple allocation scenarios were run to determine possible options for reducing the sediment and phosphorus loads to the recommended TMDL loads. Feedback from the stakeholder meeting members guided the selection of the preferred allocation scenarios for each TMDL watershed. The various sediment allocation scenarios are presented in **Table 6-9** and **Table 6-10,** and the various phosphorus allocation scenarios are presented in **Table 6-11**. Due to the extent of sediment and phosphorus reductions needed in Black Creek, it was not possible to provide a fourth scenario focusing only on urban source reductions to meet TMDL targets. If these sources are reduced by 100%, the TMDLs target still cannot be achieved. After weighing the relatively high costs of urban and residential BMPs and the strong partnerships likely to be developed with the agricultural community given their existing commitment to natural resources, community engagement meeting participants indicated that balanced reductions with higher reductions on agricultural load sources was the preferred scenario for the study watersheds. This preferred allocation scenario for each watershed is highlighted as Scenario 1 in the tables.

Any apparent differences in calculated values are due to rounding.

Table 6-9. Allocation scenarios for Black Creek sediment loads.

Black Creek Sediment (2-BKC000.08)		**Scenario 1 (preferred)**		**Scenario 2**		**Scenario 3**	
Source	Existing	Red.	Allocation	Red.	Red.	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*%*	*%*	*TSS (lb/yr)*
Hay	59,587	15	50,649	26.6	43,737	33.4	39,685
Pasture	253,951	30.5	176,496	26.6	186,400	33.4	169,132
Forest	87,308	-	87,308	-	87,308	-	87,308
Trees	32,305	-	32,305	-	32,305	-	32,305
Shrub	2,666	-	2,666	-	2,666	-	2,666
Harvested	14,012	-	14,012	-	14,012	-	14,012
Wetland	453	-	453	-	453	-	453
Gravel	908	6	854	26.6	667	-	908
Turfgrass	15,476	6	14,547	26.6	11,359	-	15,476
Developed pervious	1,789	6	1,681	26.6	1,313	-	1,789
Developed impervious	67,858	30	47,501	26.6	49,808	-	67,858
Streambank Erosion	21,197	20	16,957	26.6	15,558	33.4	14,117
VA0089729*	1,613	-	20,118	-	20,118	-	20,118
TOTAL+	**559,123**		**465,547**		**465,704**		**465,827**

**Existing conditions shows TSS load calculated using average flow data from facility. TMDL scenarios are calculated using the design flow of the facility and TSS concentration limit.*

+Totals do not include Margin of Safety (52,982) or Future Growth (10,592) allocations

Table 6-10. Allocation scenarios for Hat Creek sediment loads.

Hat Creek Sediment (2-HAT000.14)		**Scenario 1 (Preferred)**		**Scenario 2**		**Scenario 3**		**Scenario 4**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	12,919	3.5	12,467	8.9	11,769	9.5	11,692	-	12,919
Hay	102,647	3.5	99,055	8.9	93,512	9.5	92,896	-	102,647
Pasture	1,173,980	10.9	1,046,016	8.9	1,069,495	9.5	1,062,452	-	1,173,980
Vineyard	15,794	3.5	15,241	8.9	14,389	9.5	14,294	-	15,794
Forest	364,328	-	364,328	-	364,328	-	364,328	-	364,328
Trees	57,301	-	57,301	-	57,301	-	57,301	-	57,301
Shrub	5,220	-	5,220	-	5,220	-	5,220	-	5,220
Harvested	17,614	-	17,614	-	17,614	-	17,614	-	17,614
Wetland	176	-	176	-	176	-	176	-	176
Gravel	3,028	1.0	2,998	8.9	2,759	-	3,028	38	1,878
Turfgrass	28,358	1.0	28,074	8.9	25,834	-	28,358	38	17,582
Developed pervious	2,191	1.0	2,169	8.9	1,996	-	2,191	38	1,358
Developed impervious	87,040	1.0	86,169	8.9	79,293	-	87,040	38	53,965
Streambank Erosion	275,435	6.0	258,909	8.9	250,921	9.5	249,268	38	170,770
Domestic Sewage General Permits	91	-	91	-	91	-	91	-	91
TOTAL+	**2, 146,122**		**1,995,828**		**1,994,698**		**1,995,949**		**1,995,623**

+Totals do not include Margin of Safety (226,849) and Future Growth (45,370) allocations.

Table 6-11. Allocation scenarios for Black Creek phosphorus loads.

Black Creek Watershed		**Scenario 1 (Preferred)**		**Scenario 2**		**Scenario 3**	
Source	**Existing TP (lb/yr)**	**Reduction (%)**	**Allocation TP (lb/yr)**	**Reduction (%)**	**Allocation TP (lb/yr)**	**Reduction (%)**	**Allocation TP (lb/yr)**
Groundwater	168.0	-	168.0	-	168.0	-	168.0
Hay	188.6	30.0	132.0	30.0	132.0	50.0	94.3
Pasture	81.4	30.0	57.0	30.0	57.0	50.0	40.7
Forest	17.9	-	17.9	-	17.9	-	17.9
Trees	8.6	-	8.6	-	8.6	-	8.6
Shrub	0.4	-	0.4	-	0.4	-	0.4
Harvested	2.5	-	2.5	-	2.5	-	2.5
Wetland	0.1	-	0.1	-	0.1	-	0.1
Gravel	0.4	5.0	0.4	30.0	0.3	-	0.4
Turfgrass	27.7	25.0	20.8	30.0	19.4	-	27.7
Developed Pervious	1.2	5.0	1.2	30.0	0.8	-	1.2
Developed Impervious	149.3	30.0	104.5	30.0	104.5	-	149.3
Streambank	7.4	25.0	5.6	30.0	5.2	-	7.4
VA0089729*	914	25.1	685.0	25.1	685.0	25.1	685.0
TOTAL+	**1,568**		**1,204**		**1,202**		**1,204**

**Existing conditions shows TP load calculated using average flow and TP concentration data from facility.*

+Totals do not include Margin of Safety (137) or Future Growth (27) allocations

7.0 TMDL IMPLEMENTATION AND REASONABLE ASSURANCE

7.1. Regulatory Framework

There is a regulatory framework in place to help enforce the development and attainment of TMDLs and their stated goals on both the federal and the state level in Virginia. On the federal level, section 303(d) of the Clean Water Act and current USEPA regulations, while not explicitly requiring the development of TMDL implementation plans as part of the TMDL process, do require reasonable assurance that the load and waste load allocations can and will be implemented. Federal regulations also require that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the assumptions and requirements of any applicable TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)).

At the state level, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). WQMIRA also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. After DEQ approves the TMDL study, staff will present the study to the State Water Control Board (SWCB) and request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9 VAC 25-270), in accordance with §2.2-4006A.14 and §2.2-4006B of the Code of Virginia. DEQ's public participation procedures relating to TMDL development can be found in DEQ's Guidance Memo No.14-2016 (DEQ, 2014a).

DEQ regulates stormwater discharges associated with permitted activities through its VPDES program and stormwater discharges from construction sites through its VSMP program. All new or revised permits must be consistent with the assumptions and requirements of any applicable TMDL WLA.

7.2. Implementation Plans

Implementation plans set intermediate goals and describe actions (with associated costs) that can be taken to clean up impaired streams. Some of the actions that may be included in an implementation plan to address excess sediment and phosphorous include:

- Fence out cattle from streams and provide alternative water sources
- Implement conservation tillage practices on cropland
- Conduct stream bank restoration projects in areas where banks are actively eroding

- Leave a 35 – 100 ft band of natural buffer along the stream so that it slows overland flow and filters out sediment from adjacent land (a riparian buffer)
- Encourage timely septic system maintenance and repair.
- Reduce runoff by increasing green spaces and reducing hardened spaces (asphalt or concrete)

Overall, implementation of TMDLs works best with a targeted, staged approach, directing initial efforts where the biggest impacts can be made with the least effort so that money, time, and other resources are spent efficiently to maximize the benefit to water quality. Progress towards meeting water quality goals defined in the implementation plan will be assessed during implementation by the tracking of new BMP installations and continued water quality monitoring by DEQ. Several BMPs have already been implemented in the watershed and were accounted for in the development of this TMDL (**Section 4.4**).

Implementation plans also identify potential sources of funding to help in the clean-up efforts. Funds are often available in the form of cost-share programs, which share the cost of improvements with the landowner. Potential sources of funding include USEPA Section 319 funding for Virginia's Nonpoint Source Management Program, the USDA's Conservation Reserve Enhancement Program (CREP) and its Environmental Quality Incentive Program (EQIP), the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. The Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans (DEQ, 2017) contains information on a variety of funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts. Additional sources are also often available for specific projects and regions of the state. State agencies and other stakeholders may help identify funding sources to support the plan, but actually making the improvements is up to those that live in the watershed. Part of the purpose of developing a TMDL and implementation plan is to increase education and awareness of the water quality issues in the watershed and encourage residents and stakeholders to work together to improve the watershed.

7.3. Reasonable Assurance

The following activities provide reasonable assurance that these TMDLs will be implemented and water quality will be restored in the Black and Hat Creek watersheds.

- Regulatory frameworks – Existing federal and state regulations require that new and existing permits comply with the developed TMDLs. State law also requires that implementation plans be developed to meet TMDL goals.
- Funding sources – Numerous funding sources (listed above) are available to defray the cost of TMDL implementation.

- Public participation – Public participation in the TMDL process informs and mobilizes watershed residents and stakeholders to take the necessary actions to implement the TMDL.
- Continued monitoring – Water quality and aquatic life monitoring will continue in the TMDL watersheds and track progress towards the TMDL goals. DEQ will continue monitoring benthic macroinvertebrates and habitat in accordance with its biological monitoring program stations throughout the watershed.
- Current implementation actions – Many voluntary and subsidized best management practices have already been installed in these watersheds. The Soil and Water Conservation Districts and NRCS are actively working in these areas to promote and implement additional practices that can reduce sediment and phosphorus loads.

7.4. Attainability of Designated Use

The goal of a TMDL is to restore impaired waters so that numeric and narrative water quality standards (WQSs) are attained. WQSs consist of statements that describe water quality requirements and include three components: 1) designated uses, 2) water quality criteria to protect designated uses, and 3) an antidegradation policy. However, in some streams for which TMDLs have been developed, factors may prevent the stream from attaining its designated use. In order for a stream to be assigned a new designated use, a subcategory of a use, or a tiered use, the current designated use must be removed from the state water quality standards regulations and is subject to USEPA approval. To remove a designated use, the state must demonstrate that the use is not an existing use, and that downstream uses are protected. Such uses will be attained by implementing effluent limits required under §301b and §306 of the Clean Water Act and by implementing cost-effective and reasonable best management practices for nonpoint source control (9VAC25-260-10 paragraph I).

The state must also demonstrate that attaining the designated use is not feasible because of one or more of the following reasons:

- Naturally occurring pollutant concentration prevents the attainment of the use.
- Natural, ephemeral, intermittent, or low flow conditions prevent the attainment of the use unless these conditions may be compensated for by the discharge of sufficient volume of pollutant discharges without violating state water conservation.
- Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.
- Dams, diversion, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate the modification in such a way that would result in the attainment of the use.

- Physical conditions related to natural features of the waterbody, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life use protection.
- Controls more stringent than those required by §301b and §306 of the Clean Water Act would result in substantial and widespread economic and social impact.

This and other information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted by the SWCB as amendments to the WQSs regulations. During the regulatory process, watershed stakeholders and other interested citizens, as well as the USEPA, are able to provide comment.

The process to address potentially unattainable reductions based on the above is as follows:

As a first step, measures targeted at the controllable, anthropogenic sources of all pollutants and non-pollutants causing or contributing to the biological impairment will be implemented. In addition, measures should be taken to ensure that discharge permits are fully implementing provisions required in the TMDL. The expectation would be for the reductions of all controllable sources to be to the maximum extent practicable. DEQ will continue to monitor water quality in the impaired streams during and subsequent to the implementation of these measures to determine if WQSs are being attained. This effort will also help to evaluate if the modeling assumptions used in the TMDL were correct. In the best-case scenario, water quality goals will be met and the stream's uses fully restored using pollution controls and BMPs. If, however, WQSs are not being met, and no additional pollution controls and BMPs can be identified, a UAA would then be initiated with the goal of re-designating the stream for a more appropriate use, subcategory of a use, or tiered use.

A 2006 amendment to the Code of Virginia under 62.1-44.19:7E provides an opportunity for aggrieved parties to present to the SWCB reasonable grounds indicating that the attainment of the designated use for a water is not feasible. The Board may then allow the aggrieved party to conduct a UAA according to the criteria listed above and a schedule established by the Board. The amendment further states that "if applicable, the schedule shall also address whether TMDL development or implementation for the water shall be delayed".

8.0 PUBLIC PARTICIPATION

Public participation was elicited at every stage of the TMDL study in order to receive input from stakeholders and to apprise the stakeholders of progress made. A series of two public meetings and six community engagement meetings took place during the TMDL development process. Since a TMDL implementation plan was being developed concurrently with the TMDL study, implementation actions were also discussed at several of these meetings. Public meetings and community engagement meetings included representatives from the James River Association, Nelson County Board of Supervisors, Nelson County Service Authority, Thomas Jefferson SWCD, Thomas Jefferson Planning District Commission, Virginia Department of Energy, Virginia Farm Bureau, the Nelson County Times, as well as many residents of the watersheds.

The first public meeting (32 attendees, January 25th, 2023) was held at the Nelson Memorial Library in Lovingston, VA. This meeting introduced attendees to DEQ's water quality planning process, the TMDL purpose and process, reviewed benthic monitoring data collected in the study watersheds, discussed the impairments, reviewed the preliminary results of the stressor analysis, and solicited input on the benthic stressors identified in the benthic stressor analysis study. This meeting was followed by a 30-day public comment period, which closed on February 24, 2023. No comments were received during this time.

The first community engagement meeting (24 attendees, March 1st, 2023) was held at the Nelson Memorial Library in Lovingston, VA to discuss the TMDL process and the benthic stressor analysis. In addition, the group discussed land cover estimates and loading rates assigned to each land cover type. Several meeting members noted the abundance of gravel roads in the area and that VDOT might be able to provide more information. It was also noted that a large area of cropland shown on the map in Hat Creek was orchard and/or vineyards rather than row crops, and the amount of cropland in general was overestimated. See **Section 3.4** for further information on the existing conditions and land use changes. The group also discussed the method used to account for future permitted land disturbance and how the AllForX method will be used to develop target pollutant loads for the watersheds. See **Section 5.0** and **Appendix C** for further information on future growth and the AllForX method.

The second community engagement meeting (18 attendees, May 17th, 2023) was held at the Nelson Memorial Library. Participants in this meeting discussed the changes in landcover distributions that were made based on the input from the members of the first stakeholder meeting, revisited a previous discussion about establishing a set aside for construction stormwater permits in the watershed, discussed the future growth allocation and margin of safety, reviewed the pollutant sources and BMPs in the impaired watersheds, and gathered input on the preferred sediment allocation scenario.

The third community engagement meeting was held on January 10, 2024 at the Nelson Memorial Library (18 attending). This meeting was focused on developing a phosphorus endpoint for Black Creek. The group discussed TMDL alternatives and agreed to change paths and shift to developing an advance restoration plan to address sediment and phosphorus targets in Hat and Black Creeks.

The fourth community engagement meeting was held on February 27, 2024 at the Nelson Memorial Library (9 attending). Participants prioritized a series of agricultural best management practices for inclusion in the advance restoration plan. Streambank restoration practices were also discussed and agreed on as a high priority for local stakeholders.

The fifth community engagement meeting was held on September 9, 2024 at the Nelson Memorial Library (11 attending). During this meeting, participants discussed the decision to pivot back to developing a traditional TMDL and separate implementation plan to address the impairments. The group also discussed the new path forward for the project and revisions to existing loads and reduction scenarios for the two watersheds.

The sixth and final community engagement meeting was held on December 3, 2024 at the Nelson Memorial Library (12 attending). During this meeting, the group reviewed implementation scenarios for best management practices in Hat and Black Creeks. Participants reviewed cost estimates and assisted with development of a timeline for implementation efforts. Plans for the final public meeting were also discussed.

A final public meeting was held on March 5, 2025 at The Nelson Center in Lovingston to present the draft TMDL document. The public meeting marked the beginning of the official 30-day public comment period and was attended by ## watershed residents and other stakeholders. The public comment period ended on April 4, 2025. A comment response document was compiled (Appendix D) and includes all comments received during this period in addition to responses prepared by DEQ.

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Appendix A - GWLF Model Parameters

Various GWLF parameters used for the Black and Hat Creek watersheds models are detailed below. **Table A-1** and **Table A-2** list the various watershed-wide parameters. The land use parameters for the watersheds are listed in **Table A-3** and **Table A-4**.

Table A-1. Watershed-wide GWLF parameters.

GWLF Parameter	Units	Value
Recession Coefficient	day^{-1}	0.022
Seepage Coefficient	day^{-1}	0.007
Leakage Coefficient	day^{-1}	0.008
Erosivity Coefficient (Nov-Mar)		0.12
Erosivity Coefficient (Apr-Oct)		0.33
Sediment P Concentration	mg/kg	700
Groundwater P Concentration	mg/L	0.013
Septic System Effluent P	g/person-day	1.37
Plant Nutrient Uptake P	g/person-day	0.4

Table A-2. Additional GWLF watershed parameters.

GWLF Parameter	Black Creek	Hat Creek
Sediment Delivery Ratio	0.21	0.14
Unsaturated Water Capacity (cm)	22.5	16.7
aFactor	0.000095	0.000077
Total Stream Length (m)	8,830	37,517
Mean Channel Depth (m)	1.7	2.9
ET Cover Coefficient, Apr-Oct	0.964	0.987
ET Cover Coefficient, Nov-Dec	0.828	0.832
ET Cover Coefficient, Jan-Mar	0.911	0.915

Table A-3. Land cover parameters for Black Creek.

Land Cover	Area (ha)	CN	KLSCP	Runoff P (mg/L)	Sediment Build-up (kg/ha-d)	P in Sediment Build-up (kg/kg)
Low Till Cropland	0.00	0.00	0.0000	0.14	n/a	n/a
Hay	195.48	59.38	0.0023	0.20	n/a	n/a
Pasture-Good	28.22	62.38	0.0058	0.20	n/a	n/a
Pasture-Fair	59.10	70.06	0.0234	0.51	n/a	n/a
Pasture-Poor	6.59	79.75	0.0415	0.82	n/a	n/a
Vineyard	0.00	0.00	0.0000	0.82	n/a	n/a
Forest	713.72	56.27	0.0010	0.01	n/a	n/a
Tree	134.75	60.36	0.0017	0.03	n/a	n/a
Scrub/Shrub	3.42	48.92	0.0090	0.03	n/a	n/a
Harvested-Disturbed	6.46	66.01	0.0128	0.05	n/a	n/a
Water	4.02	98.00	0.0000	0.00	n/a	n/a
Wetland	0.60	65.74	0.0045	0.00	n/a	n/a
VDOT Gravel Road	1.06	85.50	0.0034	0.05	n/a	n/a
Turfgrass	66.77	61.43	0.0016	0.38	n/a	n/a
Developed-Pervious	3.74	61.57	0.0033	0.25	n/a	n/a
Developed-Impervious	14.97	98.00	0.0000	n/a	6.2	0.00217
Impervious Local Dataset	25.53	98.00	0.0000	n/a	2.8	0.00217

Table A-4. Land cover parameters for Hat Creek.

Land Cover	Area (ha)	CN	KLSCP
Low Till Cropland	9.20	74.33	0.0103
Hay	477.28	60.52	0.0023
Pasture-Good	81.01	63.52	0.0058
Pasture-Fair	353.90	70.94	0.0233
Pasture-Poor	10.67	80.35	0.0414
Vineyard	63.57	66.16	0.0022
Forest	3,439.38	55.25	0.0014
Tree	359.76	60.64	0.0017
Scrub/Shrub	9.27	49.06	0.0098
Harvested-Disturbed	10.46	66.00	0.0150
Water	7.74	98.00	0.0000
Wetland	0.91	59.31	0.0022
VDOT Gravel Road	3.74	86.00	0.0048
Turfgrass	148.17	64.38	0.0018
Developed-Pervious	4.04	63.30	0.0053
Developed-Impervious	16.15	98.00	0.0000
Impervious Local Dataset	39.50	98.00	0.0000

Appendix B - Sensitivity Analysis

Analyses were conducted to assess the sensitivity of the model to changes in hydrologic and water quality parameters, as well as to assess the potential impact of uncertainty in parameter determination. Sensitivity analyses were run on the parameters listed in **Table B-1** and **Table B-2**. The outputs from model runs using the listed base parameter values were compared to model runs changing each of the parameters by +10% and -10% of the base value. The results are shown in **Table B-3**.

The relationships exhibit roughly linear responses with the exception of KLSCP, curve number (CN), and evapotranspiration coefficient (ET-CV). Changes in variables specific to sediment such as KLSCP had no impact on hydrology, which was to be expected. Sediment related parameters impacted phosphorus loads, but phosphorus-specific parameters such as the concentration of phosphorus in runoff or soil only affected phosphorus loads. Changes in the ET-CV had the most influence on the flow while changes in the KLSCP, followed by the recession and seepage coefficients. CN had the most influence on the sediment load. The phosphorus load was most impacted by changes in ET-CV and CN.

Table B-1. Land cover related parameters used in GWLF sensitivity analysis.

Land Cover	CN	KLSCP	Sediment Build-up (kg/ha-d)
hay	57.45	0.0028	n/a
pasture-good	60.57	0.0070	n/a
pasture-fair	68.61	0.0280	n/a
pasture-poor	78.79	0.0498	n/a
forest	53.31	0.0015	n/a
tree	56.61	0.0028	n/a
scrub/shrub	48.00	0.0068	n/a
harvested-disturbed	66.00	0.0207	n/a
water	98.00	0.0000	n/a
NWI/other	55.00	0.0032	n/a
turfgrass	60.94	0.0025	n/a
developed-pervious	59.67	0.0076	n/a
developed-impervious	98.00	0.0000	6.2
impervious	98.00	0.0000	2.8

Table B-2. Watershed parameters used in GWLF sensitivity analysis.

Parameter	Units	Base Value
Recession Coefficient	day^{-1}	0.022
Seepage Coefficient	day^{-1}	0.007
Leakage Coefficient	day^{-1}	0.008
Unsaturated Available Water Capacity (AWC)	cm	15.54
Evapotranspiration Coefficient (ET-CV)	n/a	0.797-0.992

Table B-3. Results of the GWLF sensitivity analysis.

Model Parameter	Parameter Change (%)	Total Runoff Volume Change (%)	Total Sediment Load Change (%)	Total Phosphorus Load Change (%)
CN	+10	0.79	13.18	6.38
	-10	-0.67	-13.25	-4.78
KLSCP	+10	0.00	7.84	0.74
	-10	0.00	-5.04	-0.48
Recession Coefficient	+10	1.94	0.27	1.50
	-10	-2.23	-0.33	-1.73
Seepage Coefficient	+10	-3.11	-0.71	-2.54
	-10	3.33	0.75	2.72
Leakage Coefficient	+10	0.07	0.03	0.06
	-10	-0.07	-0.02	-0.06
AWC	+10	-0.13	-0.05	-0.11
	-10	0.31	0.09	0.26
ET-CV	+10	-8.54	-2.23	-7.05
	-10	9.34	2.43	7.71
Runoff P	+10	0.00	0.00	1.05
	-10	0.00	0.00	-1.05
P in Sediment Build-up	+10	0.00	0.00	0.20
	-10	0.00	0.00	-0.20
Sediment Build-up	+10	0.00	0.09	0.22
	-10	0.00	-0.09	-0.22

Appendix C - AllForX Development

The method used to set TMDL endpoint loads for the Black Creek and Hat Creek watersheds is called the "all-forest load multiplier" (AllForX) approach, introduced in **Section 5.0**. AllForX is the ratio calculated by dividing the simulated pollutant load under existing conditions by the pollutant load from an all-forest simulated condition for the same watershed. In other words, AllForX is an indication of how much higher current sediment loads are above an undeveloped condition. After calculating AllForX values for a range of comparison monitoring stations, a regression is developed between the AllForX values and corresponding VSCI scores at those stations (**Figure C-1**, Error! Reference source not found., **Figure C-2**). This relationship between AllForX values and VSCI scores can be used to quantify the AllForX value that corresponds to the VSCI threshold score of 60.

These multipliers were calculated for a total of 13 watersheds (**Figure C-3**). Comparison watersheds used in addition to the TMDL watersheds in developing the VSCI and AllForX regression were selected to be similar in size and located near the study watersheds, ideally within the same ecoregion, to minimize differences in flow regime, soils, and other physiographic properties. Additionally, the comparison watersheds must have adequate and recent VSCI data for a watershed to be a useful data point. The VSCI scores at each station since 2001 were included in the analysis. These watersheds included both unimpaired and impaired streams to represent a wide distribution of current conditions.

For the purposes of building the AllForX regression, permitted sources were not included. This was to allow for flexibility to incorporate other watersheds into the regression that may have less available data. The same set of watershed models were run a second time, changing all of the land use parameters to reflect forested land cover while preserving the unique soil and slope characteristics of each watershed. The AllForX multiplier was calculated for each modeled watershed by dividing the original model loads by the all-forested model loads. This data is presented in **Table C-1**.

An AllForX regression was created for the sediment load in Black Creek. The AllForX values were plotted against their associated average VSCI scores and a linear regression was plotted through the values (**Figure C-1,** Error! Reference source not found.). The regression for sediment (TSS) resulted in an R^2 value of 0.624. The regression was used to quantify the value of AllForX that corresponds to the benthic health threshold (VSCI = 60) for sediment. Based on the regression, an average VSCI score of 60 corresponded to a target AllForX ratio of 3.0 for sediment. This means that the TMDL streams are expected to achieve consistently healthy benthic conditions if sediment are less than 3.0 times the simulated load of an all-forested watershed. The allowable pollutant TMDL load was then calculated by applying the AllForX threshold where VSCI = 60 to the All-Forest simulated pollutant load of the target watershed to determine the final target TMDL loading. An explicit margin of safety was implemented based on this target loading rate, setting aside 10% of the allowable load specifically for the margin of safety.

A separate regression was developed for Hat Creek to account for unique characteristics of the stream. Rather than using average VSCI scores for monitoring stations, the 33rd percentile of scores in the past 10 years was used. The results of the benthic stressor analysis for Hat Creek indicate a 'borderline' impairment, with VSCI scores repeatedly falling above and below the threshold of 60. The 33rd percentile was selected in particular because it accounts for the fact that DEQ requires two consecutive years of benthic monitoring above the VSCI threshold of 60 before delisting the stream as unimpaired. Based on a 6-yr assessment window and typical DEQ monitoring every 2 years, no more than a third (33%) of benthic scores could be below the threshold of 60 and meet the qualifications for delisting. With VSCI scores in Hat Creek falling both above and below the listing threshold, using the 33rd percentile accounts for some of the nuance in the delisting criteria that has contributed to Hat Creek remaining on the impaired list.

The AllForX values were plotted against their associated 33rd percentile VSCI scores and a linear regression was plotted through the values (**Figure C-2**). The regression for sediment (TSS) resulted in an R^2 value of 0.551. The regression was used to quantify the value of AllForX that corresponds to the benthic health threshold (VSCI = 60) for sediment. Based on the regression, a 33rd percentile VSCI score of 60 corresponded to a target AllForX ratio of 2.8. This means that the TMDL streams are expected to achieve consistently healthy benthic conditions if sediment loads are less than 2.8 times the simulated load of an all-forested watershed. The allowable sediment TMDL load was then calculated by applying the AllForX threshold where VSCI = 60 (2.8) to the All-Forest simulated pollutant load of the target watershed to determine the final target TMDL loading. An explicit margin of safety was implemented based on this target loading rate, setting aside 10% of the allowable load specifically for the margin of safety.

Table C-1. Model run results for AllForX value development.

Station ID	Average VSCI	33rd % VSCI	TSS (t/yr)	TSS All-Forested (t/yr)	TSS AllForX Ratio	TP (t/yr)	TP All-Forested (t/yr)	TP AllForX Ratio
2-BKC000.08	54.36	53.98	298.32	79.90	3.73	734.49	216.90	3.39
2-HAT000.14	58.67	52.26	979.30	365.98	2.68	2,150.53	875.82	2.46
2-POL020.03/2-POL019.63	69.33	66.48	708.15	542.76	1.30	1,543.81	1,257.14	1.23
2BECH000.53	73.25	72.45	78.11	74.52	1.05	146.22	130.39	1.12
2-LIF000.08/2-LIF000.62	74.62	74.15	91.18	87.56	1.04	187.13	170.55	1.10
2-BMT000.07	77.69	76.55	94.33	79.95	1.18	173.05	153.85	1.12
2-BUF026.43	58.13	54.02	1,492.23	646.73	2.31	2,925.15	1,475.40	1.98
2-BNF003.52	78.01	75.28	69.49	65.75	1.06	241.84	238.57	1.01
2BPRS001.90	80.76	80.75	79.60	71.29	1.12	217.14	194.48	1.12
2-RTD003.08/2-RTD003.30	52.45	52.33	597.34	265.64	2.25	2,310.40	721.58	3.20
2-TNR000.25	63.36	63.18	237.37	72.25	3.29	974.96	292.65	3.33
2BRKR012.86	61.36	60.68	450.72	130.13	3.46	841.32	311.16	2.70
2-BVC003.09	73.12	73.11	574.86	264.41	2.17	1,162.18	710.39	1.64

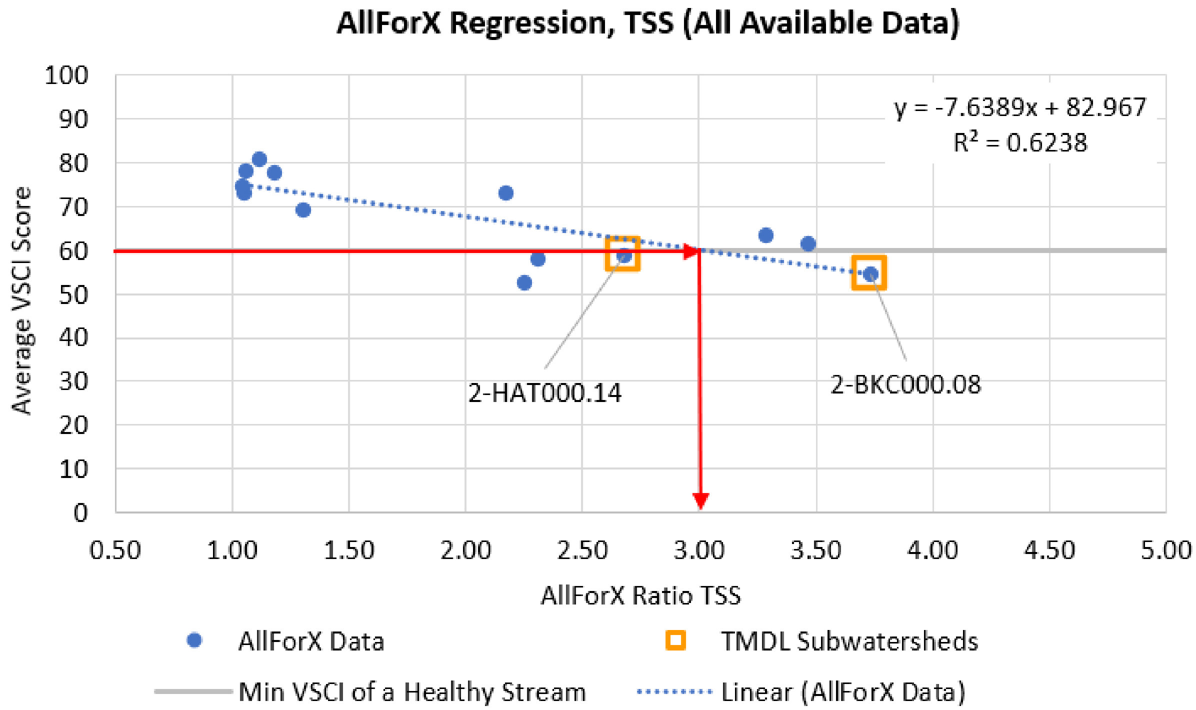

Figure C-1. Regression between the average VSCI scores and all-forest multiplier for sediment, resulting in a TSS AllForX target ratio of 3.0 in the Black Creek TMDL

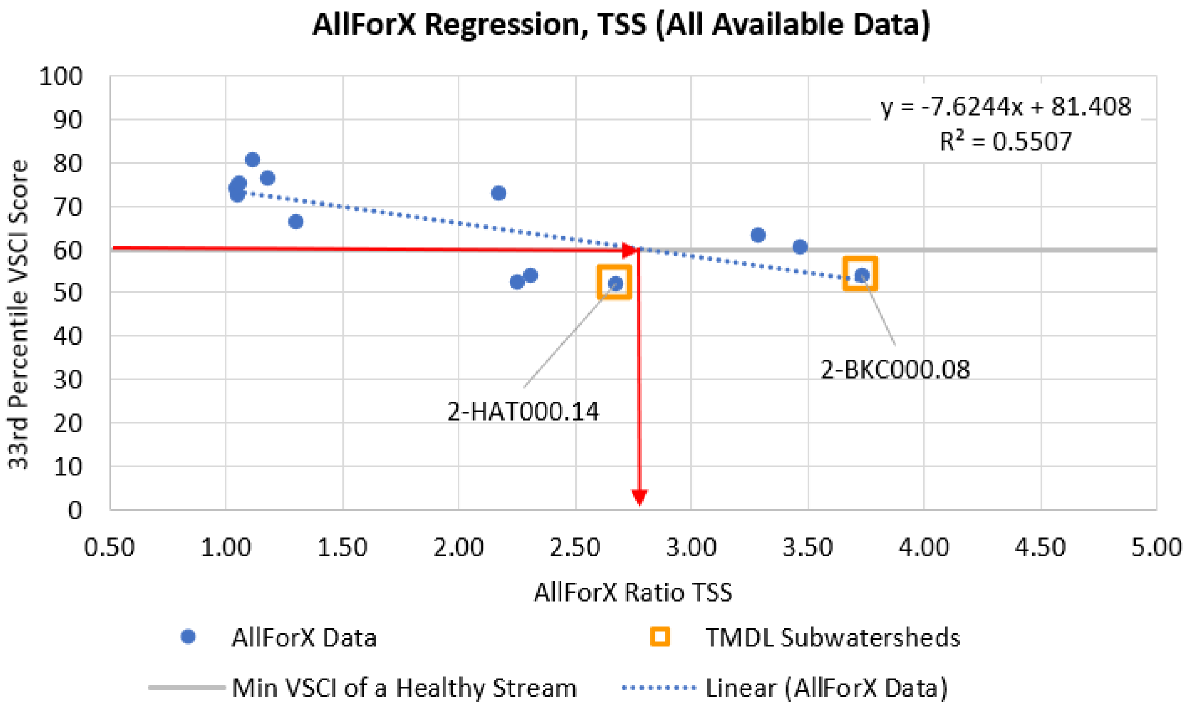

Figure C-2. Regression between 33rd percentile VCSI scores and all-forest multiplier for sediment, resulting in a TSS AllForX target ratio of 2.8 in the Hat Creek TMDL.

AllForX was considered for establishment of a phosphorus endpoint in Black Creek; however, given the proportion of the total phosphorus load in the watershed originating from the Nelson County STP (57.3%), this approach did not appear suitable for the watershed. Alternatively, a concentration-based approach was used to establish the phosphorus endpoint in Black Creek. This approach was used in the Little Otter River Benthic TMDL in 2014, where a TP endpoint was set to an average annual in-stream concentration of 0.070 mg/L based on the 90th percentile concentration at a reference station on the Big Otter River (DEQ, 2014b). Hat Creek was identified as a suitable reference for Black Creek. While the stream had a borderline benthic impairment, phosphorus concentrations in the creek are not the cause of the benthic impairment. The TP endpoint for Black Creek was set to an average annual in-stream concentration of 0.092 mg/L (Table C-2). The existing phosphorus load was calculated using the average discharge rate and total phosphorus concentration from the Nelson County Regional STP. The target total phosphorus load shown in the table below includes existing sources of phosphorus in addition to a future growth allocation and a margin of safety.

Table C-2 Target phosphorus concentration and load for the Black watershed

	Existing Condition		TMDL Target	
Impaired stream	**Mean In-Stream TP Concentration (mg/L)**	**Total Phosphorus Load (lb/yr)**	**Mean In-Stream TP Concentration (mg/L)**	**Total Phosphorus Load (lb/yr)**
Black Creek	0.16	1,568	0.092	1,368

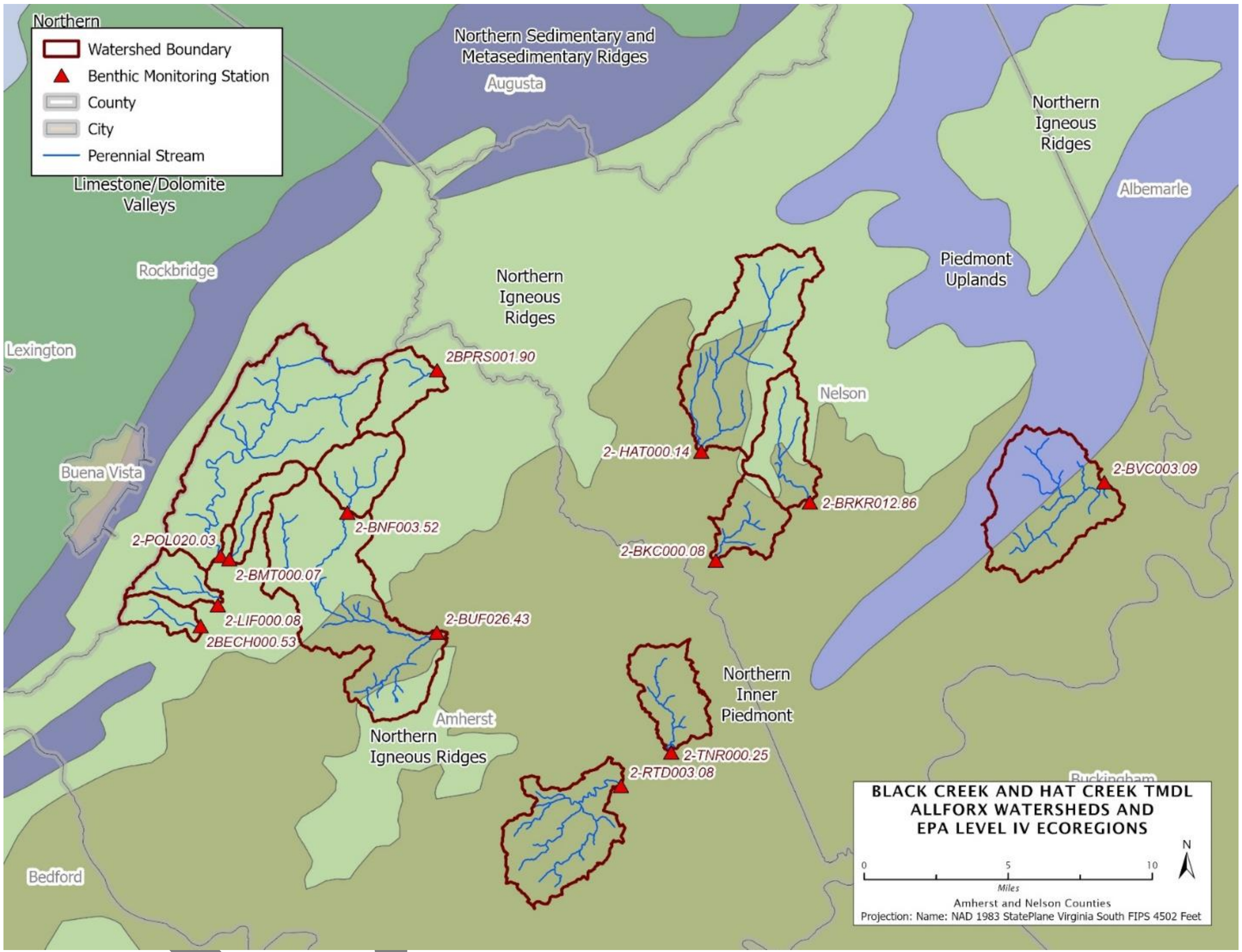

Figure C-3. Watersheds used in developing the AllForX regression.

Appendix D: Benthic Stressor Analysis

Available at: